From Housing Assistance to Student Debt: the Effects of Government Aid on Household Behavior and Welfare

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This dissertation consists of three chapters that study the effects of government assistance on household behavior and welfare. The first chapter studies the effect of the Housing Voucher Program (Section 8) on household behavior and welfare. Policymakers and researchers continuously debate the optimal structure and scope of the U.S. Housing Voucher Program. The current program features an inverse relation between subsidies and recipients' income, a high degree of rationing, and a limited scope of voucher usage. This chapter studies the effect of the Housing Voucher Program on low-income household behavior and welfare. Using several household datasets, I specify and estimate a lifecycle model that characterizes the effects of housing vouchers. Then I examine how a set of policy reforms affect household labor supply, marriage, homeownership, and well-being.

The second chapter investigates the role of job mismatch, wage dispersion, student debt, family background, and preferences in accounting for the rise in parental coresidence rates over time. Parental coresidence rates for college graduates have risen substantially over the last twenty five years, from 25% average coresidence rate for 23-27 yo for 1996 graduation cohort to over 31% for the 2014 graduation cohort. We develop a structurally estimated model of child-parent decisions to study the quantitative effect of job mismatch, wage dispersion, student debt, family background, and preferences on coresidence rates.

The third chapter examines the effect student debt on marriage and homeownership among college graduates. Student debt for the current college cohort has increased in terms of number of debtors and average amount, which subsequently impacts family formation and homeownership. Using NLSY 79 and NLSY 97 data, we develop and estimate a lifecycle model to quantify the role of student debt in college graduates' marriage and homeownership patterns. Beyond student debt, we also examine the role of housing prices, wage dispersion, and downpayment rates in accounting for the difference in homeownership and marriage.

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Preface

I would like to express my deepest gratitude to my advisors Prof. Stefania Albanesi and Prof. Rania Gihleb, who continuously and convincingly conduct excellent research, and offer me considerate guidance and persistent help. They foster my research interests in labor and structural economics. I could not thank Prof. Stefania Albanesi and Prof. Rania Gihleb enough for the time and energy they have devoted to my development throughout the past years. Without their effort and support, this dissertation would not have been possible.

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1.0 Housing Vouchers, Labor Supply and Household Formation: A Structural Approach

1.1 Introduction

The U.S. Housing Choice Voucher Program (Section 8) is the largest federal program offering rental assistance in the private housing market. Between 1998 and 2018, government expenditure on the program increased from $10.5 billion to $21 billion. According to the Department of Housing and Urban Development (HUD), the number of recipient households rose from 1.4 million to 2.5 million. The program has undergone no major reforms since its implementation, and the optimal structure and scope of the program remain open to debate (Olsen, 2003; Collinson et al., 2015, 2019). The program's effects on household behavior and well-being are critical to the evaluation of its current application and alternative designs. This paper studies the effects of the current housing voucher program and its alternatives on low-income household behavior and welfare.

This paper contributes to our understanding of how changes in subsidy structure, degree of rationing, and voucher usage options influence household decisions and well-being. Though policymakers and researchers continue to debate potential policy reforms, no study has evaluated the effects of the reforms that have been discussed on household behavior and welfare (Husock, 2004; King, 2015; Yglesias, 2020). Most research adopts a reduced form approach to estimate the current program's effects. In contrast, I apply a structural analysis to evaluate the proposed reforms that aim to improve the program's implementation.

In particular, I study three possible changes to the current program and how they would affect household decisions and welfare. First, the current program features an inverse relationship between subsidies and recipients' income, which has the effect of discouraging labor supply (Jacob and Ludwig, 2012). To mitigate the current program's work disincentives, I consider a proposed policy that removes the inverse relation between subsidy and income, whereby every recipient household receives the same amount of subsidy. Second, the current program features a high degree of rationing and no time limit on receiving benefits, which

offers continuous subsidies to only a small fraction of eligible households. Researchers argue that rationing in housing assistance programs may lead to resource misallocation and welfare loss (Olsen, 2003; Collinson et al., 2015, 2019). I simulate two policy proposals that intend to expand the scope of households assisted by the program: one provides lower benefits to more households and the other offers time-limited subsidies. Third, current housing vouchers can only be used for renting. Olsen et al. (2007) argue that the housing voucher program is biased against homeownership because the subsidy decreases the relative cost of renting versus homeownership. I explore the effect of a policy that allows households to buy homes with their vouchers. For all the policy reforms, I consider the program's effects not only on labor supply and homeownership but also on marriage as vouchers may alter the insurance value of marriage and impact marriage dynamics (Moffitt, 1998; Mills et al., 2006). Finally, to shed light on the general equilibrium effect, I apply a separate framework developed by Zhang (2020) to study the role of housing assistance on rental and housing prices and apply it to each policy experiment. The ability to evaluate these policies and household behavior in a coherent and unified framework is one of the main advantages of my paper.

Beyond the contribution to evaluating major program reforms, this paper also contributes to our understanding of the program's effect on multiple fronts. First, this paper contributes to the understanding of in-kind transfers such as housing vouchers on household behavior and welfare. I explicitly model housing subsidies as an in-kind transfer by incorporating both goods and housing consumption, where housing vouchers subsidize housing consumption. Second, in my model, households choose whether to participate in the voucher program, and the data from the American Housing Survey (AHS) allows me to estimate the key parameter that governs household participation in the program. Other studies have to assume participation due to data limitations (Keane and Moffitt, 1998). Third, evidence of the effects of housing vouchers on family formation and homeownership is still inadequate. Most of that limited evidence is descriptive rather than causal (Olsen et al., 2007; Carasso et al., 2005). I explore the causal impact of the program on marriage and homeownership. Finally, whereas existing literature either employs local samples or explores the short-term effects (Heintze et al., 2006; Painter, 2001; Jacob and Ludwig, 2012), I study the program nationally and explores its long-term effects.

I establish stylized facts about the housing voucher program, which shows that vouchers are associated with lower employment, marriage and homeownership. Motivated by these stylized facts, I specify and estimate a structural lifecycle model to understand the mechanisms underlying the current program's effects on household behavior and welfare. My model captures the features of the program as well as household decisions on labor supply, marriage, and homeownership. I model both goods and housing consumption, where vouchers only subsidize housing consumption. Since participation in the program is self-selective, I endogenously model program participation. Conditional on program participation, households receive a voucher with a certain probability. Along with the decision to participate in the program, households choose whether to work, to marry, to buy a home, and how much to save.

To estimate my model, I use data from the Survey of Income and Program Participation (SIPP) and the American Housing Survey (AHS). Most of the information on households eligible for vouchers is in the SIPP. The information on household participation in the program is in the AHS. I show that the model matches the targeted moments, such as household labor supply, marriage, homeownership, and participation in the voucher program. The model also replicates salient features of untargeted moments and empirical estimates from existing literature. I then explore the behavioral response and welfare implications of several program reforms. The first reform offers the same amount of subsidy to voucher recipient households, regardless of household income. The second experiment preserves the negative relation between subsidy amount and income and provides modest subsidies to all eligible households that apply for vouchers. The third policy introduces time-limited subsides, i.e., 5-year subsidies. My final experiment gives households the option to buy a home with their vouchers.

The effects on the behavior of low-income households across my four experiments differ, though the government budget is neutral in all cases. In the first one, where every recipient household receives the same amount of subsidy, households will work more. The flat subsidy overcomes the disincentives generated by the current program towards labor supply to some extent. In particular, this policy increases single men's labor supply by 2 percentage points (3 percent relative to the mean) and single women's labor supply by 2 percentage points (4

percent relative to the mean). However, this policy has no significant impact on marriage and homeownership. The second policy experiment provides modest subsidies to all eligible applicants, where the subsidy amount is inversely related to household income. As a result, household labor supply decreases as the negative effect on labor supply spreads out over more households. This program change, with its negative effect, also decreases marriage and homeownership by changing the attractiveness of outside options to marriage and the relative cost of homeownership. The third experiment, in which vouchers only last 5 years, has a much smaller negative effect on labor supply, marriage, and homeownership. Fourth, the homeownership rate among eligible households rises by 4 percentage points (16 percent relative to the mean) when households are given the option to use the vouchers to buy homes. It also promotes marriage by 1.5 percentage points (3 percent relative to the mean) as the increase in homeownership makes marriage more attractive. However, this policy has no impact on household labor supply.

I also evaluate the effect of the policy reforms on household welfare. Compared to the current program, the policy that provides the same amount of subsidy to every recipient household reduces overall welfare among eligible households. In the current program, each recipient household receives a subsidy inversely related to household income. However, according to the policy, each recipient household receives the same amount so that relatively low-income households lose some benefits, while relatively high-income households gain some benefits. Since relatively-low income households have a higher marginal utility from a subsidy, the welfare loss for low-income households dominates the welfare gain from high-income households, yielding an overall reduction in welfare. The policy that provides lower benefits to all eligible households that apply for vouchers improves welfare because it assists more needy families who have a greater marginal utility at the lower benefit level. Introducing time limits also increases overall welfare by attenuating the rationing problem of the program. The policy that offers households the option to use vouchers to buy homes makes households better off as it promotes homeownership and homeownership is associated with higher utility flow. When considering general equilibrium effects, the effect of each policy on housing and rental prices is limited, assuming that the elasticity of housing supply is at the national median level. This implies that the main results are robust to general equilibrium

effects of housing vouchers.

In the robustness analysis, I provide more perspective into the program design by experimenting with various degrees of program targeting and transferring in-kind versus transferring in cash. In addition, I discuss the evidence of the housing voucher program's effect on rental prices. I also show that the results are robust when relaxing several model assumptions and incorporating moving costs.

The rest of the paper is structured as follows. Section II reviews the background of the Housing Voucher Program; Section III describes the data sets and stylized facts; Section IV describes the lifecycle model and discusses the agent's problem; Section V discusses the identification strategy, the structural parameter estimates as well as the internal and external fit of the model along several key dimensions; Section VI presents the policy experiments and reports on the effects on household behavior and welfare of potential program reforms; Section VII experiments with a variety of program targeted populations and shows the robustness of the results to alternative assumptions. The last section concludes this paper.

1.2 The Housing Voucher Program

In this section, I provide a brief review of the Housing Voucher Program (Section 8). The national shortage of affordable housing for low-income households is more than 7.2 million in 2018 (National Low Income Housing Coalition, 2018). The housing problem is not simply an inadequate supply of housing for low-income Americans to live in, however, but also extraordinarily high housing costs and undesirable living conditions. For example, an estimated 12 million households pay more than 50% of their annual incomes for housing, and most low-income households live in neighborhoods with high poverty rates, unsanitary conditions, and fewer employment opportunities (HUD, 2019).

To tackle such problems, the federal government administers affordable housing programs targeting low-income households to improve their housing conditions. The most important is the Housing Choice Voucher Program (Section 8), which started in the 1980s to assist low-income families to rent in private markets. Figure 1 illustrates shows that low-income housing

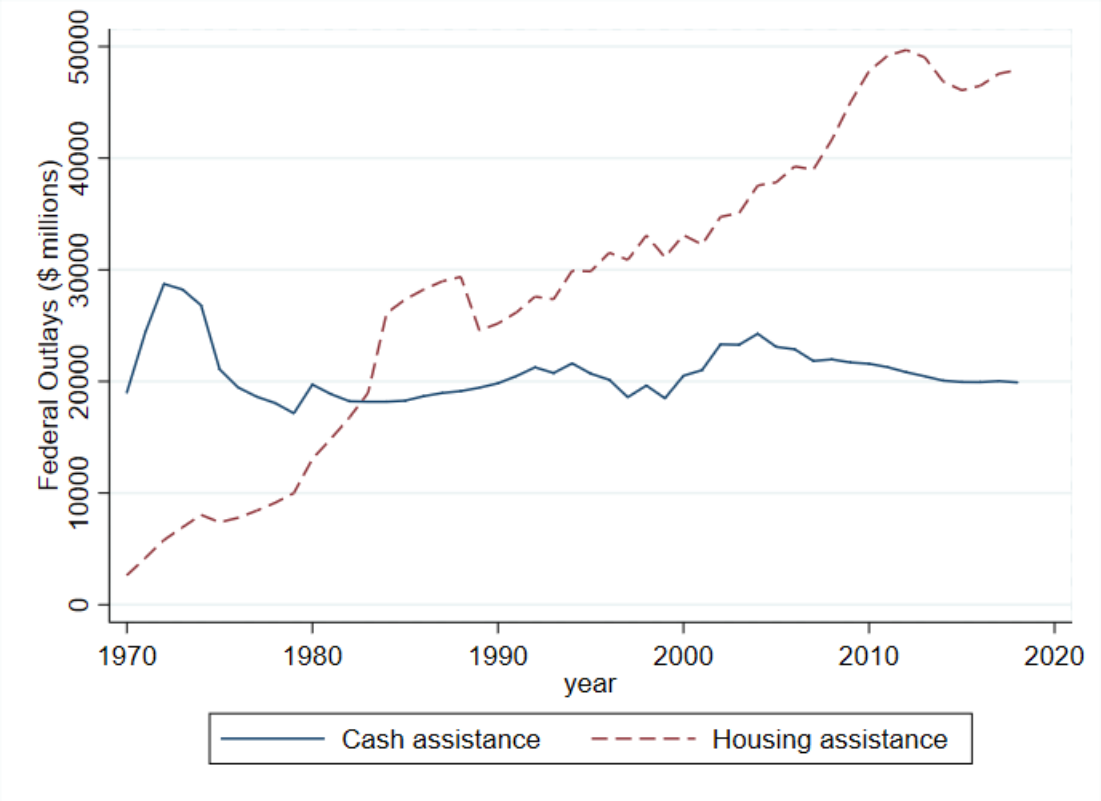
subsidies have more than quadrupled since 1980, while outlays for other cash assistance programs have remained constant. The increase has coincided with a change in housing policy from supply-side to demand-side housing subsidies, i.e., the introduction of the Certificate Program in the 1970s and the Section 8 Voucher Program in the 1980s. The Section 8 Voucher Program and the Certificate Program were consolidated into one program in 1998, which is today's Section 8 Housing Voucher Program (Olsen, 2003). The housing voucher program has grown rapidly during the past 20 years, both in terms of the number of households assisted and the amount of subsidy per household (Figure 2).

Housing vouchers are administered locally by public housing agencies (PHAs). Voucher recipients are responsible for finding suitable units where the landlords agree to rent under the program. The maximum subsidy available to families, essentially equal to the fortieth to fiftieth percentile of the local private-market rent distribution, is governed by the Fair Market Rent (FMR). Once households receive a voucher and find a suitable apartment, families contribute 30% of their adjusted income to rent and utilities, with the rest covered by vouchers. According to the HUD Picture of Subsidized Households (1998-2016), the average housing voucher subsidy for a family is nearly $8000 per year, equivalent to the annual salary of a minimum wage part-time worker.

Eligibility for the housing voucher program depends on family size and income. To be eligible, a four-person family's gross income may not exceed 50% of the median income for the local Metropolitan Statistical Area (MSA). The income cutoff is adjusted by family size.[1] Although, roughly 25 million households qualify for federal rental assistance based on their income, my calculation based on the SIPP and Census data shows that only 7% of eligible households receive vouchers. By law, a public housing authority (PHA) must provide 75% of available vouchers to applicants whose incomes do not exceed 30% of the local median income, namely, extremely poor households. In particular, PHAs collect information on family income, assets, and family composition to determine program eligibility. If eligible,

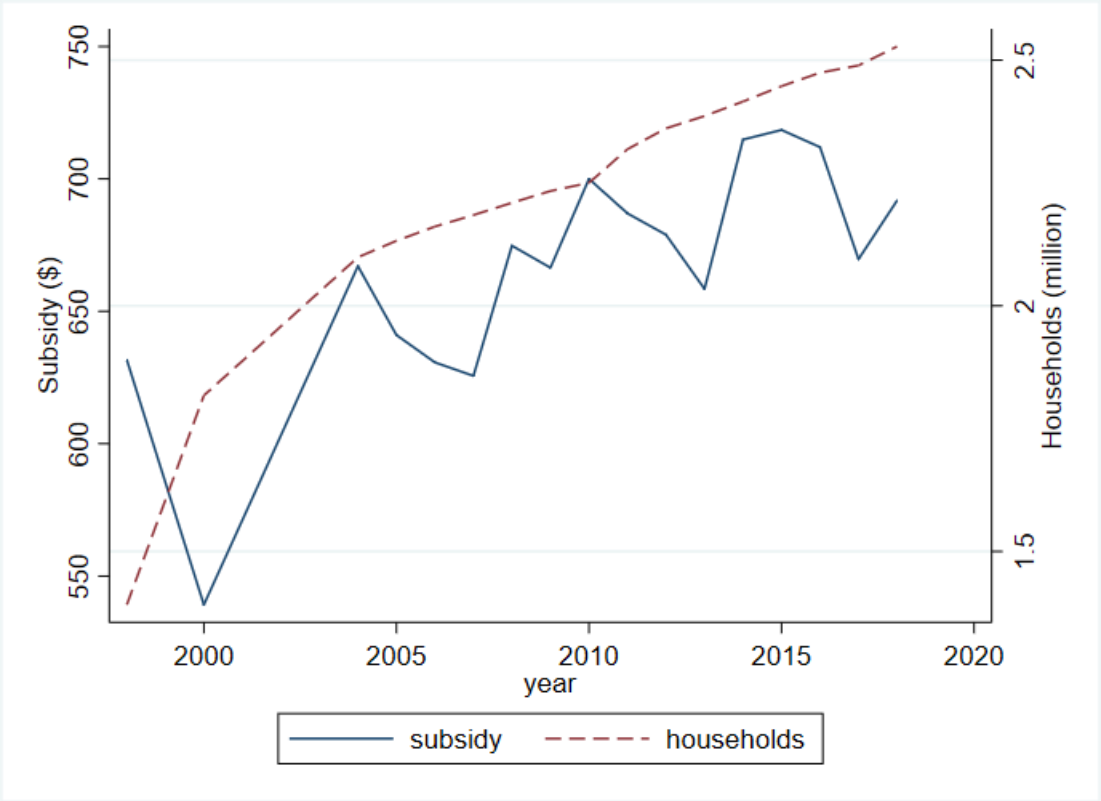
[1]For a three-person family, the household income cutoff is 90% of the four person's family. For a two-person family, the household income cutoff is 80% of the four person's families. For a one-person family, the household income cutoff is 70% of the four person's family. For a five-person family, the household income cutoff is 108% of the four person's families. For a six-person family, the household income cutoff is 116% of the four person's families. For a seven-person family, the household income cutoff is 124% of the four person's family. For eight and above person's family, the household income cutoff is 132% of the four person's family.

Figure 1: Federal Outlays for Housing and Cash Assistance Programs



Note: Outlays reported by the US Office of Management and Budget represented in 2010 dollars, deflated using Consumer Price Index. Low-income cash assistance includes outlays associated with Temporary Assistance for Needy Families (TANF) and Aid to Families with Dependent Children (AFDC). The data is a 5-year moving average of the raw data.

Figure 2: Number of Households Receiving Housing Vouchers and Average Subsidy



Note: The red line is the number of households receiving housing vouchers from 1998-2018 and the blue line the average subsidy amount per household per month in real terms (take 2010 as the base year). Department of Housing and Urban Development's (HUD's) Office of Policy Development and Research (PDR).

PHAs put applicants on a waiting list. Housing authorities (PHAs) organize waiting lists in three ways: (a) first come, first served; (b) random lottery; and (c) local preferences.[2] Due to high demand, waiting periods are lengthy, averaging as long as two years (HUD Picture of Subsidized Households). Some housing authorities may even close their waiting lists when they cannot assist more families in the near future.

Once they receive vouchers, families can keep receiving subsidies for as long as they stay income eligible. According to the HUD Picture of Subsidized Households, the average length of stay for housing voucher recipients was 5 years in 2004 and increased to 10 years by 2014. The rationale for continuously subsidizing families is to assist the neediest families in the long run and address the problem of low permanent income (Collinson et al., 2015).

The literature on the housing voucher program has evolved in three groups: (a) reduced form papers that estimate the effect of the current housing voucher program on individual outcomes such as labor supply, earnings, residential location, children's outcomes, rental prices, housing and neighborhood quality;[3] (b) papers that estimate structural models to evaluate the counterfactual consequences of the program (Moffitt, 1998; Mansur et al., 2002; Leung et al., 2012); and (c) papers that summarize the housing assistance programs and related research (Olsen, 2003; Collinson et al., 2015, 2019; Ellen, 2020). This strand of the literature enhances our understanding of affordable housing programs and inspires more research including my paper.

1.3 Data and Stylized Facts about Housing Vouchers

1.3.1 Data

The main data set comes from the Survey of Income and Program Participation (SIPP) 1996, 2001, 2004, 2008, and 2014 panels. The data set contains detailed information on

[2]For example, according to the Housing Vouchers Fact Sheet from HUD: "*PHAs may give preference to a family that is homeless or living in substandard housing, pays more than 50% of its income for rent, or is involuntarily displaced.*"

[3]See Jacob and Ludwig (2012); Jacob et al. (2015); Collinson and Ganong (2018); Kling et al. (2005); Galiani et al. (2015); Eriksen and Ross (2015); Chetty et al. (2016) for more details.

household demographics. In particular, it includes information on whether a household is granted a housing voucher through the Section 8 program.[4] I focus on the working age (18-60) sample of household heads and their spouses who are eligible for housing vouchers, i.e., household income less than 50 percent of the local median income. The sample includes 13,738 individuals with 146,560 observations.[5] I use this sample to provide a bunch of stylized facts about the housing voucher program. When estimating the lifecycle model, I further restrict the sample to the cohort aged 18-28 in 1996 (born between 1968 and 1978), which includes 3,474 individuals with 37,227 observations.

It is important to mention that the SIPP data only contains information on whether or not a household receives a housing voucher, without further information on whether households applied for a housing voucher but failed to get it. To obtain the program participation data, I turn to the American Housing Survey (AHS), where household heads were asked, "Have you reported income to the local public housing authority (PHA)?" The answer to this question could be a good proxy for applications to housing assistance because on the one hand, only households who applied for housing assistance need to report their income to PHAs; on the other hand, PHAs are only responsible for housing assistance programs. Therefore, households who report their income to PHAs must apply for housing assistance. This proxy may overestimate the application rate of the housing voucher program because PHAs are responsible for both the housing voucher program and the public housing program. The application rate calculated in this way also includes the application for the public housing program. However, the overestimation issue is not a serious problem because the housing voucher program is the largest federal housing assistance program and the public housing program is becoming less popular (Center on Budget and Policy Priorities, 2009). The other concern is that the data is only available for years 1997-2005, so I assume that application

[4]For 1996-2008 panels, households are surveyed every 4 months for a few waves. To avoid the well-known "seam effect" in the SIPP (Young, 1989), I keep only the 4th monthly observations in a given wave for each household. For the 2014 panel, respondents are interviewed annually rather than three times per year; the reference period covered in each interview is the previous 12 months. To be consistent with the 1996-2008 panel data, I keep the 4th, 8th, and 12th-month observation for the 2014 panel.

[5]The geographical area provided in SIPP is the state and a dummy variable indicates metro vs non-metro area. I use the median incomes for each state's metro vs non-metro areas as the cutoff income to infer household program eligibility. I compare the inferred SIPP eligible sample to American Housing Survey eligible sample inferred from MSA median income and I do not find a significant difference between the two samples.

rates for the years 2006-2016 are the same as previous years. In the robustness check section, I will test robustness of the main result by relaxing the assumptions. To make it consistent with the SIPP data, I apply the same sample selection criteria to the AHS data as well.

1.3.2 Stylized Facts

In this section, I present stylized facts about the housing voucher program: a) housing vouchers recipients have lower socioeconomic status, and housing assistance can reduce household rent burden by as much as 50%; b) housing vouchers are negatively associated with people's employment, homeownership, and family formation.

I present summary statistics of the sample from the SIPP in Table 1. Column (1) reports the characteristics for the full sample. The statistics for voucher recipients and nonrecipients are reported in columns (2) and (3). Column (4) reports the summary statistics for the sample used for estimating the model. Voucher recipients have a much lower employment rate than nonrecipients. Average monthly earnings are \$1,310 and \$1,850 for people with or without vouchers. Voucher recipients have a lower marriage rate (16%) and a higher divorce rate (23%). About 33% of the overall sample and 27% of the estimation sample owns a home. The percentages of people that ever received a voucher throughout the observation periods are 12% and 14% for the full sample and estimation sample, respectively. Voucher recipients have a much lower average rent (\$324) due to the assistance. Most of the sample, voucher users in particular, consists of female-headed households and households with children.

To compare the characteristics of voucher applicants to nonapplicants. I apply the AHS data and divide the sample based on applications. I further compare the statistics of voucher recipients to nonrecipients conditional on applications. Column (1) of Table 2 reports the characteristics for the full sample, which uses the same selection criteria as the SIPP data. Columns (2) and (3) report the characteristics of the sample that either receives or does not receive vouchers conditional on applying for vouchers. Column (4) reports the characteristics for the sample that does not apply for vouchers and the last column reports the characteristics for the estimation sample. The average application rate is 15% for the full sample and 17% for the estimation sample. Comparing voucher applicants to nonapplicants, we can see that

Table 1: Summary Statistics (SIPP)

Variables	All sample (1)	Receiving housing vouchers (2)	Not receiving housing vouchers (3)	Estimation sample (4)
Employment				
Male employment rate	0.58	0.27	0.58	0.58
Female employment rate	0.42	0.37	0.43	0.43
Monthly earnings	1,833	1,310	1,850	1,766
Household formation				
Married	0.39	0.16	0.40	0.44
Divorced	0.19	0.23	0.19	0.12
Homeownership	0.33	0.01	0.35	0.27
Share with children	0.51	0.59	0.5	0.7
Vouchers and rent				
Share ever w/ vouchers	0.12	1	0	0.14
Rent	666	324	673	683
Demographics				
Age	41	40	41	33
Male	0.36	0.21	0.37	0.33
White	0.69	0.52	0.69	0.69
N. of obs	146,480	5,812	140,668	37,227
N. of individuals	13,181	1,656	12,084	3,474

Note: Data is drawn from the SIPP (1996, 2001, 2004, 2008, and 2014 Panel) and AHS (1997-2005). Employment is defined as usual hours worked greater than or equal to 20 hours per week. "Share ever w/ vouchers" is the share of people that ever received a voucher throughout the years I observe them. Earnings is defined as labor income, such as wage and salary.

Table 2: Summary Statistics (AHS)

Variables	All sample	Applying for housing vouchers		Not applying for housing vouchers	Estimation sample
		Receiving	Not receiving		
	(1)	(2)	(3)	(4)	(5)
Application rate					
Application rate	0.15	1	1	0	0.17
Earnings and rent					
Monthly earnings	1,790	1,409	1,502	1,841	1,818
Rent	666	561	762	694	683
Household formation					
Married	0.34	0.14	0.17	0.38	0.34
Divorced	0.18	0.25	0.2	0.17	0.09
Homeownership	0.3	0	0	0.36	0.18
N. of children	1.3	1.6	1.3	1.3	1.6
Demographics					
Age	38	37	37	38	29
Male	0.42	0.17	0.29	0.46	0.38
White	0.63	0.49	0.48	0.66	0.6
N. of obs	50,153	1,381	6,310	42,462	14,244

Note: Data is drawn from AHS (1997-1999 and 2001-2005). The overall sample is individuals who age between 18-60 and are eligible for the housing voucher program. The estimation further restricts the sample to the cohort born between 1968-1978. Earnings is defined as labor income, such as wage and salary. The AHS data doesn't provide information on employment so it's not reported here.

applicants are negatively selected in terms of earnings and household formation. Between voucher recipients and nonrecipients, we see that recipients have a lower average earning and a lower marriage rate, but a higher divorce rate. Recipients are likely to be women and have more children.

I now provide empirical evidence of the relation between the program and labor supply, family formation, and homeownership. The reduced form evidence contributes to existing literature by providing evidence using a national and long time span sample. It also contributes to the literature by providing more evidence of the effect of housing vouchers on family formation and homeownership. To control for selection across families, I employ the individual fixed-effect model to explore the within-individual change of receiving housing vouchers.

In particular, I estimate the following specification

$$Y_{it} = \beta Voucher_{it} + X_{it}\gamma + f_t + f_i + \epsilon_{it}$$

where i denotes individual and t denotes year-4th month. Y_{it} is the set of outcomes of interests, including employment dummy, marriage dummy, divorce dummy, and homeownership dummy. $Voucher_{it}$ is a dummy variable of receiving a housing voucher. It equals to one if the individual's family receiving a housing voucher and zero otherwise. X_{it} is a set of individual-level controls, including gender, race, disability, age, education, state fixed effect, state-specific time trend. The terms f_t and f_i are year-4th month fixed effect and individual fixed effect. The error term is ϵ_{it}.

The fixed-effect estimates are reported in Table 3. Column (1) shows that receiving a voucher is associated with a 2.1 percentage points decline in employment, which is equivalent to a 4.5 percent reduction of the mean employment rate. The point estimate is significant at the 5% level. Moreover, the coefficient in column (2) is -0.034 and significant at the 1% level, implies that vouchers are associated with a 3.4 percentage points decline in homeownership (10 percent of the mean homeownership rate). When it comes to marriage and divorce, having a voucher is negatively correlated with marriage (2.5% reduction and significant at the 1% level) and positively correlated with divorce (1% increase). The magnitude of the estimates from the individual fixed-effect model is much smaller than that from the pooled

OLS model (showed in Table 25), implying a negative selection of voucher recipients. To sum up, the reduced form evidence suggests that vouchers are negatively associated with people's employment, homeownership, and family formation.

Table 3: Effects of Housing Vouchers on Household Behavior

Variables	(1) Employed	(2) Homeowner	(3) Married	(4) Divorced
Housing vouchers	-0.021**	-0.034***	-0.025***	0.009
	(0.009)	(0.005)	(0.006)	(0.006)
Individual fixed effect	Yes	Yes	Yes	Yes
Mean of Dep. Var	0.46	0.33	0.40	0.18
Observations	146,480	146,560	146,560	146,560
Number of Individuals	13,181	13,181	13,181	13,181

Note: Data is drawn from the SIPP (1996, 2001, 2004, 2008, and 2014 Panel). All estimates control for disability status, age, individual fixed effect, state fixed effect, metro dummy, year fixed effect, and state-specific time trend. Eligibility is inferred from state median income and metro status. Standard errors are in parentheses, clustered by individuals. *** p<0.01, ** p<0.05, * p<0.1

1.4 A Model Demonstrating Household Decisions

Economic theory yields ambiguous predictions about the effect of housing vouchers on labor supply, marital status, and homeownership. In addition to providing generous subsidies, the amount of rent paid by the program is inversely related to family income. The static labor supply theory implies a negative effect on labor supply through both income and substitution effects. However, the dynamic response of labor supply to housing assistance may be different. On the one hand, vouchers are associated with long-term benefits, which increase lifetime permanent income. On the other hand, once households receive vouchers, their marginal tax rate will be higher. If people work more in periods when wage rates are high, and if the intertemporal substitution effect dominates the lifetime income effect, then labor supply could increase (Jacob and Ludwig, 2012). Other than the static and dynamic substitution and income effects, the program could also affect labor supply through multiple

channels. For example, housing vouchers could generate nonlinearities in budget constraints, housing and non-housing goods could be complementary, and vouchers are associated with changing labor market opportunities (Shroder, 2002; Jacob and Ludwig, 2012; Chan and Moffitt, 2018; Moffitt and Kosar, 2020). Therefore, the effect of housing vouchers on labor supply is ambiguous due to the composition of multiple channels.

The housing voucher program also alters the insurance value of marriage and has an ambiguous effect on family formation. On the one hand, housing assistance subsidizes housing consumption and promotes wealth accumulation, which makes individuals more attractive in the marriage market and increases marriage rate. On the other hand, housing assistance may depress marriage rate by raising the value of outside options to marriage. Without housing vouchers, some low-income people have to rely on their partners for housing consumption. But if given vouchers, these people could afford to live independently. In addition, housing assistance eligibility depends on family size, which is closely associated with marital status. Ceteris paribus, changes in family size due to marriage or divorce may directly alter the probability of receiving a housing voucher. Therefore, the motivation for marriage and divorce depends on housing benefits associated with family formation (dis-formation).

As implied in the term "housing assistance," the housing voucher program could substantially impact homeownership decisions. The program subsidizes rent and is favorable to non-homeowners. Households with vouchers face reduced rental rates in the private market, which makes renting more attractive and discourages home buying. Despite these factors, housing assistance may in fact promote homeownership by increasing wealth accumulation, which is a prerequisite for home buying. Hence, the overall effect of housing assistance on homeownership is ambiguous.

Another important issue is how much these lifecycle decisions, i.e., labor supply, marriage, and homeownership, interact with each other. For instance, employment/unemployment may decrease/increase benefits of marriage, which affects family formation. Labor income and marriage are important determinants of homeownership (De Gayardon et al., 2018), and homeownership has a dynamic impact on labor supply and marriage (Fortin, 1995; Stevenson and Wolfers, 2007). What is needed is a unified framework to incorporate all the lifecycle decisions; this will allow us to study the impact of the housing voucher program on household

behavior and welfare.

The stylized facts from Section 3 show that housing vouchers are negatively associated with employment, marriage, and homeownership. Motivated by stylized facts and economic theory, I have built a lifecycle model to study the effect of the current program and alternative reforms on household behavior and welfare. People work from age $j \in \{1, 2, ..., J\}$, after which point they retire. Each period in the model corresponds to 5 years in real life. People obtain utility from two forms of consumption: goods and housing, where housing consumption comes from renting or owning. In addition to consumption, people suffer from the disutility of working and the stigma cost of participating in the housing voucher program.

At the beginning of each period, we can predict men (M) and women's (F) labor productivity as well as women's likelihood of having children, depending on their marital status and age. There is a certain probability of single people (S) meeting a potential partner randomly drawn from the distribution of remaining singles. Given a random initial love shock and their specific characteristics, single people and potential partners (if they meet) will decide whether to get married. Married couples (M) know the realization of a love shock to marriage at the beginning of each period and decide whether to remain married or not. Single households or married households also decide whether to apply for a voucher in each period. Based on the rationing system, they may get a voucher depending on gender, whether having children, and household income. If the applicant does receive a housing voucher, they will receive subsidized rental housing, for which they contributes a sum equal to 30% of their monthly income. The voucher recipients may lose their vouchers either due to ineligibility or shocks to their voucher status. Besides housing assistance, they may also receive welfare benefits from TANF, Food Stamps, and EITC, which are exogenously given and depend on gender, labor income, number of children, and marital status. In all cases, they also make labor supply and homeownership decisions, how much to save in non-housing assets, and how much to consume in goods. The housing voucher program affects households' decisions regarding labor supply, homeownership, and family formation through its impact on budget constraints and subsidies to housing consumption.

1.4.1 Preference

The utility of a single agent of gender $g \in \{W, M\}$ in period t is denoted by

$$u_{it}^{Sg}(c, l, N, B) = \frac{(c_{it}^{\alpha} s_{it}^{1-\alpha})^{1-\sigma}}{1-\sigma} - \phi^{Sg}(N) l_{it} - \nu B_{it}$$

where $c_{it} > 0$ is goods consumption and $s_{it} > 0$ is housing consumption, which is defined as

$$s = \begin{cases} h, & if\ rent \\ \omega h, & if\ own \end{cases} \tag{1}$$

where $h \in [h_{min}, ..., h_{max}]$ is the housing size (quality). If renting a house, housing consumption is the same as the housing size, h. If owning a house, housing consumption is ωh, where $\omega > 1$ captures the extra utility of owning a house. In addition, the term $l_{it} \in \{0, 1\}$ stands for labor supply, a measure of extensive labor supply margin; the term $\phi^{Sg}(N)$ is the disutility from working, which is gender and children dependent. Only single female's disutility of working depends on children. Children affect males if he is married to a woman. The term $B_{it} \in \{0, 1\}$ is the housing voucher program application decision and ν is the stigma cost associated with an application.

The utility of married men and women is denoted by

$$u_{it}^{Mg} = \frac{((\gamma_e c_{it})^{\alpha} (\gamma_e s_{it})^{1-\alpha})^{1-\sigma}}{1-\sigma} - \phi^{Mg}(N) l_{it}^{Mg} - \nu B_{it} + Q_{it}$$

where $c_{it} > 0$ and $s_{it} > 0$ are joint goods consumption and housing consumption. The parameter $\gamma_e \in (0.5, 1)$ captures the economy of scale within a household. The utility of married men and women depends on the disutility from working $\phi^{Mg}(N) l_{it}^{Mg}$, the stigma cost of housing voucher application νB_{it}, and the match quality Q_{it} (love shock).

1.4.2 Shocks To Household

Households face three sources of shocks: earnings, marriage and fertility, and the housing voucher program.

Earnings The earnings processes for men and women $g \in \{W, M\}$ are specified as

$$logw_{it}^{g} = \beta_0^g + \beta_1^g j + \beta_2^g j^2 + z_{it}^g + \epsilon_{it}^g$$

$$z_{it}^{g} = z_{it-1}^{g} + \zeta_{it}^{g}, \quad \zeta_{it}^{g} \sim N(0, \sigma_{\zeta^g}^2)$$

where z_{it}^g is the permanent income component that follows a random walk process with innovation ζ_{it}^g; the term ϵ_{it}^g is the measurement error, which is i.i.d and normally distributed as $N(0, \sigma_{\epsilon^g}^2)$. Because a large share of low-income people (both man and woman) do not work, I take into account endogenous selection in work when estimating the wages.

Marriage and fertility In each period, a single agent meets with probability λ_j a potential spouse (of the same age group), who is characterized by certain labor productivity, assets, and housing. The probability λ_j varies by age as marriage rate varies by age. The potential couple then draws a match quality $Q_0 \sim N(0, \sigma_{Q0}^2)$. If they decide to marry, their match quality follows a random walk with innovations ξ_Q

$$Q_{it} = Q_{it-1} + \xi_Q, \ where \ \xi_Q \sim N(0, \sigma_Q^2)$$

Fertility is stochastic and exogenous. The probability of having children depends on females' marital status (M_{it}) and age (j), which is:

$$Pr(N_{it} = 1 | N_{it-1} = 0; M_{it}, j)$$

For simplicity, I assume each woman only have one child.

Housing assistance For housing assistance, households can apply for a housing voucher in each period. Since each PHA may have its own preference for ranking applicants on a waiting list and thereby the probability of receiving a voucher is not purely random, I model the probability of getting vouchers as a function of gender, children dummy, and household income (I), i.e., $\gamma(g, N, I)$. This will capture local preferences based on observable

demographics.[6] Once receiving a voucher, households can hold it as long as it remains eligible. But households with vouchers also face a shock ξ that vouchers may be destroyed.

In addition to housing assistance, low-income households tend to be recipients of other welfare benefits, i.e., Food Stamps, TANF, and EITC. The targeting of TANF and EITC is mainly female-headed households.[7] Since endogenously modeling multiple welfare take-up and benefits is complex, I estimate take-up and benefits of Food Stamps, TANF, and EITC using the SIPP data outside the model. For Food Stamps, I estimate the welfare benefit as a linear function of gender, marital status, children, and labor income. Similarly, I model the welfare benefit of TANF as a linear function of marital status, children, and labor income and it is only estimated using a female-headed household sample. For EITC, the benefit is calculated based on marital status, children, and labor income according to EITC policies. The EITC is only applied to single female or married couples.

1.4.3 Household Problem

1.4.3.1 Single Women

At each age of j, a single female-headed household decides whether to work, whether to apply for a housing voucher, whether to buy a house, and how much to consume and save. The decision to marry (or divorce) takes place at the beginning of each period, after labor market shocks and marriage shocks are realized, but before any consumption and program participation decisions. Application for a voucher will be conditional on the marriage decision that occurs at the beginning of the period. Conditional on realization of a voucher, households will make a decision on labor supply, saving, goods consumption, and housing consumption.

[6] Local governments establish their preference of what priorities they give to applicants and people have a uniform marginal cost of program participation. However, the stigma cost could be heterogeneous and differs by income, gender, and fertility. Both government priorities and individual-specific stigma cost would introduce some heterogeneity into the group of people who get into the housing voucher program. Since government priorities and heterogeneous stigma cost are not separately identified, I combine them both into the government decision, leaving the stigma cost as homogeneous.

[7] Single men without children could be eligible for EITC benefits, though the benefits are much smaller (https://www.cbpp.org/research/federal-tax/policy-basics-the-earned-income-tax-credit). Allowing them to have EITC benefits does not affect the outcomes of this paper.

If she receives a voucher, her budget constraint is:

$$c + d' = 0.7[wl + b(1-l) + tanf] + fs + eitc + a$$

If she doesn't receive a housing voucher, her budget constraint becomes:

$$c + d' + P^H h' 1_{\{own\}} + P^R h 1_{\{rent\}} + \Phi(h', h) = wl + b(1-l) + tanf + fs + eitc + a,$$

where d is the non-housing assets, w is the wage rate, and b is the unemployment benefits. The terms $tanf$, fs, and $eitc$ represent benefits from TANF, Food Stamps, and EITC. The terms P^H and P^R denote the housing price and rental price. The term $1_{\{own\}}$ (or $1_{\{rent\}}$) is an index function equal to 1 if being homeowners (or renters) and 0 otherwise. The term $\Phi(h, h')$ denotes transition costs if an agent buys a house or sells a house. Similar to Yang (2009), it is defined as

$$\Phi(h, h') = \begin{cases} \kappa_b P^H h' + \kappa_s P^H h, \ if \ h \neq h' \\ 0, \ if \ h = h' \end{cases}$$

In addition, the term a is total assets including both housing assets (if homeowners) and non-housing assets, which is $a = P^H h + (1+r)d$.

The budget constraint depends on whether a single woman gets a housing voucher or not. If getting a voucher, she needs to contribute 30% of gross income (labor income and benefits from TANF) to rent (left with 70% of gross income).[8] If not getting a voucher, she has to pay rent if she's not a homeowner. If being homeowners, households have access to collateralized borrowing. The term η captures the tightness of collateralized borrowing constraint $d' \geq -\eta P^H h'$. The borrowing interest rate r_d^H is supposed to be higher than the savings interest rate r_d^L.

The state vector for a single woman is $\Omega_{it}^{SW} = \{z_{it}^F, N_{it}^{SW}, h_{it}^{SW}, d_{it}^{SW}, v8_{it}^{SW}\}$, which is composed of labor productivity, children, housing, non-housing assets, and housing vouchers. With probability λ_j, at the beginning of each period a single woman meets a man with

[8]The HUD rent calculations exclude certain benefits but include others in the determination of income. Benefits that count toward income and rent calculations include: UI, SSDI, SSI, and TANF; HUD excludes most benefits tied to medical expenses from the calculation of adjusted income used to set rent. HUD excludes SNAP benefits, LIHEAP, earnings from or payments from participation in WIA programs, and EITC refunds in the income calculation (Collinson et al., 2015).

characteristics $\{\widetilde{z_{it}}, \widetilde{d_{it}}, \widetilde{h_{it}}, \widetilde{v8_{it}}\}$, where $\widetilde{v8_{it}} \in \{0,1\}$ indicates whether the man has a housing voucher. The potential couple then draws an initial match quality Q_{i0}. If a match is formed, then $M_{it} = 1$; otherwise $M_{it} = 0$.

Let $V_{it}^{SW}(\Omega_{it}^{SW})$ denote the value function for a single woman at time t and $V_{it}^{MW}(\Omega_{it}^{MW})$ denote the value function for a married woman at time t. A single woman maximizes the following value function s.t. the budget constraint.

$$V_{it}^{SW}(\Omega_{it}^{SW}) = \max_{\{c,h',d',l,B\}} u_{it}^{SW}(c,s,l,B) +$$
$$\beta E[\lambda_{t+1}[(1-M_{i,t+1})V_{it+1}^{SW}(\Omega_{it+1}^{SW}) + M_{i,t+1}V_{it+1}^{MW}(\Omega_{it+1}^{MW})] + (1-\lambda_{t+1})V_{it+1}^{SW}(\Omega_{it+1}^{SW})]$$

1.4.3.2 Single Men

A single male-headed household also decides whether to work, whether to apply for a housing voucher, whether to buy a house, and how much to consume and save in each period. However, a single man will be affected by children only if he is married to a woman. The state space for a single man is $\Omega_{it}^{SM} = \{z_{it}^{M}, h_{it}^{SM}, d_{it}^{SM}, v8_{it}^{SM}\}$.

If he receives a housing voucher, his budget constraint is:

$$c + d' = 0.7[wl + b(1-l)] + fs + a$$

If he doesn't receive a housing voucher, his budget constraint is:

$$c + d' + P^H h' 1_{\{own\}} + P^R h 1_{\{rent\}} + \Phi(h', h) = wl + b(1-l) + fs + a$$

The budget constraint of a single man is similar to a single woman, but a single man is only eligible for Food Stamp benefits.

Let $V_{it}^{SM}(\Omega_{it}^{SM})$ denote the value function for a single man at time t and $V_{it}^{MM}(\Omega_{it}^{MM})$ denote the value function for a married man at time t. The problem for a single man is to maximize the following value function s.t. the budget constraint.

$$V_{it}^{SM}(\Omega_{it}^{SM}) = \max_{\{c,h',d',l,B\}} u_{it}^{SM}(c,s,l,B) +$$
$$\beta E[\lambda_{t+1}[(1-M_{i,t+1})V_{it+1}^{SM}(\Omega_{it+1}^{SM}) + M_{i,t+1}V_{it+1}^{MM}(\Omega_{it+1}^{MM})] + (1-\lambda_{t+1})V_{it+1}^{SM}(\Omega_{it+1}^{SM})]$$

1.4.3.3 Married Couple

When a man and a woman get married, they make joint decisions on labor supply, program participation, consumption, and savings to maximize the joint household value. Each partner is equally weighted (0.5) in the joint household value.

The joint budget constraint of a married couple with a housing voucher is

$$c + d' = 0.7[w_M l_M + w_W l_W + b(1 - l_M) + b(1 - l_W) + tanf] + fs + eitc + a$$

The joint budget constraint of a married couple without a housing voucher is

$$c+d'+P^H h' 1_{\{own\}}+P^R h 1_{\{rent\}}+\Phi(h',h) = w_M l_M+w_W l_W+b(2-l_M-l_W)+tanf+fs+eitc+a$$

The state space for a couple is $\Omega_{it}^M = \{z_{it}^F, z_{it}^M, N_{it}^M, Q_{it}, h_{it}^M, d_{it}^M, v8_{it}^M\}$. Let $V_{it}^M(\Omega_{it}^M)$ be the joint value function of a married couple. Then the problem of a household is to maximize the following value function s.t the household budget constraint.

$$V_{it}^M(\Omega_{it}^M) = \max_{\{c,h',d',l,B\}} 0.5(u_{it}^{MM}(c,s,l,B) + u_{it}^{FM}(c,s,l,B)) + \beta E[(1-d_{i,t+1})V_{it+1}^M(\Omega_{it+1}^M)+$$

$$d_{i,t+1}(0.5V_{it+1}^{SM}(\Omega_{it+1}^{SM}) + 0.5V_{it+1}^{SW}(\Omega_{it+1}^{SW})]$$

where $d_{i,t+1}$ is the divorce decision at next period.

Men and women will get married or remain married if and only if the value of being married is no less than the value of being single, i.e.,

$$V_{it}^{MW}(\Omega_{it}^M) \geq V_{it}^{SW}(\Omega_{it}^{SW})$$

$$V_{it}^{MM}(\Omega_{it}^M) \geq V_{it}^{SM}(\Omega_{it}^{SM})$$

where

$$V_{it}^{MW}(\Omega_{it}^M) = \max_{\{c,h',d',l,B\}} u_{it}^{MW}(c,s,l,B) + \beta E[(1-d_{i,t+1})V_{it+1}^{MW}(\Omega_{it+1}^M) + d_{i,t+1}V_{it+1}^{SW}(\Omega_{it+1}^{SW}]$$

$$V_{it}^{MM}(\Omega_{it}^M) = \max_{\{c,h',d',l,B\}} u_{it}^{MM}(c,s,l,B) + \beta E[(1-d_{i,t+1})V_{it+1}^{MM}(\Omega_{it+1}^M) + d_{i,t+1}V_{it+1}^{SM}(\Omega_{it+1}^{SM}]$$

are value functions of married women and men.

1.5 Estimation

The estimation is based on the 1970 cohort of households that are presumably eligible for the housing voucher program. I estimate the model parameters in three steps. First, I calibrate some parameters outside the model. Second, I estimate earnings parameters, fertility process, and the distribution of potential spouses directly from the data without imposing the model structure. Finally, I estimate the remaining parameters internally by the Method of Simulated Moments (MSM). These parameters include preference parameters $(\omega, \phi^{SM}, \phi^{MM}, \phi^{SW}, \phi_0^{MW}, \phi_1^{MW}, \nu)$, those governing marriage dynamics $(\sigma_{Q0}^2, \sigma_Q^2, \lambda_y, \lambda_m)$, policy parameters related to the uncertainty around receiving a voucher, $\gamma(.)$ as well as parameters governing the probability of losing housing vouchers, ξ. I simulate the theoretical moments and minimize the difference between simulated moments and data moments.

1.5.1 Initial Conditions

I first specify the initial conditions of the model. In the model, people start at age 18. By that age, only a small share of men and women have gotten married and given birth. Almost none of the sample owns a house or has experienced a divorce. Therefore, the proportions of married men and women, the proportion of women with children (separately for married and single women), and the proportions of men and women owning a house at age 18 are all set to zero.

1.5.2 Externally Calibrated Parameters

The values and references of the externally calibrated parameters are reported in Table 26. Agents are assumed to have a constant risk aversion coefficient of $\gamma = 1.5$. The annual discount factor is $\beta = 0.98$, which turns into a 5-year discount factor of $\beta = 0.9$. Following Kaplan et al. (2017), the share of goods consumption in the utility function is $\alpha = 0.8$. In other words, the share of housing consumption in the utility function is 0.2. Following Eckstein et al. (2019), the economy of scale is set to 0.7, so a couple needs 40% more

expenditure than a single person to obtain an equivalent consumption level. I obtained the downpayment rate from the Freddie Mac Loan-to-Value ratio for prime mortgages, which is 0.2. Based on Yang (2009), I set the transition costs as 2.5% of home value for buying and 7% of home value for selling. The interest rates for positive assets (savings) and negative assets (debt) are 2% and 7%, set to match the bank net interest margin.

1.5.3 Externally Estimated Parameters

For both men's and women's earnings, selection into employment is a concern because wages are not observed for unemployed people and decisions to work depend on wage offers. To estimate the age profiles of men's and women's wages and to account for non-working when estimating the variance of the productivity shocks, I apply a two-step Heckman selection correction procedure. Following Low and Pistaferri (2015), the exclusion restrictions in the employment equation are "simulated" welfare benefits. I use state, year, and demographic variation in simulated Food Stamp, EITC, and Unemployment Insurance (UI) benefits for a single man who works part-time at the federal minimum wage. In contrast, for single women with varying numbers of children who work part-time at the federal minimum wage, I added TANF benefits. In each specification, I control for time and state fixed effect so the instruments capture differential changes in policy over time and states. The key identification assumption is that the welfare benefits affect men and women's wages only through their impact on employment. The first stage showing the effect of welfare benefits on employment for men and women is in Table 39.

I then apply a variance-covariance decomposition framework with selection correction to estimate the variance of productivity shock and variance of measurement error. I report wage parameters in Table 28. The variances of permanent income shock for men and women are 0.09 and 0.08. The variances of measurement error for men and women is 0.11 and 0.06, respectively. Men's and Women's wages have a concave lifecycle profile as expected.[9]

I compute the transition probability for women from no children to one child using the SIPP data. The Markov process for fertility is a function of a woman's age and marital status.

[9]For more details in estimating earning process, see online appendix C.

The estimated transition probabilities are in Figure 25. The distribution of characteristics of single men and women come from the age-dependent distribution of characteristics for singles in the data. According to the model, people will form expectations about the matches they may be involved in based on the distribution of remaining singles.

1.5.4 Internally Estimated Parameters

I apply the Method of Simulated Moments (MSM) (McFadden, 1989) to estimate the remaining parameters. I choose parameters that will minimize the distance between the data moments and the simulated moments generated from the model.

$$min_{\{\Theta\}}(\phi_{data} - \phi_{sim})'W(\hat{\phi}_{data} - \phi_{sim})$$

The vector Θ contains the extra utility from being homeowners (ω); the variance of initial match quality (σ^2_{Q0}) and the variance of shocks to existing marriage (σ^2_Q); the probability of meeting someone at young and middle age (λ_y, λ_m); the disutility from working for single men (ϕ^{SM}) and for married men (ϕ^{MM}), the disutility from working for single women (ϕ^{SW}), for married women without children (ϕ_0^{MW}), and married women with children (ϕ_1^{MW}); the stigma cost of participating in the program ν; the shock to losing vouchers for voucher recipients (ξ) and the probability of receiving a voucher for men and women with higher and lower-income, and for women with or without children $\gamma(.)$.

Empirical moments ϕ_{data} are calculated from the 1968-1978 birth cohort for the years 1996-2016. I focus on household heads and their spouses who are aged 18-48. I group the sample into 5-year bin age groups: 18-22, 23-27, 28-32, 33-37, 38-42, and 43-48. The marriage and divorce rates are calculated in corresponding age bins. Simulated moments ϕ_{sim} are computed using the full numerical solution of the model, with the inverse of the variance-covariance matrix of the empirical moments as the weighting matrix W.

1.5.5 Identification

Although all of the moments are used to estimate all of the parameters, some moments are especially important in identifying certain parameters. I provide a heuristic argument for how each of the parameters can be identified from a subset of the moments and give the intuition for identification.

The first set of moments includes conditional moments for labor supply, i.e., proportions of men employed by marital status and fractions of women employed by marital and fertility status. These moments pin down the disutility of work for men and women. The second set of moments consists of the proportion of households that applied for a housing voucher and the proportions of applicants that receive a voucher by income, gender, and fertility. The application rate helps determine the stigma cost of participation, and the proportions of voucher recipients by income, gender, and fertility help indicate the probability of getting a voucher for different demographics. In addition, the proportion of households who have lost housing vouchers determines the probability of losing housing vouchers in the model. The third set of moments contains the average homeownership rate, which pins down the extra utility from being homeowners. The fourth set of moments includes marriage and divorce rates by age, as well as the share of having ever been married by age. These moments contribute to pinning down the variance of marriage shocks and the probability of meeting a partner.

1.5.6 Model Fit and Estimated Parameters

The model fit for the moments is shown in Table 19 and the one for the evolution of marriage and divorce by age is shown in Figure 12.[10] The model can replicate the targeted moments and also reproduce statistics that were not targeted by the estimation procedure. An important set of statistics are employment, marriage, and divorce rate conditional on housing voucher recipients. Another important set of statistics consists of homeownership and application rates by gender. These statistics are not targeted by the model but demonstrate the behavior by voucher recipients and gender. Table 29 shows that the model can

[10]The fraction of ever married by age is shown in Figure 19.

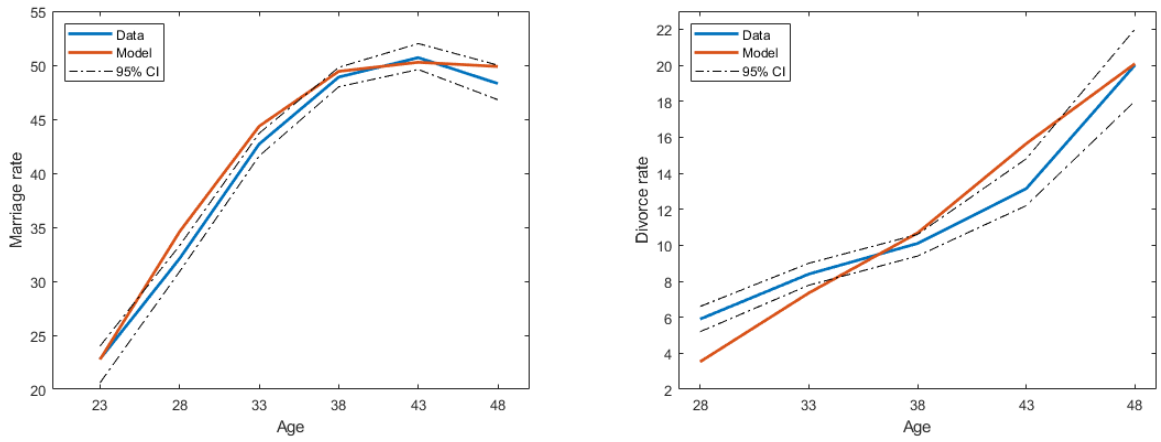
replicate behavior of the voucher users as well as gender differences.

Table 4: Model Fit (Percentage)

	Model	Data	95% CI
Homeownership rate	27	27	(26, 28)
Single male employment	58	58	(56, 59)
Married male employment	76	77	(75, 78)
Single female employment	53	53	(52, 54)
Married female w/o children employment	45	46	(42, 48)
Married female w/ children employment	36	35	(34, 36)
Housing assistance application	18	17	(16, 18)

Note: Homeownership rate and employment rates and their 95% confidence intervals (CI) are calculated from the SIPP. Housing assistance application and its 95% CI is calculated from the AHS.

Figure 3: Marriage and Divorce by Age (Percentage)



Note: The blue lines are the marriage and divorce rate by age calculated from the SIPP data. The red lines are the marriage and divorce rate by age simulated from the model. The dotted lines are the 95% CI.

In addition to validating non-targeted moments, I have compared predictions of the model with evidence from the reduced form literature. What I found is that the model can reproduce statistics about the housing voucher program that are not targeted by the estimation procedure (external validity). I simulate the model for men and women over 35-year period. I then use the simulated data to estimate the effects of housing vouchers on labor supply, homeownership, marriage, and divorce. Table 30 presents the results. The first

column shows the effect of housing voucher use on labor supply. Housing vouchers reduce labor supply by 3.4 percentage points, implying a 6.3 percent reduction of the average labor supply and a 6 percent reduction of the control mean (the control group is the group that didn't receive housing vouchers). Estimates from the model-simulated data are similar to the findings from Jacob and Ludwig (2012), according to which housing vouchers reduce labor supply by around 4 percentage points (6 percent of the control mean). Similarly, Mills et al. (2006) found that housing vouchers reduced the quarterly employment rate by 4 percentage points (8 percent of the control mean); however, the effect is only significant during the first year with vouchers.

Table 31 reports internally estimated parameters and their standard errors. The parameter governing the extra utility of being homeowners is estimated to be 1.01, implying that homeownership yields a higher utility flow. The variances of the shock to the initial marriage match and to existing marriages are estimated to be 0.08 and 0.1, respectively. The probabilities of meeting someone at a young age (18-38) and middle age (38-48) are 0.42 and 0.63, respectively. The disutility from working is higher for married women than that for single women and the disutility from working for women with children is higher than that for women without children. These parameters help us to match the employment patterns for single and married women with or without children.

The stigma cost of housing is estimated at 0.135, which is identified by the eligible households who are not applying for housing vouchers. To understand the magnitude of the parameter, I compute the proportional decrease in average consumption that an individual would be willing to bear for one period in order to avoid incurring the stigma for the same period, i.e., I find the τ such that $u(\bar{c}(1-\tau)) = u(\bar{c}) - \nu$, where $\bar{c}$ is an agent's average per period consumption. The result shows that $\tau = 6\%$.

The probability of losing housing vouchers is estimated at 0.21 for a model period (5 years), converted to 0.04 annually. The low annual probability of losing vouchers suggests that housing vouchers tend to concentrate on a few households for a long period of time. The conditional probabilities of applicants receiving vouchers are reported for high-income and low-income males ($\gamma_{lm} = 0.18, \gamma_{hm} = 0.2$), high-income and low-income females with children ($\gamma_{lwc} = 0.35, \gamma_{hwc} = 0.45$) or without children ($\gamma_{lwnc} = 0.2, \gamma_{hwnc} = 0.2$). The

parameters imply that females are more likely to receive a voucher than males and females with children are more likely to get a voucher than females without children.

1.6 Policy Experiments

The most important use of the model and structural estimates is to study the effects of potential reforms on household behavior and welfare. I consider four reforms in policy experiments. First, I change the housing subsidy into flat assistance, where every recipient household gets the same amount of assistance. The policy attempts to remove the negative substitution effect of housing vouchers. Second, I provide lower benefits to all eligible households that apply for the program. Third, I introduce time limits on receiving housing subsidies. For instance, I consider a scenario where housing voucher users can only receive assistance for a maximum of 5 years. The intent behind the second and third reforms are to mitigate the problem of rationing. Fourth, I allow households to use vouchers to buy homes, for example, using vouchers to pay for downpayments. For each policy, I show the implications for low-income household labor supply, family formation, homeownership, program participation, and welfare. I calculate the welfare effect by measuring a household's willingness to pay for the new policy through a proportional reduction in consumption at all ages that would make the individual indifferent ex-ante between the status quo and the policy change considered. To keep government revenue neutral, government expenditure on the housing voucher program in all experiments is matched to that in the baseline. These policy experiments are best interpreted as investigating the partial equilibrium effects of each reform because I do not take into account general equilibrium effects, nor do I consider introducing multiple reforms simultaneously. In Section 1.7, I will discuss the evidence of the program's effect on rental prices and provide suggestive evidence of the general equilibrium effect on my results.

1.6.1 Flat Housing Assistance

In the current policy (baseline), the amount of housing assistance is inversely related to recipients' income. In this experiment, I consider the effect of a revenue-neutral change of assistance into a flat subsidy for voucher recipients. The amount of flat assistance is set such that government expenditure on the program in the experiment is equal to that in the baseline. The new policy removes the negative substitution effect on labor supply and redistributes assistance across recipient households: in the baseline model, relatively lower-income households get more assistance than relatively higher-income households while in the experiment, every successful applicant receives the same amount of assistance. The new policy shifts resources from relatively lower-income households to relatively higher-income households.[11]

The first two columns in Table 5 show the effect of the policy. The first column presents the moments from the baseline and the second column shows the moments from the flat assistance experiment. The policy has a positive impact on household labor supply due to the removal of the negative substitution effect. In particular, the employment rate for single men increases by 2 percentage points, which is about a 3.4 percent increase relative to the mean employment rate in the baseline. Similarly, the employment rate for single women increases by 2 percentage points, which is about a 3.8 percent increase relative to the mean baseline employment rate. Furthermore, the effect of the policy on married men's and women's employment is negligible because only a small share of married households receive housing vouchers in the baseline and experiment. At the same time, the policy has a positive impact on program participation. The application rate for the program rises from 18 percent in the baseline to 19 percent in the experiment, and it is the high-productivity households that increase their applications. Housing vouchers are more attractive for high-income households as they obtain more assistance in the policy environment. I have not found a significant impact of the policy on marriage or homeownership.

[11]The sample for all the policy experiments is still the low-income households that are eligible for the voucher program. "Low-income households" here refers to the extremely low-income households while "high-income households" refers to the low-income households that are relatively rich.

Table 5: Policy Experiments (Percentage)

Variables	baseline	flat assistance	lower to all	time limits	home buying
	(1)	(2)	(3)	(4)	(5)
Employment					
single male	58	60	41	58	58
married male	76	76	75	76	76
single female	53	55	49	52	53
married female w/o kids	45	45	45	45	46
married female w/ kids	36	35	36	36	35
Household formation					
marriage	40	40	37	40	42
divorce	9	10	8	9	9
homeownership	27	27	22	28	31
Program participation					
overall	18	19	37	18	19
low-productivity	26	21	51	21	26
high-productivity	10	17	25	15	12

Note: "baseline" is the current program; "flat assistance" is the first experiment where every voucher recipient household get a same amount of subsidy; "lower to all" is the second experiment where the government provide lower benefits to all households applied for the program; "overall" is the application rate for the full sample; "low-productivity" is the application rate among low labor productivity households and "high-productivity" is the application rate among high labor productivity households.

1.6.2 Expanded Access with Lower Benefit Levels

In the second experiment, I consider providing modest benefits to an expanded population, i.e., all eligible households applying for housing vouchers. The current program provides substantial subsidies to only a few families, as it aims to address the problem of low permanent income. However, the current program might be suboptimal because the more money that is provided to the same households, the lower the marginal benefits become. Furthermore, if not properly targeting the families in most need, the high degree of rationing will generate search costs, resource misallocation, and welfare loss in the long run (Glaeser and Luttmer, 2003; Olsen, 2003; Collinson et al., 2019). In this experiment, housing vouchers are not rationed, indicating that every needy family will be granted a voucher, though the subsidy is less generous. To keep government revenue neutral and to preserve the negative relation between subsidy amount and household income, voucher recipients still contribute 30% of their income for rent, but the fair market rent (or the maximum subsidy) is downwardly adjusted. I adjust the fair market rent to be 45% lower such that the government budget is the same as the baseline.

Column (3) in Table 5 presents the result of the policy change. Providing lower benefits to all applicants substantially increases program participation rate from 18% to 37% because households will receive a voucher for sure if applied. The policy has a negative impact on employment, marriage, and homeownership. In particular, the policy change reduces single men's and women's labor supply by 17 percentage points and 4 percentage points. It also reduces marriage and homeownership by 3 percentage points and 5 percentage points. Two mechanisms are playing roles in affecting household behavior. On the one hand, as more people are now receiving assistance from the program, the negative impacts of housing vouchers on labor supply, marriage, and homeownership apply to a larger population. On the other hand, the subsidy is less generous for the original voucher recipients in the baseline, suggesting smaller disincentives for labor supply, homeownership, and marriage for these households. The result shows that the former effect dominates the latter one, yielding an overall negative impact on labor supply, marriage, and homeownership. What can explain the large impact on labor supply for single men? This is because the new policy substantially

increases single men's incidence of receiving housing vouchers while the baseline policy favors female-headed households by allocating the majority of vouchers to women. The share of single men that receive a voucher increases from 4% in the baseline to 39% in the experiment, which result in considerable working disincentives for males.

1.6.3 Time-limited Subsidies

Instead of a subsidy for an indefinite period, the third policy considers imposing time limits on receiving housing assistance. This is the key spirit of of the Personal Responsibility and Work Opportunity Reconciliation Act of 1996 (PRWORA), which was to introduce lifecycle time limits on receipt of welfare benefits. The current program allows households to hold vouchers as long as they are eligible, which causes a high degree of concentration. According to HUD, the average length of stay for housing voucher recipients in 2004 was 5 years, which increased to 10 years by 2014. The increase in the length of stay has several consequences. First, it may discourage voucher users from working as increasing their income will probably render them ineligible for the program. Second, a large subsidy for a long period of time will alter the insurance value of marriage, thereby affecting family formation. Third, housing voucher users tend to remain renters, if rent is continuously subsidized. Therefore, apart from the impacts on voucher users, it will also affect households who are in need of vouchers but cannot get one. When the households are hit by negative income shocks, the insurance value of housing vouchers will be limited. This policy experiment seeks to mediate the negative impact of concentration by imposing a maximum of 5 years (one model period) of benefits. The subsidy amount that a household can receive within the 5-year is the same as the baseline, which is the difference between rent and 30% of family income. Accordingly, the probability of receiving a voucher conditional on applications will be increasing to maintain the same government budget as the baseline. As a result, housing vouchers can reach more families in need, but for a limited time. The new policy aims to address the problem of income volatility rather than low permanent income.

I present the effect of introducing time limits in column (4) of Table 5. This policy has a small negative impact on single female employment. This is likely because the negative

income effect on labor supply is applied to an increased share of single female-headed households, who make up the majority of voucher recipients. However, the effect of this policy on other demographic groups' employment is negligible. Beyound employment, I do not detect any significant impact of the policy on marriage or homeownership, nor do I find a significant impact on applications to the program. However, if we take a closer look at the application rate for high-productivity people vs low-productivity people, the application rate of low-productivity people decreases as they gain less from the program due to time limits. On the contrary, the application rate of high-productivity people increases as they have a higher chance of receiving housing assistance.

1.6.4 Home Buying Option

In the last experiment, I consider giving households the option to use vouchers to buy homes, instead of only using them for rent. In reality, the HUD has a Housing Choice Voucher (HCV) homeownership program, which gives household assistance for homeownership. The program allows families that are assisted under the HCV program to use their vouchers to buy a home and receive monthly assistance in meeting homeownership expenses. However, though the HCV homeownership regulations provide a downpayment grant option (where the PHA offers a single downpayment assistance grant to the family instead of a monthly homeownership subsidy), funding has not been appropriated for this purpose and this regulatory provision has never been implemented. In this experiment, households can use a voucher as a downpayment grant, as downpayments are the main constraint for low-income households to buy a house (Herbert and Tsen, 2007). Compared to the current program, this policy changes the relative cost of renting versus homeownership and promote homeownership among low-income households. It may also encourage more people to apply for housing vouchers, especially those who prefer to be homeowners.

The last column of Table 5 shows the effect of this policy. Allowing the home buying option has a positive effect on marriage and homeownership. The homeownership rate in the experiment increases by 4 percentage points, which is a 16 percent increase relative to the baseline homeownership rate. The marriage rate increases by 1.5 percentage points,

equivalent to 3 percent of the average marriage rate in the baseline. The positive effect on marriage is likely due to the increased homeownership that makes marriage more attractive. As documented in existing literature, homeowners are more attractive in marriage market because homeownership can yield higher utility flows (Stevenson and Wolfers, 2007). Homeowners also have higher incentives for marriage as partners can share their mortgage payments (Fortin, 1995). In addition, the policy change also has a positive effect on program participation. The application rate increases from 18 percent to 19 percent. If we take a further look at the application rate by labor productivity, it is high-productivity people who increase their applications. I do not find any impact of this policy on household labor supply.

1.6.5 Welfare

To study the welfare consequences of different policies, I measure welfare benefits (costs) by the compensation variation, i.e., the percentage by which the consumption of people would have to be increased in each state and in each period to leave that person indifferent ex-ante between the baseline and the new policy. From a public policy perspective, welfare is the most important indicators for policymakers to consider for future program reforms.

Table 6: Percent Change in Welfare

Compensation Variation	All	Women	Men
Policy 1: flat assistance	-0.2	-0.22	-0.18
Policy 2: lower subsidy to all	+1.5	+1.2	+1.8
Policy 3: time-limited subsidy	+0.6	+0.8	+0.4
Policy 4: home buying option	+0.24	+0.23	+0.25

Note: The welfare for the current program (baseline) is normalized to 1.

For each scenario, welfare benefits (costs) for all low-income people as well as for men and women separately are presented in Table 6. Compared to the baseline, the first policy of changing housing assistance into a flat subsidy reduces overall welfare. This is because low-income households' welfare losses from a reduced subsidy dominates high-income households' welfare gains from a greater subsidy, as low-income households have a higher marginal utility of consumption. If we look at welfare by gender, it is women that are losing more, since the

new policy benefits high-income households (or hurts low-income households) and men earn more than women. Providing lower benefits to all eligible applicants substantially improves welfare for both men and women (second row of Table 6). In the baseline the government provides continued large assistance to only a few families, and marginal utility decreases as benefits increase; in the new policy, housing subsidies are lower but assist more needy families who have a greater marginal utility at those benefit levels. Men gain more from the the policy because the policy substantially increases their incidence of receiving vouchers. Time-limited subsidies increase overall welfare, especially for women. This increase in welfare comes from families that have a higher chance of receiving vouchers due to the new policy. Both of the latter two policies promote overall welfare by mitigating the rationing problem. The last row of Table 6 presents the compensation variation of the experiment that allows the home buying option. This policy improves welfare as it promotes homeownership and the homeownership rate is associated with higher utility flow.

1.7 General Equilibrium Effects of Housing Vouchers

As a demand-side housing subsidy, the current housing voucher program and policy reforms may impact rental and housing prices, which affect household behavior and welfare through general equilibrium effects. A price increase would depend on elasticity of housing and rental units supply. Susin (2002) uses the 90 biggest metropolitan areas in the U.S. and finds that vouchers have raised rent by 16 percent on average, a large effect consistent with low supply elasticity in the low-quality rental housing market. In contrast, Eriksen and Ross (2015) use the U.S. national sample and do not find any effects of housing vouchers on overall price of rental. In addition, using a California sample, Mansur et al. (2002) estimate a general equilibrium model to show that the effect of housing vouchers on rent is quite small: the increase in rent is below $70 a year and constitutes less than 1% of the base rent.

The existing evidence shows different impacts of housing vouchers on rental prices but is consistent with the fact that the effect of housing vouchers on rent hinges critically on the elasticity of housing supply. To provide more suggestive evidence of the voucher pro-

gram's effect on rental prices, I develop a separate framework (Zhang, 2020) and apply it in each scenario. The framework builds a stationary equilibrium model to study the general equilibrium effect of introducing housing vouchers and a variety of public policies related to housing.[12] Since elasticity of housing supply is critical to determining the effect on rental prices, I experiment with various values of supply elasticity to examine the effect of the current program on rental prices. I then apply the national median elasticity of housing supply to investigate the effect of each policy change on rental prices. The result is presented in Table 32.

Panel A of Table 32 shows the effect of the current program on rental prices. In an inelastic housing supply case, e.g., where the elasticity of housing supply is lower than 1, introducing the current program will increase rental prices by 5%. However, in an elastic housing supply case, e.g., where elasticity of housing supply is 1.5, introducing the current program will increase rental prices by 2%. In a more elastic housing supply case, e.g., where the elasticity of housing supply is 2.3, introducing the current program barely has any effect on prices.

Panel B of Table 32 shows the effect of the four policy reforms on rental prices. I consider the case with a housing supply elasticity of 1.5, which is the national median elasticity among all MSAs (Saiz, 2010). Compared to the baseline (where prices are normalized to 1), flat housing assistance and time-limited subsidies have no significant impact on prices. Providing lower benefits to all will increase rental prices by 2%. Since the average rent for low-income households is $670 (during the sample period), a 2% increase in rent implies that rent will increase by $13 per month, which is small. Allowing households to use vouchers to buy homes has no impact on rental prices. When I apply the increase in rental prices in the baseline as well as the experiments, the main results are robust with regard to the price change. This is consistent with the existing evidence that housing vouchers have no impact on rental prices when using national sample (Eriksen and Ross, 2015). Note that the general equilibrium framework I applied here can at best provide suggestive evidence of the program's effect on rental prices because the assumptions for the general equilibrium model are quite different than the ones for the current model.

[12] The detailed description of the general equilibrium model is presented in section D of the online appendix.

1.8 More Results and Robustness Check

In this section, I first experiment with various program targets and the in-kind nature of the program. I then examine the robustness of the main results with regard to the general equilibrium effect of the housing voucher program and with regard to a variety of modeling assumptions.

1.8.1 Various Program Targets

The effect of the housing voucher program depends on program targets. In this subsection, I consider a variety of program targets to examine the program's effect on household behavior and welfare. First, since low-productivity households are in greater need of vouchers than high-productivity households, I consider only giving housing vouchers to low-productivity households. Second, since female-headed households are most likely to have children and housing has potential spillover effects on children's outcome (Jacob, 2004; Jacob et al., 2015; Chetty et al., 2016; Schwartz et al., 2020), I consider only giving housing vouchers to female-headed households. The results of the two experiments are reported in Table 33 (column (2) and (3)) and in 34 (row (2) and (3)) in the appendix.

Column (2) of Table 33 shows that the effect on household behavior is minimal if housing vouchers are only given to low-productivity households. However, this policy substantially increases household welfare, as shown in the second row of Table 34. This is because low-productivity households have a higher marginal utility of consumption. Column (3) of Table 33 shows that the female labor supply decreases if housing vouchers are only given to female-headed households because the disincentives for working apply to more female-headed households. In contrast, male-headed households work more as they cannot receive housing assistance in this policy experiment. This policy also raise female-headed households well-being and decrease male-headed households well-being, as shown in the third row of Table 34.

1.8.2 Transfers in-kind vs Transfers in-cash

Transfers in-kind and transfers in-cash have different implications for household behavior and welfare (Moffitt and Kosar, 2020; Chan and Moffitt, 2018). In this subsection, I consider the effect of giving equivalent cash transfers instead of in-kind transfers to households. The cash transfers can be used for both goods consumption and housing consumption. The results are shown in column (4) of Table 33 in the appendix. Compared to in-kind transfers, cash transfers have a larger negative impact on labor supply. This is consistent with existing literature (Gahvari, 1994) showing that cash transfers create larger disincentives for working. They are also more attractive to low-income households as they can spend the money on whatever they want, so the application rate increases by 13 percentage points. In addition, cash assistance can improve household welfare as they can consume any goods as needed (last row of 33).

1.8.3 Robustness: Downpayment Rate for Low-income Households

In the model, the downpayment rate is 20% and uniformly applys to all households. However, some households may qualify for lower downpayment rates, while others may not qualify for mortgages. The very low-income households do not qualify for mortgages due to low credit scores. On the other hand, some households may qualify for Federal Housing Administration (FHA) loans and face lower downpayment rates. For instance, the downpayment rates attached to FHA loans can be as low as 3.5%. In this experiment, households will get different downpayment rates based on their credit scores. The credit score of each household is predicted based on income, age, and cohort. People with a credit score below 600 do not qualify for mortgages. According to *The Ellie Mae Origination Insight Report (2019)*, about 20% of new home buyers get FHA loans. Therefore, I assign FHA loan downpayment rates to 20% of the home buyers based on their credit scores. The estimation result is shown in Table B.3 in the online Appendix.

1.8.4 Robustness: Application Rate Changes Over Time

The application information is only available until 2005. The application rate in the model is an upper bound estimation of the true rate of application within low-income households. In this robustness check section, I first relax the assumption that the application rate is fixed over time and allow it to grow after 2005. To predict the growth rate of the application rate, I apply the annual growth rate of the number of households receiving housing voucher from HUD Picture of Subsidized Households (2006-2016) and assume the growth rate of the application rate is the same as the growth rate of households receiving vouchers over time. Therefore, the application rate is growing by 4% every year after 2005. After this adjustment, the average application rate between 1996 and 2016 increases from 17% to 21%. Second, to account for the overestimation of the application rate due to the public housing program, I employ the housing voucher program and the public housing program data from the HUD Picture of Subsidized Households (1998-2016). The data set includes information on the total number of households in each housing subsidy program and the percent of households moved in the subsidized units less than a year. Such information allows me to construct the flow of households into the housing voucher program and the public housing program. The average increase of the number of households into the housing voucher program is 386,089 while the average increase of the number of households into the public housing program is 164,243 (28% of the overall application). Assuming the application rate of the two programs is proportional to the assisted rate of the two programs, the original application rate of the housing voucher program is overestimated by 28%. Thus, the average application rate between 1996 and 2016 decreases from 21% to 15%. After the two adjustments, the average application rate is 15%, which is similar to the original application rate, 17%, used in the model. The main results are robust to such adjustments.

1.8.5 Robustness: Moving Costs

The current model does not feature moving costs, implying households can freely move when receiving housing vouchers. However, the SIPP data shows that about 70% of households stay at their original house after receiving a housing voucher. The reluctance to move

to areas with better housing could be explained by a number of barriers, including insufficient available housing, a lack of landlord recruitment, discrimination, limited information, and a lack of familiarity, social ties, and acceptance (Schwartz et al., 2017).

To accommodate the barriers that prevent households from moving, I introduce moving costs for the households. I estimate the model with moving costs and present the estimated parameters in the table 35. The moving cost is about 4 months of average rent, which is pinned down by matching the share of households moved to the data. Except for stigma cost of program participation, all the values of the other estimated parameters are almost the same as the ones without introducing moving costs. The stigma cost in the model with moving costs is lower because the expected benefits from vouchers are less due to the moving costs. Using the estimated parameters, I redo all the experiments and show that the results of introducing moving costs in table 36. The simulations from models with or without moving costs are similar, suggesting the main results are robust when introducing moving costs.

1.9 Conclusion

Economic theory yields ambiguous predictions of the housing voucher program's effect on labor supply, family formation, and homeownership. The evidence of the program's effect on household behavior and welfare from existing literature is limited. Until now, no study has employed a national sample and has built a unified framework to examine the long-term effect of the current program and its alternatives on household behavior and welfare. In this paper, I take advantage of the welfare program take-up data and household socioeconomic status data available from the SIPP and AHS to construct a structural model to study the program's long-term effect. This paper shows the behavioral response and welfare implication of some stylized program reforms and provides a rigorous framework to examine any possible program reforms. Despite its academic merits, this framework can be used as a practical tool for policymakers to evaluate affordable housing policies.

The political debate focuses on the trade-off between the incentive costs and assistance aspects of the program. For instance, the Bush administration proposed a "Flexible Voucher

Plan" that reduces work disincentives and promotes self-sufficiency by introducing a time-limited subsidy and flat subsidy (Husock, 2004). The Obama administration expanded the housing voucher program to assist more low-income families (King, 2015). The Trump administration proposes large cuts to affordable housing programs and subsidy adjustments by local conditions (Fischer, 2017). The 2020 presidential candidate, Joe Biden, proposes universal housing vouchers to every qualified family (Yglesias, 2020).

This study is relevant to the policy debates about the optimal design of housing programs that date back to the launch of affordable housing policies in the 1930s. One of the debates is on the trade-off between the disincentives created by the program and the assistance aspect (anti-poverty) of the program (McClure, 2008). The flat housing assistance experiment shows that the negative substitution effect distorts household labor supply decisions. If housing assistance is flat instead of inversely related to family income, households will respond by increasing labor supply. However, this policy will decrease welfare as it redistributes resources from relatively low-income households to relatively high-income households.

My findings also provide rigorous evidence to the debate on the degree of rationing. The debate centers around whether we should provide modest subsidies to an increased number of households and whether we should consider time-limited subsidies (Collinson et al., 2015; Olsen, 2016; Collinson et al., 2019). The policy experiment shows that providing lower subsidies to more households will improve the overall welfare and such improvement in welfare comes from the fact that more households are assisted by the program. This paper also contributes to the understanding of the program to address the problem of low permanent income. Unlike other welfare programs that addressing temporary income shocks, the housing voucher program continuously subsidizes the needy family in the long-term, which addressing the problem of low permanent income (Collinson et al., 2015). Constantly subsidizing the families for the long-term is not optimal due to decreasing marginal utility from providing additional money to the same families. Instead, proving modest subsidies to a larger population will make low-income households better off.

This study is also relevant to the discussion about the subsidy to renting vs home-ownership. Researchers and policymakers argue that housing vouchers are biased against homeownership and call on a program reform that allows households to use vouchers for

homeownership (Olsen, 2003; Olsen et al., 2007; Kingsley, 2017). My findings show that housing vouchers are biased against homeownership and policy reforms that allow households to use vouchers to buy homes will promote homeownership and marriage among the eligible households.

Last but not least, this paper contributes to the understanding of the difference between transfer in kind and transfer in cash (Chan and Moffitt, 2018; Moffitt and Kosar, 2020), and the importance of the targeting of the program. The results demonstrate that transfer in cash will create larger disincentives for working than transfer in kind. Though transfer in cash results in higher disincentives for working, households are better off if they are given the equivalent cash transfer instead of housing subsidy as they can spend it either on goods or housing, depending on the optimal choices. Moreover, The effect of the program depends on the targeting of the program. The overall welfare will increase if the vouchers are only given to low-productivity households or female-headed households.

2.0 Boomerang College Kids: Coresidence and Job Mismatch

Joint with

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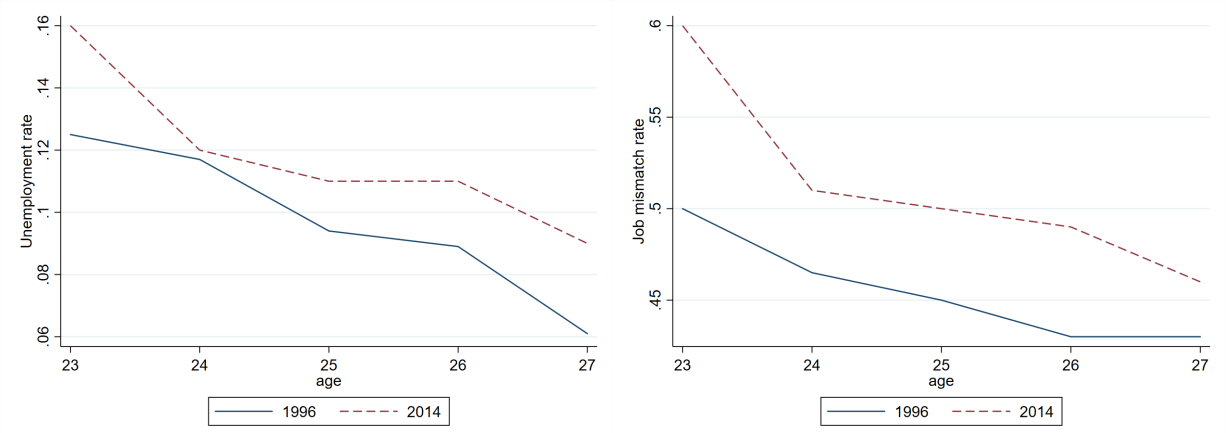
2.1 Introduction

Millennial college graduates have faced difficulties in finding economic security compared to older generations due to more challenging labor market conditions. This can be clearly seen in panel a) of Figure 4, which compares the unemployment rate at age 23 to 27 years old for the 1996 and 2014 college graduation cohorts in the Panel of Survey of Income and Program Participation. The average unemployment rate for this age group in the 1996 cohort is 9% whereas it rises to 12% for the 2014 cohort. Additionally, an increasing fraction of employed college graduates experience job mismatch, which we define as being employed in a position that does not require a college degree.[1] This can be seen in panel b) of Figure 4. The right panel shows that the job mismatch rate for the 2014 graduation cohort at age 23 to 27 years is around 52% on average, which is 7% higher than for the 1996 graduation cohort at the same age. Moreover, college graduates in mismatched jobs earn substantially less than their counterparts in matched jobs. As shown in Table 7, based on SIPP data, total monthly earnings at a matched job are 12% higher than at mismatched jobs for the 1996 graduation cohort and 34% higher for the 2014 graduation cohort. Additionally, earnings in mismatched jobs declined from $3,090 for the 1996 cohort to $2,854 for the 2014 cohort.

[1]To measure the job mismatch rate, we use the data from the U.S. Department of Labor Occupational Information Network (O*NET). We use the following question from the O*NET Education and Training Questionnaire to determine whether an occupation requires a college degree: "If someone were being hired to perform this job, indicate the level of education that would be required." We consider a college education to be a requirement for a given occupation if at least 50 percent of the respondents working in that occupation indicated that a bachelor's degree is necessary to perform the job. We then merged these data on the educational requirements for each occupation with data from SIPP on individual workers and their occupations. A college graduate is considered getting a mismatched job if he or she is working in an occupation that does

Figure 4: Youth Labor Market Outcomes



Note: Unemployment rate and job mismatch rate for college graduates age 23-27 not enrolled in school. College graduates hold bachelor's degree. Data is drawn from the Survey of Income and Program Participation (1996 and 2014) and Department of Labor, O*NET Education, Experience, Training.

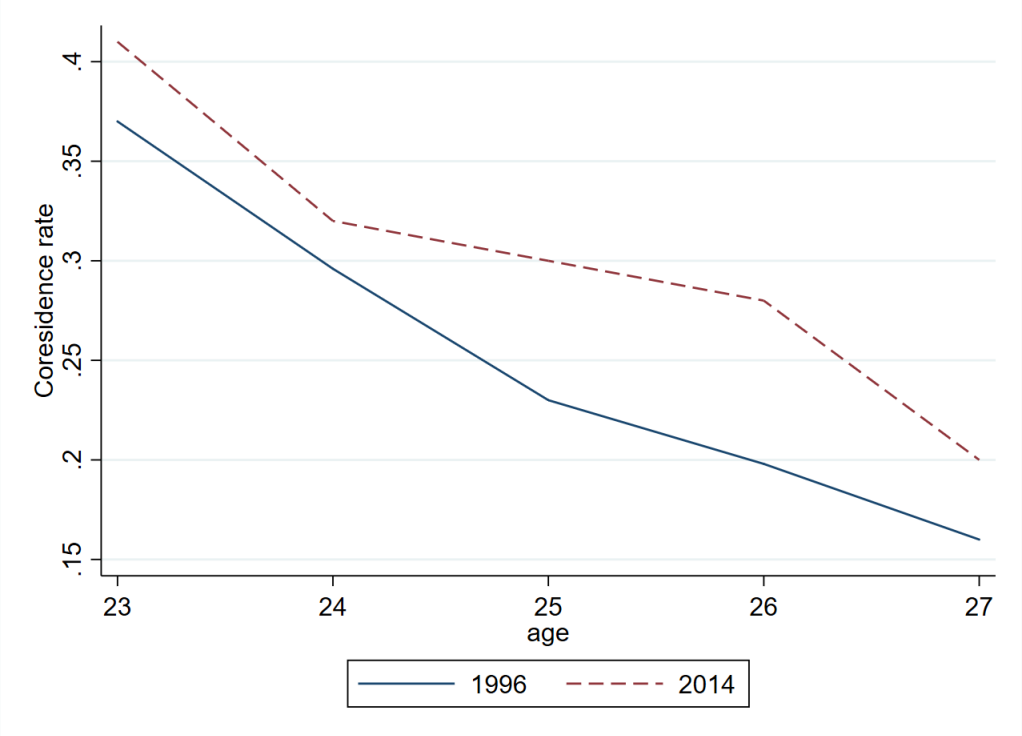
College graduates have also been faced with increasing student debt burdens in addition to adverse labor market conditions. The fraction of college graduates with student loans and the average student loan balances have been increasing since the early 1990s, almost doubling since then (see Figure 20). Specifically, for the 2014 graduation cohort, Table 7 shows that the fraction with student loans is 41%, compared to 18% for the 1996 graduation cohort. Conditional on having student debt, average balances were $25,091 for the 2014 graduation cohort, an increase of $5,000 relative to the 1996 graduation cohort. The increase in both fraction and amount of student loans resulted from the rise in college tuition and cost (Lucca et al., 2018).

Many young college graduates, in response to mounting student debt and labor market uncertainty, have chosen to move back to their parents' home. Figure 5 shows that more than 31% of the the 2014 college graduation cohort live with their parents at age 23 to 27 years old, compared to only 25% for the 1996 graduation cohort. The coresidence rate declines with age, as do the unemployment rate and the job mismatch rate, shown in Figure 4, suggesting that as labor market outcomes improve, young college graduates are more likely

not typically require a bachelor's degree.

to live independently. While we focus on the 2014 graduation cohort in comparison to the 1996 cohort, the differences in outcomes for these two cohorts reflect systematic trends that can be documented since at least the early 1990s. Figures 21 and 22 in Appendix A show the evolution of the job mismatch rate and the coresidence rate for young college graduates between 1990 and 2018, indicating a common countercyclical pattern for both variables. Our choice of of the 1996 and 2014 graduation cohort is mainly driven by data availability and limitations.[2]

Figure 5: Youth Coresidence Rate



Note: Coresidence rate for college graduates age 23-27 not enrolled in school. College graduates hold bachelor's degree. Data is drawn from the Survey of Income and Program Participation (1996 and 2014).

Living with their parents allows young adults to smooth their consumption and help them to search for a better-matched job in the labor market. Coresidence increases college graduates' outside option on the labor market, which increases their reservation wage and allows them the opportunity to find a better-matched job than other college graduates com-

[2]The 2014 cohort is the most recent cohort for which panel data is available from the SIPP data, while the 1996 cohort is the earliest panel for which we have the same complete information with 2014 cohorts.

peting for the same jobs without this option. This initial advantage will likely cumulate over the life cycle, as a better job match at the beginning of one's career is associated with higher earning growth (Barnichon and Zylberberg, 2019). Coresidence can therefore play an important role in mitigating the adverse impact of worsening labor market conditions for college graduates at the start of their career.

In this paper, we examine the joint determinants of coresidence and labor market outcomes. We quantify the role of economic factors, such as family background, outstanding student loan balances, job mismatch rate, wage dispersion, and rental costs, in accounting for the differences in living arrangements, employment and wages between the 1996 and 2014 college graduation cohorts, using a structural model estimated using 2014 SIPP panel data. The model centers around a dynamic game between parents and college children in which coresidence status and labor market outcomes for the children are jointly determined as a function of earnings, assets, and other family characteristics, as well as preferences. We find that coresidence at the early career stage has important quantitative implications for college graduates in terms of life time earnings. Using the estimated structural model, we decompose the impact on changes in parental income, student debt burden, matched job arrival rate, dispersion of offered wages, and rental costs. Our counterfactual analysis suggests that these factors can jointly explain the 54% of the difference in matched job rates and 63% of the difference in coresidence rates between the 1996 and 2014 college graduation cohorts. We also find that changes in preferences over marriage and household formation are important in shaping the evolution of coresidence behavior between the two graduation cohorts.

Our paper is related to the literature that studies the determinants of coresidence, focussing on the effect of labor market shocks on coresidence outcomes (Rosenzweig and Wolpin, 1993, 1994; Wiemers, 2014; Bitler and Hoynes, 2015; Matsudaira, 2016). This research shows that young workers experiencing negative employment and earnings shocks are more likely to move back with their parents. In addition, Bleemer et al. (2014) and Dettling and Hsu (2018) show that student debt is a big contributing factor to the increase in coresidence for the young in the United States. Moreover, a growing literature using European data (Manacorda and Moretti, 2006; Giuliano et al., 2004), Asian data (Sakudo, 2007), and American data (Kaplan, 2012) finds that preferences play an important role in determining

coresidence behaviors. Marriage formation (White, 1994; Sakudo, 2007; Yu and Kuo, 2016), housing costs (Ermisch, 1999; Guo et al., 2019; Rosenzweig and Zhang, 2019) and public benefits (Hoerger et al., 1996; Hu, 2001) also affect young people's living arrangement with parents.

Our paper is also related to the literature studying the effect of coresidence on economic outcomes. Rosenzweig and Wolpin (1993) find that both shared residence and financial transfers help sons smooth consumption. Moreover, they also find that an increase in welfare benefits affects the provision of parental support in terms of transfers and coresidence (Rosenzweig and Wolpin, 1994). Krolikowski et al. (2017) extend the idea of coresidence by studying the effect of living in the same neighborhood as parents on earning recoveries. They find that young people who live close to their parents experience stronger earnings recoveries after a job displacement than those who live farther away.

Our paper contributes to these literatures by quantifying the dynamic impact of coresidence on college graduates' ability to find a matched job and to their life cycle earning potential. We also quantify the role of student debt and labor market conditions, such as the availability of matched jobs and wage dispersion for college graduates, on coresidence patterns. Finally, we examine the effect of family background and housing costs in the joint determination of labor market outcomes and coresidence patterns for young college graduates.

Our theoretical model builds on Kaplan (2012), who examines that the role of coresidence as an insurance channel against labor market risk for high school graduates. We instead focus on college graduates, since they have experienced a marked increase in coresidence in the last twenty years, whereas coresidence rates have remained stable for high school graduates. This can be seen in Figure 23, which plots the coresidence rate for the 2014 and 1996 college graduation cohorts and for young adults in the same age range without a college degree. Our focus is on the impact of increased student debt burdens and job match rates college graduates on coresidence.

The paper is structured as follows. In section 2, we show the suggestive evidence on coresidence and job mismatch. Section 3 is the outlining of our structural model. The identification and estimation of the model are presented in section 4. We conduct a series of

counterfactual analysis in section 5. The conclusion is in the last section.

2.2 Data and Empirical Evidence

2.2.1 SIPP Data

Our data is drawn from the 2014 and 2018 Panel of Survey of Income and Program Participation (SIPP). The 2014 Panel has 4 waves, covering from January 2013 to December 2016. The 2018 Panel has one wave, covering the entire year 2017. Each wave in both panels used the previous 12-month as the reference period and tracks each individual of the sampled households for the entire time span. The survey contains extensive information on each youth's labor market behavior and educational outcomes, together with detailed information about family and community background. The SIPP (2014 and 2018) also provides detailed individual and household assets and debt information.[3]

The 2014 SIPP is ideal to study the dynamics of parent-college graduates living arrangements as it has detailed information on monthly coresidence, student debt, and labor market outcomes, along with the large representative sample size. At each interview, the survey asked respondents to list the father/mother household number if they are living together with them. It also asks whether the children move in/out of the parental house and the number of family members in the household within that month. From these questions, it is possible for us to construct a monthly panel of parental coresidence for each respondent. Furthermore, the data also contains information on labor market outcomes and debt at the times that coresidence transitions take place.

2.2.1.1 Sample

Our analysis focuses on college graduates who obtained their bachelor's degrees in 2011-2013. The graduates in those years are in the cohort born between 1990-1993 and face

[3]While we use both 2014 and 2018 SIPP panels, we sometimes refer to both as the "2014 SIPP panel" for expositional ease moving forward.

similar economic conditions at graduation, and we refer to them as the 2014 graduation cohort. For comparison purposes, we also consider individuals who graduate in 1994-1996, born in 1972-1976, who we refer to as the 1996 graduation cohort. For both cohorts, we exclude individuals who pursue a postgraduate degree.[4] Conditioning on the sample that not attending graduate school allows us to focus on the interaction between residential status and labor market outcomes. Additionally, graduate training may be a function of labor market conditions at graduation and will also affect labor market outcomes. The final 2014 graduation cohort sample consists of 2,169 college graduates with 28,339 year-month-youth observations. The detailed steps of sample selection are described in Table 37.

2.2.1.2 Descriptive Statistics

We find that among college graduates in the 2014 graduation cohort, nearly 36% co-reside with their parents for at least one month during the sample period. The average duration of time spent co-residing with their parents is 5 months. Additionally, approximately 6% of individuals in this cohort co-resided with their parents for at least one month after initially moving away.

The 2014 SIPP data contains detailed information on each category of assets and debt. Financial assets include savings accounts, checking accounts, stocks, mutual funds, and bonds.[5] Debt includes student loans, credit card loans, and loans on stocks/funds. We present assets and debt statistics for the 1996 and 2014 college cohort in Panel A of Table 7. For both cohorts of college graduates, student debt is the major component of their debt and net assets. The share with student debt increased from 18% for the 1996 cohort to 41% for the 2014 cohort. For those who have student loans, the average amount increase by 25% from the 1996 cohort to the 2014 cohort. As the 2014 cohort has more student debt both extensively and intensively, their net assets, which is defined as the total assets minus total debt, are much lower than that for the 1996 cohort.

[4] In the 2014 SIPP sample, about 9% of the college graduates pursue a postgraduate degree.

[5] We do not consider mortgages as the share of college graduates with a mortgage is less than 10% in earlier ages.

Table 7: Assets and Earnings: SIPP 1996 VS 2014 College Cohort

	1996		2014	
Panel A: Assets and debt	share	amounts (> 0)	share	amounts (> 0)
Total assets	30%	\$4,845	60%	\$4,415
Total debt:	34%	\$10,502	52%	\$22,110
Student loans	18%	\$20,594	41%	\$25,091
Other debt	20%	\$2,847	27%	\$4,561
Net assets (total assets-total debt):		-\$1,647		-\$7,299
Panel B: Earnings				
Matched job earnings		\$3,459		\$3,837
Mismatched job earnings		\$3,090		\$2,854

Note: Total assets include savings accounts, checking accounts, stocks, mutual funds, and bonds. Total debts include student loans and other debts, where other debts include credit card loans and debt on stocks or bonds. Net assets are defined as total assets minus total debts. Individual earnings in SIPP includes wages and salary, nonfarm self-employment income, and farm self-employment income. All values reported are in real terms, taking 2014 as the base year. Sources: Survey of Income and Program Participation (1996 and 2014).

2.2.2 HRS Data

Since there is no parental transfer or completed parental income information included in the SIPP,[6] we turn to the Health and Retirement Study (HRS) to obtain information on college graduates parental background. The Health and Retirement Study (HRS) is a nationally representative longitudinal study of the economic, health, family status, as well as public and private support systems of older adults conducted every two years. The survey has detailed information about older citizens' income and their children's education level, which allows us to estimate the parental income for college graduates in our analysis. The data also records the level of monetary transfers from parents to their adult children in each calendar year. According to HRS (2014-2018), the average annual transfer from parents to college graduates is \$6,058. We will use the parental transfer data from HRS to proxy the transfer in our sample.

2.2.3 Labor Market Outcomes and Coresidence

We now examine the relation between coresidence and labor market outcomes. We first estimate the impact of labor market performance on coresidence in the short run. Additionally, we examine the relation between coresidence and subsequent labor market performance over a longer horizon. In both cases, we proxy labor market performance with employment, having a matched job and earnings.

Table 8 shows the logit estimation results for the relation between coresidence and selected contemporaneous labor market outcomes using the SIPP 2014 data. In particular, we consider a dummy variable for whether an individual was working in a given month, a dummy variable for whether they were employed in a mismatched job, and log monthly earnings. For the models with mismatch and log earnings as the independent variable, the sample is restricted to those employed. All specifications include a set of fixed and time-varying control variables including age, age square, age cubic, race, metro area, marital status, gender fixed effect, and year fixed effect. We also control for lagged coresidence dummy to capture

[6] As with other household surveys, SIPP only reports parental income information if the parents and youths are living in the same household.

the mechanical effect of previous coresidence behavior.

Table 8: Labor Market Performance and Coresidence

	(1)	(2)	(3)	(4)	(5)	(6)
	Logit Coresidence			Fixed effect logit Coresidence		
Employed	-0.101			-0.357		
	(0.295)			(0.594)		
Mismatch		0.673**			1.070	
		(0.316)			(0.717)	
Log earnings			-0.460***			-1.010***
			(0.128)			(0.274)
Includes fixed effects				Yes	Yes	Yes
Observations	25,962	17,418	17,418	2,925	2,177	2,177
Individuals	2,008	1,632	1,632	2,21	199	199

Note: All estimates include controls for age, age square, age cubic, race, metro dummy, marital status, lag of coresidence, and gender fixed effect as well as year fixed effect. Standard errors are in parentheses, clustered by individuals. Parameters are multiplicative effects of probability of working, or marginal change in earnings, on probability of living with parents. The sample is college graduates, who are 23-27 years old between 2013-2017. Coresidence is a dummy variable that equals one if the college graduate lives with either one of his/her parents or both during the reference month. Employed is a dummy variable that equals one if the college graduate reported working during the reference month. Earnings are measured by the total person's earned income for the reference month, which includes wages and salary, nonfarm self-employment income, and farm self-employment income. Log earnings are the logarithm of earnings. The first three columns do not control for individual fixed effects and the last three columns control for individual fixed effects.

Columns (1)-(3) show the regression result without control for individual fixed effects. Column (1) shows that employed individuals are less likely to be living with their parents than those who are not employed. The point estimate for the Logit model is -0.1, which converts to a small average marginal effect of employment on coresidence at -0.001. Among employed individuals, those who engage in a mismatched job are more likely to live with their parents. The Logit point estimate at 0.67 is statistically significant at the 5% level, converting to an average marginal effect of 0.03, which implies that mismatched college graduates are 3% more likely to live with their parents on average. Moreover, individuals with higher earnings are also less likely to live at home. The point estimate implies that a 10% increase in earnings will decrease the probability of coresidence by 2%. To control

for unobserved heterogeneity that may be correlated with labor market outcomes, columns (4)-(6) report results from an individual fixed-effects (conditional) Logit model. The main results are consistent with the baseline specification but with a much larger average marginal effect. For instance, the point estimate in column (5) implies that college graduates with mismatched jobs are 5% more likely to live with their parents.

2.2.4 Long Run Effects of Coresidence

The evidence from the previous section suggests that improved labor market performance is inversely related to coresidence over the short run. We now provide evidence that coresidence is also important for long-term labor market outcomes. Particularly, we show that unemployment and job mismatch have persistent negative effects on earnings for college graduates. However, these negative effects are mitigated by coresidence and the ability to move back with their parents after a job displacement or job mismatch. To illustrate this, we look at becoming unemployed or being employed in a mismatched job after graduation on future earnings. For most of the college graduates in our sample, we can observe earnings up to age 27. Therefore, we regress log earnings at age 27 on an indicator variable for unemployment or mismatched employment at age 23, which is the initial period we can observe them.

The results are displayed in Table 9. Column (1) of Table 9 shows that unemployment or job mismatch at age 23 can have a significant negative impact on future earnings. College graduates who are unemployed or employed in a mismatched job at age 23 have earnings at age 27 that are on average 37% lower than those who did not. In columns (2)-(3), we divide the sample by coresidence status. Column (2) considers those who do not coreside with their parents, whose earnings at age 27 are 44% lower, whereas, column (3) considers those who were coresiding with their parents when unemployed or working in a mismatched job, for whom the effect on earnings is much smaller. In columns (4) and (5), we further divide the sample of college graduates who were not coresiding if unemployed of working in a mismatched job, into those who moved back with their parents after this spell, and those who did not, respectively. Column (4) considers the effect on earnings at age 27 for the first

group, which is very small and not statistically different from zero. Column (5) considers the effect on earnings at age 27 for the second group. Unemployment or employment at a mismatched job at age 23 is associated with a 45% reduction in earnings at age 27 for this group. Taken together, these results suggest that coresidence strongly reduces the negative impact on earnings of early career unemployment or job mismatch.

Table 9: Long Run Impact of Job Mismatch and Coresidence

	(1)[a]	(2)[b]	(3)[c]	(4)[d]	(5)[e]
Dependent Variable	Log earnings at age 27				
mismatch & unemployed	-0.470***	-0.590***	-0.304***	0	-0.602***
	(0.0489)	(0.0624)	(0.0785)	(0.032)	(0.063)
Observations	1,680	1,044	636	36	1,008

Note: College graduates in 2014 SIPP panel. In particular, the sample for each column is: a: All employed college graduates at age 23; b: All employed college graduates not coresiding at the time of mismatch or unemployed at age 23; c: All employed college graduates coresiding at the time of mismatch or unemployed at age 23; d: All employed college graduates not coresiding and who moved back with parents in after mismatch or unemployement at age 23; e: All employed college graduates not coresiding and who did not move back with parents after mismatch or unemployed at age 23.

2.3 Quantitative Analysis

We now examine the joint determination of labor market outcomes and coresidence for young college graduates through the lens of a structural model. The model examine the causal relation between family background, student debt and other factors and coresidence and labor market outcomes, and helps to model the long run implications of the rise in coresidence for college graduates. We also use the model to examine a number of counterfactuals to quantify the impact of these factors.

The model, which builds on Kaplan (2012), is parsimonious but is rich enough to enable estimation of the key parameters governing asset accumulation, coresidence, and labor market status for young college graduates. The economy is populated by families consisting of a parent/child pair, where children are assumed to be young college graduates. Parents have

exogenous labor income and assets, while children face a frictional labor market. They can be unemployed or employed at a matched or mismatched job. A matched job, is interpreted as corresponding to one that requires a college degree. Wages at matched jobs are higher and grow over time. The arrival rate for matched jobs is higher than for a mismatched job, so there is option value to waiting for a matched job. Parents can provide their children support via monetary transfers or coresidence. Children and parents engage in negotiations to determine whether the child will coreside with their parent or live independently. Parents care about their children's welfare via a warm glow motive. Both parents and children prefer to live independently.

2.3.1 Environment

The economy is populated by families who live for $t = 0, 1, ...T$ periods, where the unit of time is a month. A family consists of a college graduate and his/her parents. Families are indexed by i, an adult parent is indexed by p, and a college child is indexed by c. In any given period t, the child can be in either one of two residence status $r_{it} \in \{0, 1\}$. If $r_{it} = 0$, the child lives with his/her parents, else if $r_{it} = 1$, the child lives independently.

2.3.1.1 Children's Preferences

The child's utility is defined over consumption, work, and living arrangement, with period utility additively separable across these three states. Children obtain utility from two types of consumption goods: c^y is the private good, consumed exclusively by them; G is the total public good inside the family. It consists of the youth's own purchase of the good, g^y, as well as a public good provided by the parent, g^p. The public good provided by parents is only available inside the parental home and the youth can only get access to it if he lives with the parent, with:

$$G_{it} = g^y_{it} + (1 - r_{it})g^p_{it}$$

Let U^y_{it} denote the period utility for a child in family i in time t:

$$U^y_{it} = \frac{[c^{y(1-\phi)}_{it} G^{\phi}_{it}]^{(1-\gamma)}}{1-\gamma} - h_{it}v + r_{it}z_{it} \tag{2}$$

where h_{it} denotes work status, working if $h = 1$, or not working, if $h = 0$. The disutility of working is fixed at v.

Utility over the two types of consumption good takes a Cobb-Douglas specification, with the parameter ϕ indexing the weight of the public good in total consumption. For $\phi = 1$, only public goods are consumed and there are full economies of scale, while with $\phi = 0$, all consumption is private. The preference for living away from home is captured by the shock z_{it}, which follows an AR(1) process, with $z_{it} = E[z_t] + \rho_z z_{i,t-1} + \varepsilon_{it}$ where $\varepsilon_t \sim \hat{A}\ N(0, \sigma_z^2)$. The mean preference for living away from home, $E[z_t] = \alpha_z + \gamma_z t$, is allowed to increase linearly with age. The parameter γ_z is estimated to be positive, which captures the fact that more youths will live away from home as they get older. The autocorrelation coefficient ρ_z and the variance σ_z^2 do not depend on age. The preference shocks capture the effect of non-economic heterogeneity, especially taste for independence, on college graduate coresidence behavior.

A child's lifetime utility is given by:

$$V_0^y = E_0 \sum_{t=0}^{T} \beta^t U_{it}^y + \beta^{T+1} V_{T+1}^y \tag{3}$$

where V_{T+1}^y is a terminal value function.

2.3.1.2 Parent's Preference

Parents derive utility from their own private consumption, c^p, and public consumption in the family, g^p:

$$U_{it}^p = \frac{[c_{it}^{p(1-\phi)} g_{it}^{p\phi}]^{(1-\gamma)}}{1-\gamma} \tag{4}$$

Parents are altruistic towards their children, so the parents' overall value is given by their value from consumption and the children's value weighted by altruism factor η.

$$V_0^p = \tilde{V_0^p} + \eta V_0^y = E_0 \sum_{t=0}^{T} \beta^t U_{it}^p + \beta^{T+1} V_{T+1}^p + \eta V_0^y \tag{5}$$

In the model, we assume that parents do not derive utility from the public good purchased by the children when the children live at home, so that the intergenerational link between

parent and child works through the parent's altruism. Because parents are altruistic towards their children, they have an incentive to provide income transfers to their children, enabling them to have more resources and to live on their own. In addition, parents do not have a direct preference for coresidence but they have an indirect preference over the residential state because they care about their children's welfare. Since $\eta < 1$, parents have a weaker preference for their children's independence than their children's.

2.3.1.3 Budget Constraints

In each period, children can be employed or unemployed. If employed, they earn a monthly wage of w_{it}, which is a stochastic process depending on their type of job. The labor income will be taxed according to the tax function τ.[7] If the child is not employed, they will receive an unemployment benefit, b.

Children use their income to purchase consumption, c^y_{it} and g^y_{it}. In addition, they accumulate net savings, denoted with a_{it+1}, with a gross rate of return R.[8] Children start their life in the model with an exogenously assigned level of net savings drawn from the net asset distribution from SIPP data, which mainly reflects variation in student loan balances. Children cannot borrow during the course of their lives, so if they start with negative net savings, their level of debt can only fall over the course of their life. Children can also receive a transfer T_{it} from their parents. For children who do not coreside, there is a per period fixed cost of housing, χ. If the children were coresiding last period and move out this period, they will incur a one period moving cost κ. The moving cost includes time and monetary costs. We assume there are no costs associated with moving back to their parents' home. Therefore, a college graduate's budget constraint is given by:

$$c^y_{it} + g^y_{it} + a_{i,t+1} + r_{it}[\chi + (1 - r_{it})\kappa] \leq (1 - \tau)w_{it}h_{it} + b(1 - h_{it}) + Ra_{it} + T_{it} \tag{6}$$

Parents' income I^p_i, is exogenously given and differs across families. Parents can use their income for private good purchases, c^p_{it}, public good purchases, g^p_{it}, housing cost χ, and

[7] The tax function is constructed based on the US tax system in 2014.

[8] Since for young college graduates in the data most of their net savings correspond to student loan balances, we use the federal student loan interest rate for R, which annualized was 4.66% in 2014.

making transfers to their children, T_{it}. Hence the parents budget constraint is given by:

$$c_{it}^{p} + g_{it}^{p} + T_{it} + \chi \leq (1-\tau)I_{i}^{p} \tag{7}$$

2.3.1.4 Key Assumptions

The model makes three key assumptions about access to asset markets and transfers between parents and children. First, parents cannot save or borrow. This is mainly a simplifying assumption to reduce the computational burden associated with solving the model, stemming from imperfect altruism for the parents and the lack of commitment in the relation between children and parents.[9] The key implication of this assumption is that it forces the parents to face a trade-off between making a transfer to children and their own consumption. If we allow parents to hold assets, they could smooth their consumption over time through assets. By ruling out parental savings, we limit the extent to which parents can use a financial transfer to offset the effect of labor market shocks to the youth. This makes coresidence a more attractive way of intergenerational resource sharing. Second, we assume that children cannot borrow, though they may start their lives with negative net assets, reflecting outstanding student loans. This assumption reflects limited access to consumer credit, other than educational loans, for young borrowers.

Finally, we assume that children don't make transfers to parents or pay housing costs and services when living at home. This assumption is based on empirical evidence. The SIPP data provide information about who pays the household rent and how much they paid. It shows that when college graduates live with their parents, only 0.5% of them contribute to part of the rent cost. The low contribution is because most of the parents (85%) own their homes rather than rent their homes. Even for the rest who rent the house, children rarely share rent costs when living with parents. To check whether children contribute to public good consumption, we turn to the National Survey of Families and Households (NSFH), which contains information about cost-sharing within families. We focus on the most recent wave of NSFH which is the 2001-2002 wave. Focusing on the subset of youth with a college degree and aged 21-28, we found that 18% of the sample contributes something to the

[9] See Barczyk and Kredler (2014a,b) for a full discussion of the issues.

household and the average contribution is \$212. Therefore, about 80% of youth doesn't make contributions to households, and among those who made contributions, the amount is very small.

2.3.2 Labor Market

Young college graduates can be unemployed (U), working in a matched job (MA), or working in a mismatched job (MI). A matched job is interpreted as corresponding to one in which a college degree is required, while a mismatched job is one in which a college degree is not required. Mismatched jobs pay lower earnings and can also be performed by those with only a high school education. There is no on-the-job search. Each period an unemployed individual receives one job offer of type $j \in \{MA, MI\}$ with probability λ^j, which he/she can accept or reject. The wage offers are drawn from the job type specific lognormal distribution:

$$w^j \sim N(\mu_0^j, \sigma_0^j)$$

Since the mean wage of matched jobs is higher than that of mismatched jobs, waiting for a matched job is beneficial. In addition, the job, regardless of the type, is exogenously destroyed with probability δ in each period.

Let V^U, V^{MA}, and V^{MI} denote the value of being unemployed, working in a matched job, and working a mismatched job. The values depend on youths' state variables (Ω) which include wage offers (w), preference for coresidence (z), assets (a), and parents' transfer (T). The value of being unemployed is:

$$V^U(\Omega) = u(b) + \beta E\{max\{\lambda^{MA}\int_0^\infty V^{MA}(\Omega')dF_{MA} + \lambda^{MI}\int_0^\infty V^{MI}(\Omega')dF_{MI},\ V_U(\Omega')\}\}$$

where b is unemployment benefits, λ^{MA} and λ^{MI} are arrival rates of matched and mismatched jobs. The terms F_{MA} and F_{MI} are wage distributions for matched and mismatched jobs. The expectation E is taken over the next period distribution of coresidence taste (z'). The values of working in a matched or mismatched job are:

$$V^{MA}(\Omega) = u(w^{MA}) + \beta E\{max\{(1-\delta)\int_0^\infty V^{MA}(\Omega')dF_{MA}(w') + \delta V^U(\Omega'),\ V^U(\Omega')\}\}$$

$$V^{MI}(\Omega) = u(w^{MI}) + \beta E\{max\{(1-\delta)\int_0^{\infty} V^{MI}(\Omega')dF_{MI}(w') + \delta V^{U}(\Omega'),\ V^{U}(\Omega')\}\}$$

A youth who receives a wage offer of job type j will accept it if his/her value of accepting the offer is larger than the value of being unemployed and keeping search.

Given that the state variables (w, z, a, T) change over time, a youth working in a mismatched job or a low wage matched job may quit their jobs, become unemployed and search for a new job in the following circumstances: 1) he/she becomes less averse to moving back home; 2) he/she pays off student loans; 3) his/her parents provide more transfers; 4) he/she experiences negative shocks to current wages. In particular, a youth will reject or quit working in a matched (or mismatched) job if $V^{U}(\Omega) > V^{MA}(\Omega)$ (or $V^{U}(\Omega) > V^{MI}(\Omega)$).

After an initial wage draw, the wage process for individual i working in job type j at time t evolves as:

$$logw_{ijt} = \theta_t + log\ job_{ijt}$$

Where θ_t is the experience effect that is common for everyone regardless of job types. The term $log\ job_{ijt}$ is the job type-dependent component.

If it's a matched job $(j = MA)$,

$$log\ job_{ijt} = \mu_d + log\ job_{ijt-1} + \varepsilon_{ijt}$$

where the term μ_d is estimated to be positive, reflecting on the job wage growth for matched jobs. The term $\varepsilon_{ijt} \sim N(0, \sigma_j^2)$ is i.i.d, capturing job-type specific shocks to current wages.

If it's a mismatched job $(j = MI)$,

$$log\ job_{ijt} = log\ job_{ijt-1} + \varepsilon_{ijt}$$

The difference between a matched and mismatched job is that: 1) the initial wage offer distribution of a matched job is different than that for a mismatched job. Matched jobs have a higher mean of initial wage offers; 2) a matched job features trend growth (μ_d) in addition to growth related to the accumulation of on the job experience by the individual worker; while the wage growth for a mismatched job only only reflects individual experience effect. The trend growth in matched job wages is assumed to reflect economywide skill biased technological change.

In this environment, the ability to coreside with their parents for young college graduates may have long-run effects on labor market outcomes. Specifically, there is an option value of waiting for a matched job offer, so those who can wait longer for jobs are more likely to obtain a matched job offer. Children with higher value of unemployment will be more likely to reject a mismatch job offer and wait for the arrival of a matched job. The ability to coreside with their parents or higher parental transfers increase the value of unemployment for youth.

2.3.3 Initial Conditions and Terminal Values

Closing the model requires specifying a set of initial and terminal conditions. The initial age $t = 0$ corresponds to 21-22. Initial assets a_0 are drawn from the empirical distribution of net worth at age 21-22 in SIPP data, corresponding to Jan 2013. Additionally, we assume that an exogenous fraction of agents at $t = 0$ is living at home, corresponding to the empirical value in Jan 2013. Similarly, an exogenous fraction of these individuals are assumed to be working at $t = 0$, to match the corresponding empirical value in Jan 2013. The initial fraction employed in matched and mismatched jobs is also taken directly from the data. Their wages are given by the empirical distribution of monthly wages for that age group conditional on type of job.

Following Kaplan (2012), we set the terminal age to 30 years old, which corresponds to $T = 90$ given that the model is monthly. At the terminal period, all interaction between parents and children ceases. There is no coresidence happening and children have to move out of their parents' home. Additionally, parents stop making financial transfers. Children's labor supply becomes inelastic and there is no uncertainty about future earnings, corresponding to the assumptions we make for parents. The above assumptions and specifications allow us to obtain closed-form solutions for the terminal value functions.

2.3.4 Feasible Allocations and Markov-Perfect Equilibrium

Given housing cost (χ) and interest rates (R), an allocation is a mapping of labor market outcomes and preference shocks $\{w^t, j^t, z^t\}$, initial conditions $\{a_0, w_0, h_0, j_0, r_0\}$, and parental

income $\{I^p\}$ into values for $\{r_t, h_t, c_t^p, c_t^y, g_t^p, g_t^y, T_t, a_{t+1}\}$. An allocation is feasible if it satisfies both the parental and the children's budget constraint (6) and (7), and the non negativity constraints for transfers, net assets, and consumption.

We specify the order in which children and parents make decisions to guarantee the uniqueness of the equilibrium household allocation. This sequence can be interpreted as a subgame perfect equilibrium of a sequential game played by the children and their parents, in which at every stage, the players take into account the optimal response of the other players in the subsequent stages. The sequence of choices is as follows. In stage 1, given the state variables, children make their residence decisions. In stage 2, parents will take the children's residence choice as given and make their transfer and consumption decisions. In the third stage, children will make their work, assets, and consumption decisions given the choices made by their parents in the previous stage. The timing of actions is summarized in Table 10.

Table 10: Stages of the Game

Stage	State variables	Choice	By whom
1	$(a_t, r_{t-1}, w_t, j_t, z_t)$	r_t	Children
2	$(a_t, r_{t-1}, r_t, w_t, j_t, z_t)$	$T_t,\ g_t^p,\ c_t^p$	Parents
3	$(a_t, r_{t-1}, r_t, w_t, j_t, z_t, T_t, g_t^p)$	$h_t,\ a_{t+1}, c_t^y, g_t^y$	Children

Based on these timing assumptions, an equilibrium allocation is a feasible allocation such that: (1) given the prices $\{\chi, R\}$, labor market shocks $\{w_t, j_t\}$, preference shocks, z_t, college graduates choose their living arrangement r_t to maximize their lifetime utility; (2) given children's optimal residence decisions and their states, parents choose $\{T_t, c_t^p, g_t^p\}$ to maximize their lifetime utility; (3) given parents' transfer and public good consumption $\{T_t, g_t^p\}$, children choose asset holdings, working and consumption $\{a_{t+1}, h_t, c_t^y, g_t^y\}$ to maximize their lifetime utility.

2.3.5 Factors Affecting Coresidence

There are four state variables that affect living arrangements in equilibrium. The first is earnings, which are determined by employment status and job quality. The second is net assets. The third is the realized value of the preference for living independently, and the last is parental income. Children are more likely to live independently if their labor earnings, net assets, or value of independence are high. However, the effect of parental income on living away is ambiguous. On the one hand, if parents are wealthy, they can provide higher transfers to the children, which makes living independently an attractive option. On the other hand, wealthy parents are more likely to provide higher levels of household public good consumption, which increases the value of coresidence for the children.

2.4 Estimation

Our strategy for parameterizing the model is to identify a small set of parameters that can be obtained from independent evidence, which we refer to as calibrated parameters, and to rely on structural estimation for most of the key parameters. We adopt a Simulated Method of Moments (SMM) approach, based on simulating the theoretical moments and minimizing the difference between simulated moments and data moments, weighted by the variance-covariance matrix of the data moments.

2.4.1 Externally Calibrated Parameters

The value and reference of the externally estimated parameters are reported in Table 26. Parents and children are assumed to have a coefficient of relative risk aversion parameter of $\gamma = 1.5$. The annualized discount factor is $\beta = 0.96$ annualized with a corresponding monthly value of $\beta = 0.996$. Since for most young college graduates, net assets are negative and are comprised mainly of educational loans, we set the interest rate equal to the Stafford loan interest rate, which is 4.66% annualized, or 0.4% monthly. We derive the unemployment benefit as the mean of unemployment benefits for unemployed youth sample from SIPP

data, for which the mean is about \$600 per unemployment month for college graduates. The parental income distribution is estimated from the HRS data. It is discretized into a four-point grid, reflecting average parental income in each quartile of the distribution. The share of public goods consumption in utility ϕ is set to be 0.3 following Kaplan (2012). We obtain the monthly housing cost χ from the median gross rent between 2013 and 2017 drawn from US Census, which is $\$1,062$. The fixed cost of moving κ is set equal to half month housing cost, which is \$500.[10]

Table 11: Externally Calibrated Parameters

Parameter	Description	Value	Reference
γ	Risk aversion	1.5	Attanasio et al. (2008)
β	Monthly discount factor	0.996	Prescott (1986)
R	Monthly interest rate	1.004	Student debt interest rate (2014)
b	Unemployment benefits	\$600	SIPP (2014)
I^p	Parental income dist.	[3566,5562,7449,9749]	HRS (2014-2018)
ϕ	Share of public goods	0.3	Kaplan (2012)
χ	Housing cost	\$1,062	US Census (2013-2017)
κ	Moving out cost	\$500	

2.4.2 Internally Estimated Parameters

The approach to estimating the remaining parameters is simulated method of moments (SMM). We choose a set of moments related to labor market outcomes, coresidence, net assets, and parental transfers over the age range from 23-27 to identify all the parameters. The full set of moments is shown in Table 38. The estimated parameters include labor market parameters $(\delta, \lambda^{MA}, \lambda^{MI}, \mu_0^{MA}, \mu_0^{MI}, \sigma_0^{MA}, \sigma_0^{MI}, \sigma_{MA}, \sigma_{MI}, \mu_\theta, \mu_d)$; parameters governing coresidence preference $(\alpha_z, \gamma_z, \sigma_z^2, \rho_z)$, altruism η, and disutility of working ν. Since the number of moments is larger than the number of parameters, our model is over-identified.

Although all of the moments are used to estimate all of the parameters, there are certain moments that are especially important to identify certain parameters. We provide a heuristic argument for how each of the parameters can be identified from a subset of the moments and give the intuition for identification.

[10] See Appendix B for more details.

For the labor market parameters, a typical identification challenge arises as a result of the fact that rejected job offers are not observed. Therefore, the labor market parameters are estimated within the model. The job destruction rate δ is identified from the probability of not working, conditional on working in the previous month. We assume the job destruction rate is the same for a matched job and mismatched job. Moreover, the identification for parameters relevant to matched vs mismatched jobs is quite intuitive as we have the corresponding data analog. The arrival rate of matched jobs λ^{MA} is identified from the probability of working in a matched job, conditional on not working in the previous month and the proportion of college graduates with a matched job. The arrival rate of mismatched jobs λ^{MI} is identified from the probability of working in a mismatched job, conditional on not working in the previous month. The mean and standard deviation of the initial wage distribution of matched jobs $(\mu_0^{MA}, \sigma_0^{MA})$ are identified from the mean and standard deviation of the log entry earnings of matched job. Similarly, the mean and standard deviation of the initial wage distribution of mismatched jobs $(\mu_0^{MI}, \sigma_0^{MI})$ are identified from the mean and standard deviation of the log entry earnings of mismatched job. The experience effect μ_θ is identified from the mean growth of mismatched job earnings, as the only source of growth for a mismatched job is experience effect. Conditional on the experience effect, the matched job growth μ_d is pinned down by the mean growth of matched job earnings, as a matched job has earning growth in addition to the experience effect. The standard deviation of matched (mismatched) job earning shocks, σ_{MA} (σ_{MI}) is identified from the standard deviation of matched (mismatched) job earnings conditional on working for more than two consecutive periods. Conditional on the values for labor market parameters, the disutility of working ν is pinned down by the average unemployment rate.

For the parameters governing coresidence, the average proportion of college graduates living independently and the increase by age contributes to pin down the intercept and slope in the mean utility of living independently (α_z, γ_z). The average difference in earnings between children living independently and children coresiding helps determine the variance of preference shocks σ_z^2, which measures the cross-sectional heterogeneity in taste for living independently. To shed light on the intuition of the identification, suppose that there was no preference heterogeneity among children $\sigma_z^2 = 0$, we would expect to see that all coresidence

dynamics are driven by economic factors like earnings, assets, and housing costs. This would imply that children living away from home have far higher earnings than children living at home. As σ_z^2 increases, the amount of non-labor market heterogeneity increases. The heterogeneity reduces the variation of earnings across children who live independently and those who coreside. Based on the variation in observed earnings by residence status, heterogeneity in the value of independence is necessary to match the data.

The within-person time-series variation in parental coresidence pins down the persistence of the preference parameter ρ_z. In particular, we use the monthly autocorrelation of coresidence, the fraction of youth who ever move back with their parents, and the mean duration of the coresidence period. It is important to have the last moment because the extent to which duration of coresidence is different than duration in response to labor market shocks helps determine the role of preferences. Suppose a case in which there is no time-series variation in z. In this case, the duration of a coresidence spell for college graduates who experience a labor market shock will be similar to the duration of the shock itself, such as the duration of an unemployment spell or of employment at a mismatched job. Finally, parental altruism is identified by the average transfer from parents to children in a given year, as the optimal transfer decision is directly affected by the weight that parents put on the utility of children.

The estimated parameters are displayed in Table 12. We demonstrate the implication of the sign and magnitude of parameters governing coresidence. The linear growth rate of preference γ_z captures the growing preference for living independently as children get older. The point estimate for γ_z is 0.07, which shows that as college graduates getting older, they prefer living independently more and more. The autocorrelation ρ_z is estimated to be 0.85, implying high persistence in the preference for coresidence despite the large cross-sectional heterogeneity in this shock $\sigma_z^2 = 6.25$.

2.4.3 Model Fit

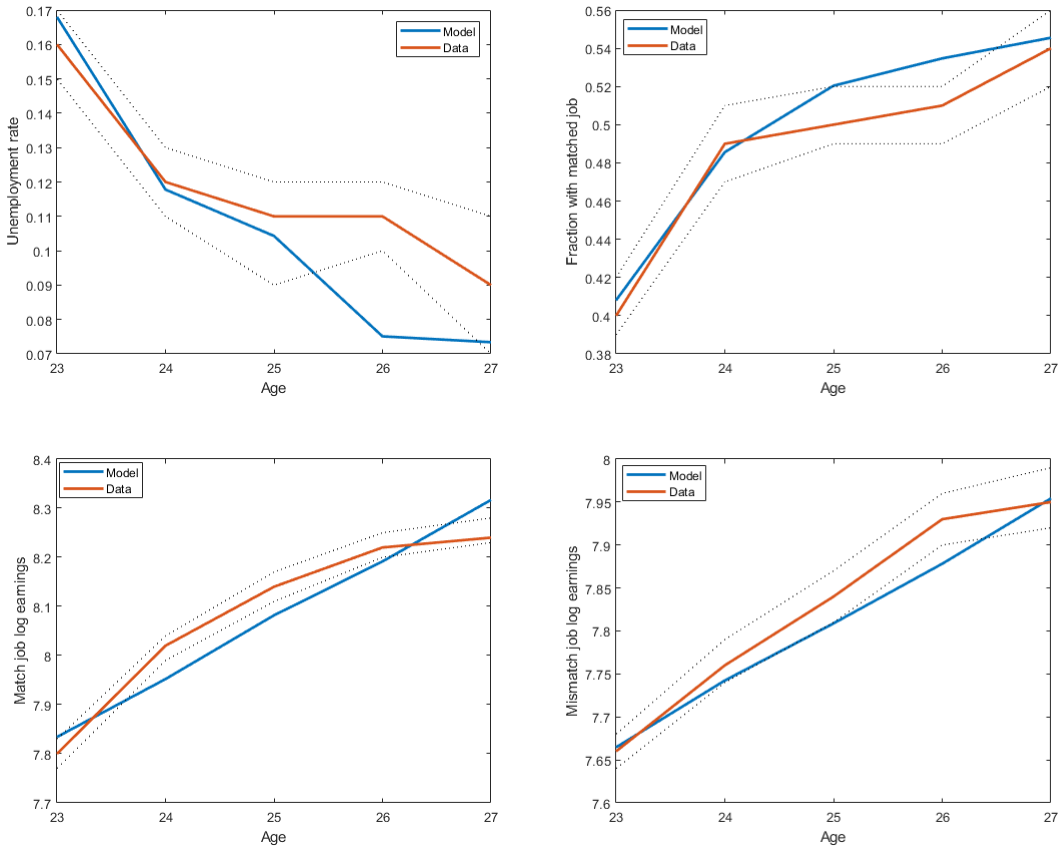
The fit of the model for selected labor market moments is displayed in Figure 6. The unemployment rate is shown in panel (a). The blue line is the average fraction not working for age 23-27 simulated from the model, while the red line corresponds to the same statistic

Table 12: Parameter Estimates

Parameter	Description	Estimate	Standard error
Labor Market			
δ	Job destruction rate	0.03	0.01
λ^{MA}	Match job arrival rate	0.53	0.13
λ^{MI}	Mismatch job arrival rate	0.44	0.09
μ_0^{MA}	Mean matched job log wage offer	7.52	2.1
μ_0^{MI}	Mean mismatched job log wage offer	7.35	2.1
σ_0^{MA}	SD matched job log wage offer	0.51	0.22
σ_0^{MI}	SD mismatched job log wage offer	0.51	0.24
σ_{MA}	SD of matched job wage shocks	0.04	0.01
σ_{MI}	SD of mismatched job wage shocks	0.06	0.01
μ_θ	Growth log experience effect	0.074	0.02
μ_d	Matched job earning growth	0.042	0.01
Preference			
α_z	Intercept mean value of living away	0.72	0.31
γ_z	Age slope mean value of living away	0.07	0.02
σ_z	variance of value of living away	6.25	0.22
ρ_z	Autocorrelation of value of living away	0.85	0.22
η	Altruism factor	0.04	0.02
ν	Disutility of working	2.9	0.57

calculated from SIPP data in years 2013-2017. The fraction of college graduates with a matched job for the same age group is displayed in panel (b). We can see that our model matches the trend and level of unemployment and job match rate for the cohort closely. Panels (c) and (d) display the comparison of data and model for matched and mismatched job earnings. We can see that the model can replicate the data very well.

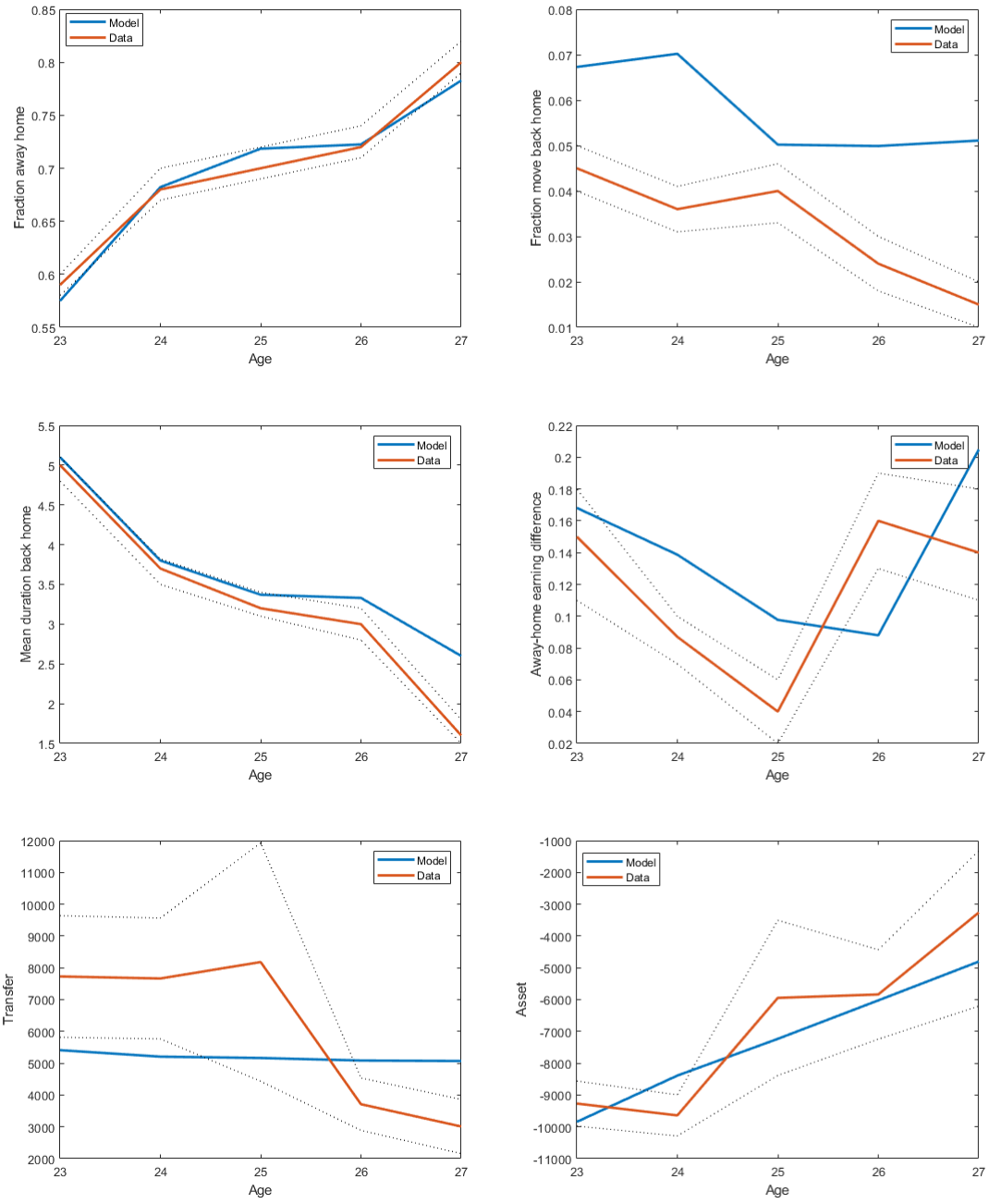
Figure 6: Model Fit



Note: Model fit for labor market moments. Solid red lines correspond to the data; solid blue line correspond to the model; dotted lines are 95% confidence interval for data. Variables are (a) fraction not working; (b) fraction working in a matched job (c) matched job log earnings; (d) mismatched job log earnings.

The fit for coresidence moments is displayed in Figure 7. The fraction of college graduates living independently is shown in panel (a). Our model can match the level and variation with age of this statistic very well. The fraction of children ever coresiding with their parents is shown in panel (b). The data indicate that children's coresidence rates decline with age from 5% at age 23 to around 2% at age 27. This trend is mostly captured by the

Figure 7: Model Fit



Note: Model fit for coresidence moments. Solid red lines correspond to the data; solid blue line correspond to the model; dotted lines are 95% confidence interval for data. Variables are (a) fraction living away; (b) fraction ever move back; (c) mean duration back home; (d) away home log earning difference; (e) average transfer; (f) average stock of net assets (total assets-total debt).

model though it over predicts the fraction coresiding at each age. Panel (c) shows the mean duration back home, which is decreasing from 5 months to 2 months. The earnings difference between children living independently and those coresiding is displayed in panel (d). Children living independently have approximately 15% higher earnings than those coresiding, and this difference decreases and then increases over age. The positive earning difference indicates that those living independently are positively selected relative to those who coreside with their parents. Our model predicts a positive earning difference and matches the data in trend and level. Transfers from parents are shown in panel (e). Parents transfer less as their children grow older. In our model, parents' transfer has the same trend but it decreases at a slower speed than the data. Finally, children's stock of net assets is shown in panel (f). College graduates pay off their debt as they aging. Between age 23-27, they close their debt by $5,000 so their net assets, defined as total assets-total debt, increase by the same amount accordingly.

2.4.4 Model Validation

There are several salient moments that are not targeted in the estimation that we examine to validate the model and assess its mechanisms. These include the fraction of college graduates with a matched job by residence status and mean net assets by residence status. The comparison between data and model is shown in Table 13. The model predicts that college graduates coresiding with their parents are less likely to have a matched job. College graduates with higher debt are more likely to live with parents. The model replicates the trend in the data very well.

2.5 Understanding Changes in Coresidence Over Time

Given the model and the parameter estimates, we can explore which factors led to the changes in college graduates' labor market outcomes and coresidence patterns for the 1996 and 2014 graduation cohorts. The goal of this section is to quantify the role of each of the

Table 13: Model Validation

	Model	Data	95% CI
Fraction with matched job			
Independent	0.53	0.52	(0.51, 0.53)
Coresiding	0.49	0.45	(0.44, 0.46)
Net assets			
Independent	-6,449	-6,227	(-7,363, -5,090)
Coresiding	-7,506	-9,621	(-10,175, -9,067)

main channels individually and the combined effects of all channels.

2.5.1 Parental Income

Parental income is one of the major channels that affect coresidence behavior and labor market outcomes. The major change in the parental income of college graduates from 1996 to 2014 is that more college graduates have lower parental income in 2014 graduation cohort. The distribution of parental income for the 2014 graduation cohort is estimated from HRS (2014-2018) as equal probability multinomial distribution over the support [3,066 5,562 7,449 9,749] in 2014 USD. To be consistent, the parental income distribution in 1996 is also estimated to be a four-point distribution with equal probability. After adjusting for inflation, the support for the distribution of parental income in 1996 is [3,628 5,658 7,566 10,343] is 2014 USD. Thus, the parental income of college graduates in 1996 is 5.3% higher than in 2014 on average. As a result of higher parental income for 1996 cohort, data shows that the parental transfers for the 1996 cohort also 5% higher than that for the 2014 cohort.

We change the parental income from the 2014 to the 1996 distribution and display the corresponding counterfactual outcomes in column (2) of Table 14. With higher parental income, the average transfers rise by 1%, which closes the transfer gap between the two cohorts by 20%. We do not detect any significant impact of the parental income change on other outcomes.

2.5.2 Student Loans Distribution

As our model predicts, the level of net assets significantly affects the coresidence and labor market outcomes of college graduates. Since the major component of net assets is student debt, we consider the change in student loans for college graduates between 1996 and 2014 and how this change affects their outcomes. The fraction of college graduates with student debt and the average amount of debt rises sharply after 2000. This is mostly due to the rise in tuition and fees associated with attending college, as argued by (Lucca et al., 2018). For the 2014 graduation cohort, the fraction of college graduates with student loans is 41%. Conditional on having student loans, the average amount of student debt is $25,901 (in 2014 USD). The corresponding values are much lower for the 1996 graduation cohort. The fraction of college graduates with student loans is 18% and the average amount for those who have student debt is $20,594 (in 2014 USD). As a result of student debt difference, the average net assets (total assets-total debt) for the 2014 graduation cohort is much lower (-$7,299 in 2014 USD), compared to the 1996 graduation cohort (-$1,647 in 2014 USD), as previously shown in Table 7.

When we change the initial net assets distribution (at age 21-22 and model period $t = 0$) of college graduates from the 2014 values to inflation adjusted 1996 values, the counterfactual outcome is shown in column (3) of Table 14. With lower student debt or higher net assets, the share of college graduates living independently increases by 1 percentage point or 2%. Given the coresidence rate gap between the two college cohorts is 9%, the higher net assets contribute to closing the gap by 22%. Due to the change in the initial distribution of net assets, the asset gap between the two cohorts is mechanically closed.

2.5.3 Matched Job Arrival Rates

In the model, obtaining a matched job is important for college graduates' welfare because a matched job has a much higher wage. The labor market environment determines the fraction of college graduates getting a matched job. For the 1996 graduation cohort, the fraction in a matched job is 55% while only 48% for the 2014 cohort. This difference is driven by variation in the arrival rates for matched and mismatched jobs for the two cohorts.

To simulate this change, we set the matched job arrival rate so that the fraction of college graduates in a matched job is the same as in the data for the 1996 graduation cohort. In the estimated model, the job arrival rate for a matched job is 0.53 and a mismatched job is 0.44 in 2014. The corresponding values for the 1996 graduation cohort are 0.55 and 0.42, respectively. This experiment allows us to examine how the change in the matched job arrival rate accounts for the change in outcomes across the two cohorts.

The result of this counterfactual experiment is shown in column (4) of Table 14. Because the matched job arrival rate is higher, the unemployment rate drops by 1 percentage points or 9%, which helps close the unemployment data gap by 36%.

2.5.4 Wage Offers

Wage dispersion has risen consistently for workers with a college degree. Autor et al. (2005) documents the rise in wage dispersion since 1990, and how this increase has been more pronounced for more experienced and educated workers. Consistent with Autor et al. (2005), we find that the wage dispersion for college graduates rise for the 2014 graduation cohort, compared to the 1996 cohort. The standard deviation of monthly earnings is \$2,577 for college graduates with a mismatched job and \$3,126 with a matched job in the 2014 graduation cohort. The corresponding inflation adjusted values for the 1996 graduation cohort are \$1,948 for those with a mismatched job and \$2,153 for those with a matched job, which implies an increase of 32% and 45% for mismatched and matched jobs across cohorts, respectively.

To assess the role of rising wage dispersion, we set the standard deviation of log wage offers for match and mismatched jobs to their values for the 1996 cohort. The result is shown in column (5) of Table 14. The unemployment rate decreases from 11% to 9% in the counterfactual, as the probability of a low wage offer declines in both match and mismatched jobs. The decrease in wage dispersion contributes to closing the unemployment gap between the two cohorts by 72%. Moreover, the fraction of college graduates living independently rises from 69% to 71%, which helps to close the gap between the two cohorts by 33%.

2.5.5 Rent

Another important change across the 1996 to 2014 college graduation cohorts is rental costs. According to the Consumer Expenditure Survey, the average rent, the main housing cost for college graduates, increased 20% in real terms from 1996 to 2014. To quantify the role of this change, we decrease rent to the 1996 inflation adjusted value.

The result is shown in the last column of Table 14. Intuitively, with a lower housing cost, more college graduates are living independently, with a rise in the corresponding fraction from 69% to 71%, closing the gap between the two graduation cohorts in this outcome by 33%. At the same time, fewer college graduates are unemployed and parental transfers are correspondingly lower. Setting rental cost to its 1996 value closes the gap in unemployment rates across the 2014 and 1996 graduation cohorts by 72%.

2.5.6 Combined Effects

In this section, we examine the combined effects of all the channels explored individually above. The combined channels may have a different impact than each individual channel because of offsetting interactions. The results from this combined counterfactual are shown in Table 15. From the table, we can see that the fraction unemployed decreases by 25% from the 2014 to 1996 graduation cohort in the data, and the combined channels predicted a 27% decrease, which accounts for all of such change. The fraction with a matched job increases by 15% from the 2014 to 1996 cohort in the data and the combined channels account for 54% of this variation. The fraction living independently is 9% higher in 1996 and the channels in the model account jointly for 63% of the overall change. Net asset accumulation over the course of their life span is 77% higher for the 1996 graduation cohort and our channels can account for all of that change. Finally, parental transfers do not experience large variation over the period and our joint channels also predict no change of parental transfers for the two cohorts.

Table 14: Counterfactual Experiments

	(1) Data	(2) Parents' income	(3) Asset dist	(4) MA arrival	(5) Wage dispersion	(6) Rent
Fraction not working						
2014	0.12	0.11	0.11	0.11	0.11	0.11
1996	0.09	0.11	0.11	0.1	0.09	0.09
% change	25%	0	0	9%	18%	18%
close the gap by		0	0	36%	72%	72%
Fraction with matched job						
2014	0.48	0.5	0.5	0.5	0.5	0.5
1996	0.55	0.5	0.5	0.55	0.49	0.49
% change	15%	0	0	10%	-2%	-2%
close the gap by		0	0	67%	0	0
Fraction living independently						
2014	0.69	0.69	0.69	0.69	0.69	0.69
1996	0.75	0.69	0.70	0.69	0.71	0.71
% change	9%	0	2%	0	3%	3%
close the gap by		0	22%	0	33%	33%
Net assets						
2014	-7,299	-7,259	-7,259	-7,259	-7,259	-7,259
1996	-1,647	-7,323	-41	-7,264	-7,225	-7,354
% change	77%	0	99%	0	0	0
close the gap by		0	128%	0	0	0
Parental transfers						
2014	6,058	5,187	5,187	5,187	5,187	5,187
1996	6,336	5,224	5,139	5,195	5,076	5,053
% change	5%	1%	0	0	-2%	-2%
close the gap by		20%	0	0	-40%	-40%

Note: This table presents counterfactual experiments when considering each of the economic factors: parental income, initial student loans, matched job arrival rate, mean and standard deviation of earnings for matched and mismatched jobs, and housing cost (rent). Column (1) shows the data moments and percent change between 2014 and 1996 college graduation cohorts. Columns (2)-(6) show the model simulation by turning each of the economic factors from the 2014 scenario into the 1996 scenario. For each of the moment we considered, the row "2014" represents the data or model simulation for 2014 college graduation cohorts. The row "1996" represents the data or model simulation by changing each of the factors from 2014 into the 1996 scenario. The row "% change" represents the gap in percentage between 2014 and 1996 college cohorts. The row "Close the gap by" represents the share that each of the economic factors can account for the gap between 2014 and 1996 college cohorts.

Table 15: Combined Counterfactuals

	Data % change	Counterfactuals 1-5	Closing the gap by
Fraction unemployed	25%	27%	100%
Fraction with matched job	15%	8%	54%
Fraction independent	9%	5.7%	63%
Net Assets	77%	95%	100%
Parental transfer	5%	-3%	0

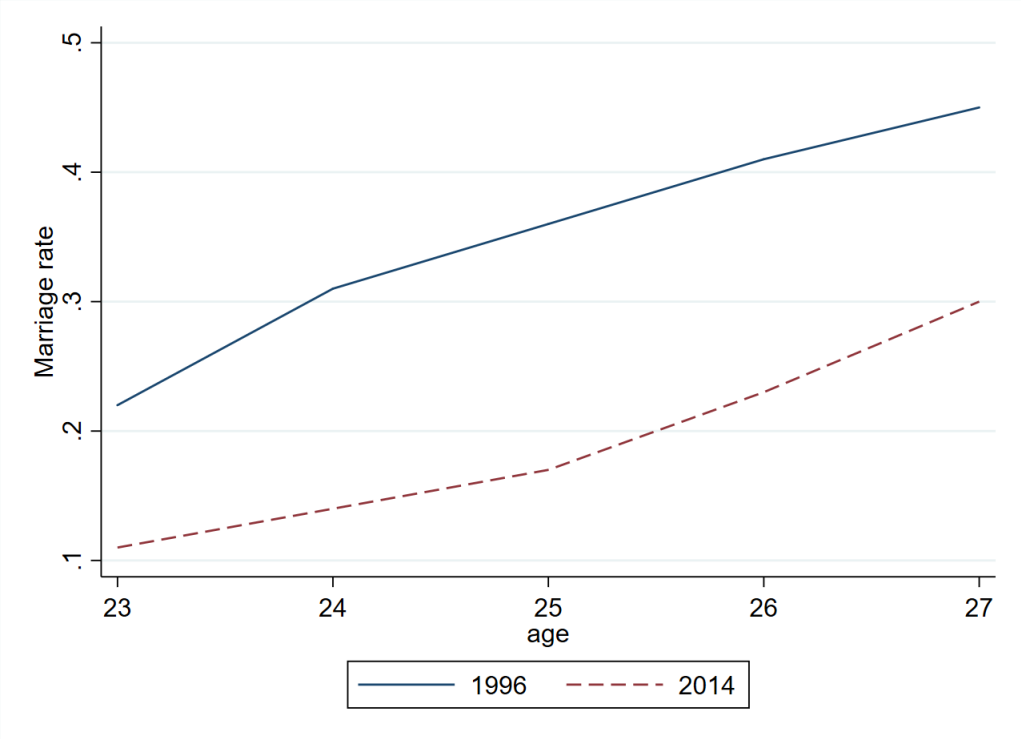
2.5.7 Taste for Independence

Our model implies that coresidence is driven by economic factors, such as net assets, job offer arrival rates, wages, parental income, as well as a preference for independence, captured by the preference shock z. The estimated model implies that 63% of the residence behavior is driven by economic factors, while the rest 37% is due to the taste for independence. This preference shock, however, not only captures the strength of preferences for independence, but also additional economic factors that are not included in our model. A key factor driving a preference for independence is the wish to marry or live with a romantic companion (White, 1994; Sakudo, 2007; Yu and Kuo, 2016), and variation in preferences over marriage may also be driving changes in coresidence rates across the 1996 and 2014 cohorts of college graduates. Figure 12 compares marriage rates for these two groups, and clearly shows lower marriage rates for the 2014 graduation cohort compared to the 1996 cohort. The average marriage rate for the college graduates in the 1996 graduation cohorts is 35% at age 23-27, while it is only 19% for the 2014 cohort. Changes in attitudes towards marriage across these two cohorts in our model are captured in the preference for independence shock.

Other underlying cultural factors influencing the taste for independence also may be changing over time. For example, (DePaulo, 2016) shows that parents of millennials have changed their parenting style and values have changed making it more acceptable for parents to support adult children directly and reducing the stigma associated with coresidence.

We also examine the characteristics of parents for the two cohorts, other than economic factors such as income, to identify other factors that may contribute to the change in cores-

Figure 8: College Graduates Marriage Rate



Note: Young college graduates are those aged 23 to 27 with a bachelor's degree or higher. All figures exclude those currently enrolled in school. Data is drawn from the Survey of Income and Program Participation, 2014 and 1996 panels.

idence rates. For instance, if the parents of 2014 graduation cohorts are more likely to live in metropolitan areas, where there is a higher concentration of matched jobs, that would provide a greater benefit from coresidence for the 2014 graduation cohort. However, we do not find substantial differences in the fraction of parents living in the metro area for 1996 and 2014 graduation cohorts.

To interpret the strength of the taste for independence in the model and therefore its role in explaining changes in coresidence rates across the 1996 and 2014 college graduation cohorts, we assess the economic role of the taste for independence by calculating its monetary value. To do so, we construct a counterfactual in which we first adjust the parameters that govern preferences for independence, the mean value of the taste for living independently and the slope of its relation to age (α_z, γ_z), to value that imply our estimated model can match the coresidence pattern for the 1996 cohort. Then, we compute the change in net assets that a 24 years old college graduate would require to compensate for the decline in welfare that would be entailed by the 2014 coresidence rate. Such a net asset transfer would make a college graduate indifferent to the change in coresidence rate and we calculate it separately for those with a matched job and with a mismatched job. We find that the net asset transfer that compensates for the change in coresidence rate for college graduates with a matched job is $\$2,900$ and it is $\$3,500$ for those with a mismatched job. These transfers just exceed the monthly labor earnings of graduates with a mismatched jobs, implying that from an economic standpoint the change in preferences for independence across cohorts is quite modest.

2.6 Conclusion

In this paper, we study the quantitative effect of job match quality, student debt, wage dispersion, parental transfer, and preferences on college graduates' coresiding behavior with parents. We estimate a structural model which features a dynamic game between parents and children and allows the choice of residence, using a sample of college graduates and their parents from the 2014 SIPP panel data and 2014-2018 HRS data. We quantify the

role of each channel by changing each of the factors from the 2014 to 1996 scenario. Our counterfactual analysis suggests that student debt burden, wage dispersion, and house costs can each account for more than 20% of the coresidence behavior change between the two college graduation cohorts. Furthermore, we change all the economic factors from the 2014 to 1996 scenario. The combined labor market, assets holdings, family background, and housing costs can jointly explain the 54% of the fraction of matched job difference and 63% of coresidence difference between 1996 and 2014 youth cohort. We also show the evidence that marriage formation and cultural change are other important factors that can explain the rising in residence with parents over time.

Our findings shed light on how individual living arrangement is affected by labor market conditions, asset holdings, family background, housing costs, as well as the taste for marriage and coresiding with parents. In particular, the quantitative decomposition of each factor individually and the combination of all factors has profound policy implications. The fact that intergenerational living arrangements and financial support respond endogenously to the realization of labor market shocks, assets holdings, as well as housing costs suggests the possibility of substantial crowding out by public programs. Among policymakers and researchers, there is an ongoing debate about attenuating the burden of student debt and help college graduates overcome labor market frictions and find a better-matched job. Lots of policy proposals might be designed to promote college graduates' job match quality or reduce student loan payment pressure. Since parental support through the shared residence and monetary transfer may respond to such policies, it is important to assess the impact of such policies on coresidence and other behavioral responses precisely when evaluating their welfare implications.

3.0 Delayed American Dream? Student debt, Family Formation and Homeownership

Joint with
Prof. Stefania Albanesi, University of Pittsburgh, Economics
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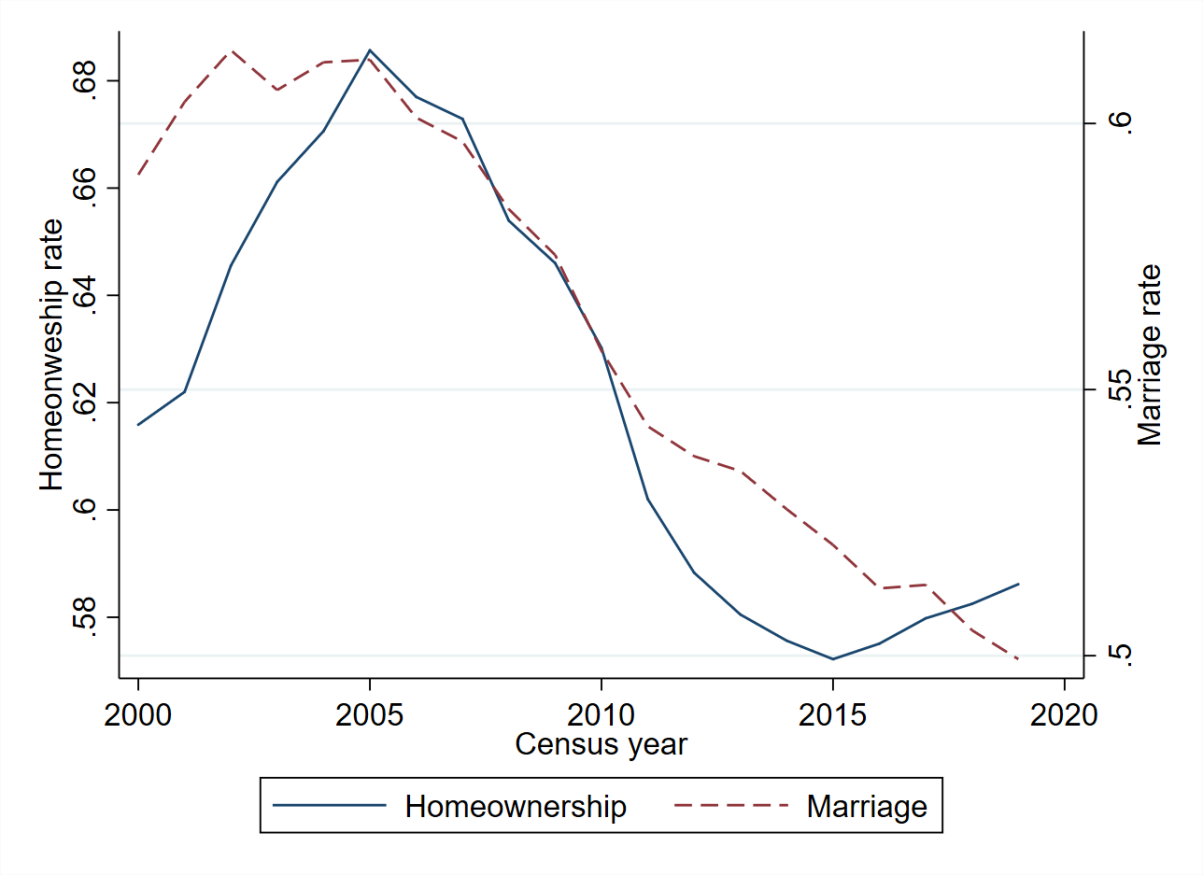
3.1 Introduction

Among American households, student debt has increased rapidly during the past two decades. Between 2003 and 2020, the share of student debt over the total household debt has increased from 0.33% to 11% and has surpassed auto loans to become the second-highest consumer debt category, second only to mortgages (New York Fed Consumer Credit Panel/Equifax). For young households aged 18-29, the share of student debt over total household debt is 35%, which comparable to the share of mortgages, 39% (New York Fed Consumer Credit Panel/Equifax, 2020Q3). As of 2019, more than 65% of college graduates have borrowed funds for education, and and each college graduate carries on average $35,359 in student debt, which is a 26% increase in five years (Experian student loan report). Substantial student debt has a profound impact on household formation and homeownership. According to the American Community Survey (Figure 9), the homeownership rate among college graduates has experienced a large decline from 65% in the 2000s to 58% in the 2010s. Similarly, the marriage rate among college graduates decreases from 67% in the 2000s to 59% in the 2010s. Student loans–along with other economic factors such as income risk, housing prices, and borrowing constraints–are critical to understanding the change in homeownership and marriage patterns among college graduates over time. This paper develops and estimates a lifecycle model for studying the quantitative effect of student loans and other economic factors on college graduates' homeownership and marriage rates.

Our paper contributes to understanding the driving force underlying the change in home-

Figure 9: College Graduates' Homeownership and Marriage Rates



Note: Homeonwership and marriage rate for young college graduates between age 25 and 35. College graduates are those with associate/junior college degree or above. Sources: American community Survey (2000-2015).

ownership and marriage rates among college graduates over time. Existing literature has documented the importance of marital status, income and divorce risk in explaining the decline in homeownership rate (Fischer and Khorunzhina, 2019; Fisher and Gervais, 2011; Chang et al., 2019). We extend on prior work that studies the factors determining marriage and homeownership by showing that student debt is crucial to accounting for the delay and decline in marriage and homeownership over time. On the one hand, student loans have a direct impact on home purchase by affecting household wealth accumulation (wealth effect). On the other hand, student loans indirectly impact home purchase by affecting the availability and cost of mortgage loans (price effect). In addition, student loans can also affect family formation by changing the insurance value of marriage.

Our paper also contributes to understanding the quantitative effect of each of the economic factors on changes in homeownership patterns over time. Within the literature that examines the contributing factors to homeownership decline, most of them provide descriptive evidence (Elliott et al., 2013; Cooper and Wang, 2014; Houle and Berger, 2015). Among the limited studies that examine the causal impact of student debt on homeownership, Mezza et al. (2020) use in-state tuition rates at public 4-year colleges as an instrument for the amount of student debt and find that a $1,000 increase in student debt decreases the homeownership rate by 1.8 percentage points for young college attendees. In addition, (Bleemer et al., 2021) exploit state-cohort variation in tuition and find that the rise in tuition and student debt contributed to a sharp decline in homeownership. In contrast to such reduced form papers, we develop and estimate a structural model to shed light on the quantitative effect of the separate and combined effects of student loans, income risks, housing prices, and downpayment constraints on college graduates' homeownership. We also endogenize marriage and divorce decisions to control for the indirect effect of such economic factors on homeownership through marriage (dis)formation.

This study also provides evidence of the quantitative effect of student debt and other economic factors on marriage rate decline over time. Existing reduced form papers (Gicheva, 2012; Bozick and Estacion, 2014; Addo, 2014) find that student debt is negatively associated with marriage, which is especially true for women. Moreover, Sieg and Wang (2018) estimate a dynamic model to study the impact of student debt on the marriage market choices of

young female lawyers and find that student debt has negative effects on marriage prospects. However, their narrow sample of female lawyers may cast doubt on the external validity of their results. In contrast, we use two national representative samples consisting of two cohorts of male and female college graduates to study the quantitative effect of student loans, income risk, housing prices, and downpayment constraints on marriage and divorce.

To highlight the correlation between student debt and marriage/homeownership, we document the student loans, marriage, and homeownership patterns for the 1960 birth cohort and 1980 birth cohort using the National Longitudinal Survey of Youth (NLSY) 1979 and 1997 data sets. Compared to the 1960 college cohort, the 1980 college cohort has much higher student debt in both extensive and intensive margins. The 1980 college cohort also has a lower homeownership rate and marriage rate before age 35. For both the 1960 and 1980 college cohorts, graduates with student loans have a significantly lower homeownership and marriage rates than those without student loans.

We then build and estimate a life-cycle model of college graduates to understand the mechanism through which student debt and other economic factors could affect their decisions on marriage and homeownership. In the model, we begin tracking college graduates at age 25, when they have entered the labor market with a certain level of labor productivity. Since we are interested in the effect of student loans per se on household behavior, we do not explicitly model student loan borrowing decisions. Instead, we assign each college graduate a given level of student loans at age 25. Student loans are not defaultable and must be paid off according to the standard 10-year repayment plan. The payment amount is determined by the total student debt each college graduate has at the initial period.

In each period of the model, we consider the problem of single and married college graduates who face several sources of shock: a permanent productivity shock, a match quality shock of marriage as well as the aggregate and idiosyncratic shocks of housing prices. At the beginning of each period, singles may meet a potential partner, drawn from the distribution of available singles, and decide whether to get married. The married couple will experience love shocks to their marriage and decide whether to remain married or get divorced given options outside of marriage. Both single and married households also decide on female labor supply, homeownership, and how much to save or consume. The model

features both goods consumption and housing consumption, where housing consumption is determined by homeownership and size of housing. Homeowners can use their housing as collateral borrowing, i.e., mortgages. Mortgages are long-term and defaultable.

We use the NLSY79 data to estimate the preference parameters regarding household decisions on homeownership, marriage, employment, and mortgage default behavior. We rely on the data variation in student loans, homeownership rate, marital status, female employment rate, and default risk for college graduates. Beyond that, we leverage comprehensive information on Experian Credit Panels to empirically estimate the effect of student loans on credit scores. Then we map each individual's credit score to his/her mortgage price. This empirical estimation allows us to capture the effect of student debt on home purchase through the availability and price of mortgages. Besides the good fit of the model to targeted moments, we have also illustrated that the model replicates salient features of non-targeted moments, which show the difference in household behavior for college graduates with and without student loans.

We finally apply the estimated model to quantify the effect of student debt, housing price, income risk, and downpayment rate, on homeownership and marriage. We apply each of the economic factors from the NLSY 79 cohort scenario to the NLSY 97 cohort scenario and examine how each factor can individually account for the homeownership and marriage difference between the two cohorts. We find that student debt per se has a substantial impact on college graduates' marriage and homeownership rates. In particular, student debt can account for 33% of the overall homeownership decline and 18% of the overall marriage decline between the NLSY 79 and NLSY 97 college cohorts. Within the student debt's effect on homeownership, the wealth effect has contributed to 33% of the gap, while the price effect plays little role in closing the homeownership gap. Furthermore, housing price increase over time can account for 45% of the overall homeownership difference but has no significant impact on marriage difference. In addition, wage dispersion can explain 4% of the homeownership decline and 18% of the marriage decline between the two college cohorts. Nevertheless, we find that relaxing downpayment constraint could enlarge the gap in marriage or homeownership between the two cohorts. Last but not least, we examine the combined effect of all factors, as the combined factors may have a different impact

than each individual one because of offsetting interactions. We find that combining all the economic factors mentioned above can account for 71% of the homeownership difference between the two college cohorts. However, the combined factors can barely explain any marriage difference between the two cohorts.

The rest of the paper is structured as follows. Section II presents the data sets and stylized facts. We describes the lifecycle model and discusses the college graduates' decisions in Section III. Section IV discusses structural parameter estimates as well as the model fit. Section V presents the counterfactual experiments, which quantify each of the economic factors that account for the change in homeownership and family formation over time. The last section concludes this paper and discusses policy implications.

3.2 Data and Stylized Facts

3.2.1 Data

The main data set is drawn from the National Longitudinal Survey of Youth 1979 and 1997 (NLSY79 and NLSY97). The NLSY79 focuses on the youth cohort born between the years 1957-1965 and follows the cohort between the years 1979-2016. The cohort was surveyed annually before the year 1994 and biennially thereafter. We can track the sample in NLSY79 from age 25 to 60. On the other hand, the NLSY97 focuses on the cohort born between the years 1980-1984 and follows the cohort between the years 1997-2017. This cohort was surveyed annually before the year 2011 and biennially thereafter, which allows us to track the sample from age 25 to 35. Both data sets contain detailed information on individual demographics, student loans, labor market outcomes, marriage dynamics, and homeownership. We focus on the sample of college graduates that have obtained Associate/Junior College (AA) degrees or above and are not currently enrolled in school. Applying this restriction criteria, the NLSY79 sample includes 2,312 individuals and 48,990 year-individual observations and the NLSY97 sample includes 8,984 individuals and 111,233 year-individual observations. We use both data sets to provide a cluster of stylized facts about the change

in homeownership and family formation between the two cohorts.

3.2.2 Stylized Facts

In this section, we present the stylized facts about student loans for the NLSY79 and NLSY97 college cohorts. We also show the homeownership and marriage patterns for the two college cohorts by student loan status. By the age of 25, Table 16 reports that the younger cohort (NLSY97) has a much higher student loan both in the extensive and intensive margin. In particular, the share of college people with student loans is 35% for the younger cohort, compared to 24% for the older cohort. Moreover, conditional on the sample of graduates that have student loans, the average amount is $19,260 for the younger cohort, almost doubled than that for the older cohort.

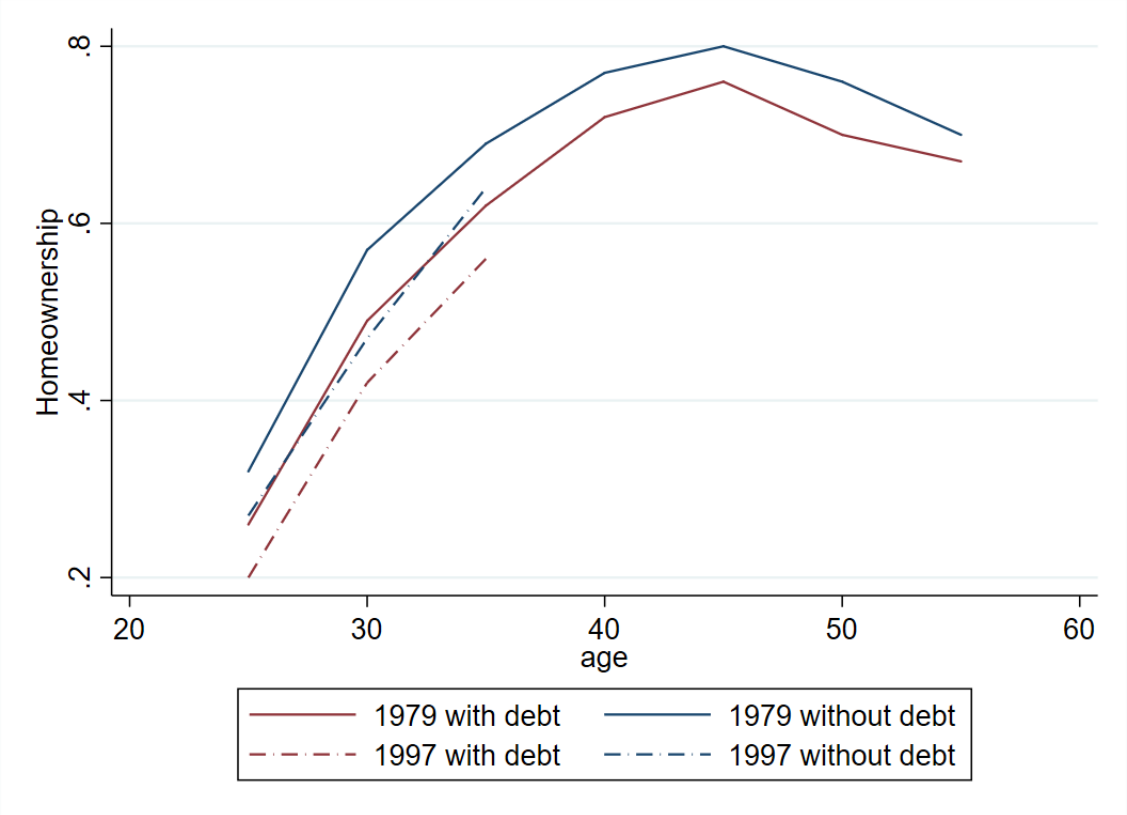
Table 16: Share and Amount of Student Loans

Age 25	Share with student loans	Student loan amount (Cond.)
NLSY79	0.24	$10,279
NLSY97	0.35	$19,260

Note: Fraction with debt and debt amount is calculated for those that are at age 25 and have obtained Associate/Junior College (AA) degrees or above. The amount is in real terms taking 2010 as the base year. Data is drawn from the National Longitudinal Surveys 79 (NLSY79) and National Longitudinal Surveys 97 (NLSY97).

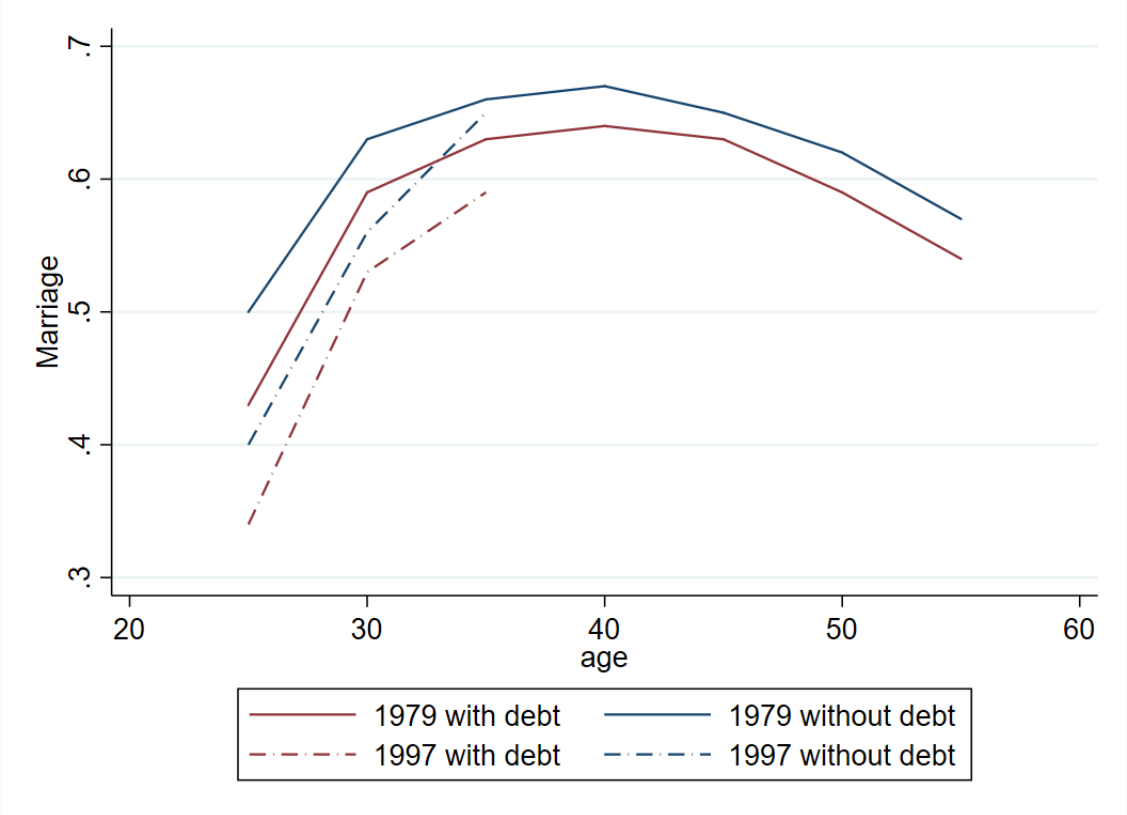
We then present the homeownership and marriage patterns for the two college cohorts by student loan status. Figure 10 documents the homeownership patterns for the NLSY79 and NLSY97 college cohorts. The homeownership rate is measured by the share of college graduates that own a home in age groups 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, and 55-59. Due to data limitations, the statistics for NLSY97 are only available until age 35. Compared to NLSY79, the NLSY97 college cohort has a lower homeownership rate at each age groups for both individuals with and without student loans. However, individuals with student loans experience a large decline in homeownership (13%) than those without student loans (11%) between the two cohorts. Figure 12 documents the marriage patterns for the two college cohorts. The younger cohort has a lower marriage rate at each age bin for both college graduates with and without student loans. The decrease in marriage rates for those with

Figure 10: Homeownership Rate



Note: The homeownership rate for NLSY79 is calculated for individuals aged 25-60. Homeownership rate from NLSY97 is only collected for individuals at age 20, 25, 30, and 35 due to data availability.Sources: National Longitudinal Surveys 79 (NLSY79) and National Longitudinal Surveys 97 (NLSY97).

Figure 11: Marriage Rate



Note: The marriage rate for NLSY79 is calculated for individuals aged 25-60. Marriage rate for NLSY97 is calculated for individuals aged 25-35 due to data availability. Data is drawn from the National Longitudinal Surveys 79 (NLSY79) and National Longitudinal Surveys 97 (NLSY97).

student loans and those without student loans are similar (12% vs 11%). To sum up, the stylized facts show that the younger college cohort has a much higher student loan in terms of both share with debt and average debt amount. Moreover, the younger cohort has a much lower homeownership and marriage rates compared to the older cohort. College graduates with student loans experience a higher decrease in homeownership rates between the two cohorts.

3.3 A Model Demonstrating Household Decisions

The effect of student loans on family formation is ambiguous due to the composition of opposing channels. On the one hand, people with student loans are constrained and less attractive in the marriage market, thus decreases the marriage rate. On the other hand, people with student loans would like to marry because marriage can insure them against income shocks while constrained by student loans, thus promotes the marriage rate.

The effect of student loans on homeownership is negative due to the wealth and price effects. Homeownership requires a substantial amount of assets for the downpayment. However, student loan payments decrease household asset accumulation, which will depress homeownership through a wealth effect. Moreover, people with student loans are facing higher mortgage prices, which increases the cost of homeownership and discourages homeownership through a price effect. In addition to student loans, other economic factors such as housing prices, wage offers, and downpayment rates could also affect family formation and homeownership decisions in nontrivial ways.

To motivate household behavior, we build a lifecycle model focusing on college graduates to highlight the mechanisms through which student loans and other economic factors could affect household decisions on marriage and homeownership. College graduates work in periods $j \in \{1, 2, ..., J\}$ and retire after period J. Each period in the model corresponds to 5 years in real life. The initial period in the model corresponds to age 25 for the college graduates, when they have left school with a certain level of student debt. College graduates obtain utility from both goods and housing consumption, where housing consumption comes

from renting or owning. Compared to renting, owning a house is beneficial because it yields a higher utility flow and housing can be used as collateral for borrowing, i.e., mortgages. Mortgages are long-term and amortized over the rest of borrowers' lives. Mortgages are defaultable but default will lead to foreclosure, which entails a utility cost for the household. Owning a house also exposes households to capital gains and losses from fluctuations in house prices.

At the beginning of each period, men (M) and women (W) know their labor productivities. Women learn whether they have a child, as a function of their marital status and age. We assume that college men always work but college women may not work due to disutility of working. With a certain probability, single agents (S) may meet a partner, which is randomly drawn from the same age group of the remaining singles. Given their states and initial match quality shock, single people and their potential partners decide whether to get married. Married couples (M) observe the realization of a love shock to marriage at the beginning of each period and decide whether to stay married or get divorced. In addition to marriage, all types of households make decisions on homeownership (determines housing consumption), saving in non-housing assets, female labor supply, and goods consumption in each period.

3.3.1 Preference

The utility of a single (S) agent i of gender $g \in \{W, M\}$ in period t is denoted by

$$u_{it}^{Sg}(c, l, N, B) = \frac{(c_{it}^{\alpha} hc_{it}^{1-\alpha})^{1-\sigma}}{1-\sigma} - \phi^{Sg}(N) l_{it} - \chi D_{it}$$

where $c_{it} > 0$ is goods consumption and $hc_{it} > 0$ is housing consumption, which is defined as

$$hc = \begin{cases} h, & if\ renting \\ \omega h, & if\ owning \end{cases} \tag{8}$$

where $h \in [h_{min}, ..., h_{max}]$ is the housing size (or quality). If renting a house, housing consumption is the same as the housing size, h. If owning a house, housing consumption is ωh, where $\omega > 1$ captures the extra utility of being homeowners. In addition, the term $l_{it} \in \{0, 1\}$ stands for female labor supply decision; the term $\phi^{Sg}(N)$ is the disutility from

working, which is gender and children (N) specific. Note that men always work so the disutility of working only applies to women. Households also incur a utility cost χ if they default on mortgages $D_{it} = 1$.

The utility of married (M) men and women is given by

$$u_{it}^{Mg} = \frac{((\gamma_e c_{it})^{\alpha}(\gamma_e hc_{it})^{1-\alpha})^{1-\sigma}}{1-\sigma} - \phi^{Mg}(N) l_{it}^{Mg} - \chi D_{it} + Q_{it}$$

where $c_{it} > 0$ and $hc_{it} > 0$ are joint goods and housing consumption. The parameter $\gamma_e \in (0.5, 1)$ captures the economy of scale within a household. The utility of married men and women depends on working (or leisure) $\phi^{Mg}(N) l_{it}^{Mg}$, default on mortgages χD_{it}, and the match quality Q_{it}. Children affect a man only if he is married to a woman.

3.3.2 Risk

Households may experience labor productivity shocks that affect their earnings, match quality shocks that affect marriage dynamics, fertility shocks that determine the number of children, and aggregate as well idiosyncratic shocks that affect housing values.

Earnings The earnings processes for men and women $g \in \{W, M\}$ are specified as

$$log w_{it}^{g} = \beta_0^g + \beta_1^g j + \beta_2^g j^2 + z_{it}^g + \epsilon_{it}^g$$

$$z_{it}^g = z_{it-1}^g + \zeta_{it}^g, \quad \zeta_{it}^g \sim N(0, \sigma_{\zeta^g}^2)$$

where z_{it}^g is the permanent income component that evolves as a random walk following innovation ζ_{it}^g; the term ϵ_{it}^g is the measurement error, which is i.i.d and normally distributed as $N(0, \sigma_{\epsilon^g}^2)$. Since some women do not work, we will take into account endogenous selection into employment when estimating the wage profile for them.

Marriage and fertility In each period, a single agent meets with a potential spouse (of the same age) with probability λ_j, who is characterized by certain labor productivity, student loans, assets, and housing. The probability λ_j varies by age as the marriage pattern is age-dependent. The potential couple then draws an initial match quality $Q_0 \sim N(0, \sigma_{Q0}^2)$. If they decide to marry, their match quality evolves as

$$Q_{it} = Q_{it-1} + \xi_Q$$

where $\xi_Q \sim N(0, \sigma_Q^2)$.

The probability of having children depends on women's marital status (M_{it}) and age (j). In particular, The probability of having a child is given by

$$Pr(N_{it} = 1 | N_{it-1} = 0; M_{it}, j)$$

Since the probability depends on marriage, fertility is partially endogenized through marital decisions. For simplicity, we assume each woman can only have one child.

Housing and mortgages We model the aggregate house price similar to Corbae and Quintin (2015). The aggregate house price is $P_t^H = P^H \times z_t$, where z_t is a three-point process $[0.7, 1, 1.3]$, with a Markov transition matrix

$$\begin{bmatrix} 0.75 & 0.25 & 0 \\ 0.045 & 0.91 & 0.045 \\ 0 & 0.625 & 0.375 \end{bmatrix}$$

Homeowners also experience an idiosyncratic house price shock, δ, in addition to the aggregate house price P^H. We assume that δ is uniformly distributed on $[\underline{\delta}, \overline{\delta}]$, where $\underline{\delta} < 0$ and $\overline{\delta} > 0$, implying the price shock covers both depreciation and appreciation. The idiosyncratic shock process is independent of aggregate shocks and obeys a law of large numbers. One possible interpretation of idiosyncratic shocks is "neighborhood effects", which alter the market value of the house independent of aggregate housing price changes (Corbae and Quintin, 2015). Rental rate P^R is a function of housing price, determined by a price-to-rent ratio from the Census data.[1]

Households can purchase homes by borrowing mortgages (m). All mortgages are long-term and amortized over the remaining life at an interest $r^m(.)$ that depends on the agent's age and student loan status. At the time of origination, the initial mortgage balance m must be less than a fraction η of the collateral value of the house being purchased:

[1] U.S. Census Bureau: Housing Vacancies and Homeownership (CPS/HVS) between years 1994 and 2015. https://www.census.gov/housing/hvs/data/reports.html

$$m \leq \eta P^H h$$

The per period mortgage payment is determined by the constant amortization formula

$$\pi_j(m) = \frac{r_m(1+r_m)^{J-j}}{(1+r_m)^{J-j}-1}m$$

Thus, the mortgage evolves according to

$$m' = m(1+r_m) - \pi$$

Mortgages are defaultable. Once households default on mortgages, foreclosure starts. Households suffer from a utility loss χ from foreclosure and are excluded from buying a house in that period.

3.3.3 Household Decisions

3.3.3.1 Single Household

At the beginning of each age of j, all shocks are realized and college graduates decide whether to marry (or divorce). Conditional on marriage, households then make a decision on labor supply, saving, goods, and housing consumption.

If not default on mortgages, a single household's budget constraint is:

$$c + a' + P^R h 1_{rent} = wl + a - \Phi(h', h)$$

where $a' = b' + [P^{H'}(1-\delta)h' - m']1_{own} - d'$ is total asset for next period, including saving b', housing asset $[P^{H'}(1-\delta)h' - m']$ if the household is a homeowner ($1_{own} = 1$), and student loans d'. The term $P^R h$ is rent if the household is a renter ($1_{rent} = 1$). Renters and homeowners are mutually exclusive. The term wl is labor income and $a = (1+r_b)b + [P^H(1-\delta)h - (1+r_m)m]1_{own} - (1+r_d)d$ is the current period total assets, in which r_b is the saving interest rate and r_d is the student loan interest rate. The term $\Phi(h', h)$ represents costs for housing transition, which is defined as Yang (2009):

$$\Phi(h,h') = \begin{cases} \kappa_b P^{H'} h' + \kappa_s P^H h, \ if \ h \neq h' \\ 0, \ if \ h = h' \end{cases}$$

The law of motion for student loan is given by:

$$d' = d(1 + r_d) - d_{pay}$$

where d_{pay} is the payment per period. Assuming student loan is paid off in 10 years (by age 35), the per period payment is defined as

$$d_{pay} = \frac{r_d(1+r_d)^{35-j}}{(1+r_d)^{35-j} - 1} d$$

If defaulting on mortgages, the foreclosure starts and the budget constraint is:

$$c + b' - d' = wl + (1 + r_b)b - (1 + r_d)d$$

The state vector for a single household is $\Omega_{it} = [j, P^H, z_{it}, h_{it}, d_{it}, m_{it}, b_{it}, N_{it}, Q_{it}]$, which is composed of age, aggregate housing prices, labor productivity, housing, student loans, mortgages, non-housing assets, children and love shocks. With probability λ_j, at the beginning of each period a single woman (man) meets a man (woman) with characteristics $[\widetilde{z_{it}}, \widetilde{h_{it}}, \widetilde{d_{it}}, \widetilde{m_{it}}, \widetilde{b_{it}}]$. The potential couple then draws an initial match quality Q_{i0}. If a match is formed, then $M_{it} = 1$; otherwise $M_{it} = 0$.

Let $V_{it}^{SW}(\Omega_{it}^{Sg})$ denote the value function for a single agent at time t and $V_{it}^{Mg}(\Omega_{it}^{Mg})$ denote the value function for a married agent at time t. A single agent maximizes the following value function s.t. the budget constraint.

$$V_{it}^{Sg}(\Omega_{it}^{Sg}) = \max_{\{c,h',b',m',l,D\}} u_{it}^{Sg}(c,s,l,N,D) + \beta$$

$$\mathrm{E}[\lambda_{t+1}[(1 - M_{i,t+1})V_{it+1}^{Sg}(\Omega_{it+1}^{Sg}) + M_{i,t+1}V_{it+1}^{Mg}(\Omega_{it+1}^{Mg})] + (1 - \lambda_{t+1})V_{it+1}^{Sg}(\Omega_{it+1}^{Sg})]$$

3.3.3.2 Married Couple

When a man and a woman get married, their assets are merged and labor income is pooled so that they solve a joint maximization problem. Each partner has equal weight (0.5) in the joint household value. The household will jointly decide on goods consumption, housing, savings, and female labor supplies.

The joint budget constraint of a married couple is:

$$\begin{cases} c + a' + P^R h_1 1_{rent} = w^F l^F + w^M + a - \Phi(h', h), \ if \ not \ default \\ c + b' - d' = w^F l^F + w^M + (1 + r_b)b - (1 + r_d)d, \ if \ default \end{cases}$$

Let $V_{it}^M(\Omega_{it}^M)$ denote the joint value function of a married couple. A household aims to maximize the following joint value function s.t the joint household budget constraint.

$$V_{it}^M(\Omega_{it}^M) = \max_{\{c,h',d',l,B\}} 0.5(u_{it}^{MM}(c,s,l,B) + u_{it}^{FM}(c,s,l,B)) +$$

$$\beta E[(1 - d_{i,t+1})V_{it+1}^M(\Omega_{it+1}^M) + d_{i,t+1}(0.5V_{it+1}^{SM}(\Omega_{it+1}^{SM}) + 0.5V_{it+1}^{SW}(\Omega_{it+1}^{SW})]$$

where $d_{i,t+1}$ is the divorce decision at the beginning of next period.

Men and women will get married or remain married if and only if the value of being married is no less than the value of being single, i.e.,

$$V_{it}^{MW}(\Omega_{it}^M) \geq V_{it}^{SW}(\Omega_{it}^{SW})$$

$$V_{it}^{MM}(\Omega_{it}^M) \geq V_{it}^{SM}(\Omega_{it}^{SM})$$

3.4 Estimation

Estimation of the model is based on the NLSY79 cohort of individuals that have obtained Associate/Junior College (AA) degrees or above. We estimate the model parameters in three steps. First, we calibrate some parameters outside the model. Second, we estimate earning parameters, fertility process, and the distribution of potential spouses directly from the data without the model structure. Third, we estimate the remaining parameters by solving the model. The internally estimated parameters include parameters associated with homeownership and labor supply decisions ($\omega, \phi^{SW}, \phi_0^{MW}, \phi_1^{MW}$), along with parameters governing marriage dynamics ($\sigma_{Q0}^2, \sigma_Q^2, \lambda_y, \lambda_m, \lambda_o$). We apply the Method of Simulated Moments (MSM) to minimize the difference between simulated moments and data moments, weighted by the variance-covariance matrix of the data moments.

3.4.1 Initial Conditions

Before we present the estimates in detail, We first specify the initial conditions of the model. The model considers college graduates' decisions starting at age 25. Before age 25, 30% of men and women have been married and 20% of women have been given birth to children. Around 7% of the sample owns a house. Therefore, the proportions of men and women being married and the proportion of women who have a child before age 25 are set to match the data. Since the proportion of the sample owning a house is small. We set the initial proportion of men and women owning a house to zero.

3.4.2 Externally Calibrated Parameters

The value and reference of the externally calibrated parameters are reported in Table 26. Agents have a constant risk aversion coefficient of $\gamma = 1.5$. The annual discount factor is $\beta = 0.98$, which transforms into a 5-year discount factor as $\beta = 0.9$. Following Kaplan et al. (2017), the share of goods and housing consumption in the utility function is $\alpha = 0.8$ and $1-\alpha = 0.2$. Following Eckstein et al. (2019), the economy of scale is set to be 0.7, so a couple needs 40% more expenditure than a single person to obtain an equivalent consumption level.

Table 17: Calibrated Parameters

Parameters	Value	Source
σ (risk aversion)	1.5	Attanasio et al. (2008)
β (discounting rate)	0.98	Attanasio et al. (2008)
α (share of c in utility)	0.8	Kaplan et al. (2017)
γ_e (economic of scale)	0.7	Eckstein et al. (2019)
r_d (student loan interest rate)	6%	Stafford student loan interest rate
η (downpayment)	20%	Freddie Mac LTV for prime mortgages
$(\underline{\delta}, \overline{\delta})$ (price shocks)	(-0.25, 0.15)	Chang et al. (2019)
(κ_b, κ_s) (transition cost)	(0.025, 0.07)	Yang (2009)
(h_1, h_2) (housing size)	(2,3)	Zillow
r_b (saving interest rate)	0.03	Federal Reserve interest rate

Student loan interest rate is set as the average of the historical Stafford student loan interest rate between 1992 and 2006, which is 6%.[2] The downpayment constraint is 20%, as indicated by the Freddie Mac Loan to Value ratio for prime mortgages. The bounds for idiosyncratic housing price shocks are drawn from Chang et al. (2019). For transaction costs of housing, I follow Yang (2009) to set 2.5% of home value for buying and 7% of home value for selling. The housing size is calibrated from Zillow and the risk-free saving interest rate is 3%.

3.4.3 Externally Estimated Parameters

When estimating females' wage profile, selection into employment is a concern because wages are not observed for women who do not work and decisions to work depend on wage offers. We apply a two-step Heckman selection correction procedure to account for the selection problem. In particular, we follow Voena (2015) to exploit variation in divorce laws across states and over time as instruments that affect women's decision to work but that are otherwise excluded from the wage equation. Since We also control for time and state fixed effect, the instruments capture differential changes in policy over time and states. The identification assumption is that the divorce laws affect women's wages only through their impact on employment. The first stage showing the effect of divorce laws on employment

[2]https://www.savingforcollege.com/article/historical-federal-student-interest-rates-and-fees

for women is in Table 39.

We then apply a variance-covariance decomposition framework with selection correction to estimate the variance of productivity shock and variance of measurement error. Since men always work, the selection correction only applies to women. We report wage parameters in Table 28. The variances of permanent income shocks for males and females are 0.09 and 0.075. The variances of measurement errors for both men and women are 0.05.

Table 18: Parameters Estimated Outside The Model

Parameters	Description	Value
Men		
β_{0M}	Constant in earnings profile	8.17
β_{1M}	Coefficient for age	0.121
β_{2M}	Coefficient for age square	-0.001
$\sigma^2_{\zeta_M}$	Variance of productivity shock	0.03
$\sigma^2_{\epsilon_M}$	Variance of measurement error	0.14
Women		
β_{0F}	Constant in earnings profile	8.96
β_{1F}	Coefficient for age	0.069
β_{2F}	Coefficient for age square	-0.0007
$\sigma^2_{\zeta_F}$	Variance of productivity shock	0.02
$\sigma^2_{\epsilon_F}$	Variance of measurement error	0.12

We compute the Markov process for fertility by examining transition probabilities as a function of a woman's age and marital status using NLSY79 data. The estimated transition probabilities are presented in Figure 25. The distribution of characteristics of single men and women comes from the age-dependent distribution of characteristics for singles in the data. College graduates will form expectations about the marriage matches they may be involved in based on the distribution of remaining singles.

3.4.4 Internally Estimated Parameters

We estimate the remaining parameters using Method of Simulated Moments (MSM) (McFadden, 1989). We choose the parameters to minimize the distance between the data

moments and the simulated moments generated from the model.

$$min_{\{\Theta\}}(\phi_{data} - \phi_{sim})'W(\hat{\phi}_{data} - \phi_{sim})$$

The vector Θ contains the remaining unknown parameters: the extra utility from being homeowners (ω); the variance of initial match quality (σ^2_{Q0}) and the variance of shocks to existing marriage (σ^2_Q); the probability of meeting someone at young, middle, and old age (p_1, p_2, p_3); the disutility from working for single women (ϕ^{SW}), for married women without children (ϕ_0^{MW}) and married women with children (ϕ_1^{MW}), as well as the utility cost for default.

Empirical moments ϕ_{data} are calculated from the NLSY79 college cohort between age 25 to 60. I group the sample into 5-year bin age groups, which are 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, and 55-59. I consider marital status, fertility, homeownership, and employment in the corresponding age bins. Simulated moments ϕ_{sim} are computed using the full numerical solution of the model.

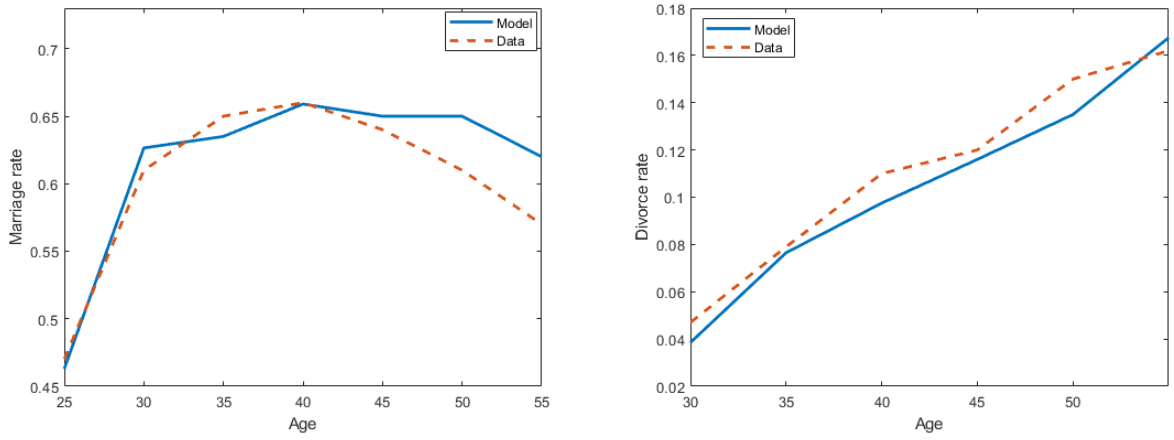
3.4.5 Identification

All the moments are jointly used to estimate all parameters. However, certain moments are particularly important to identify certain parameters. we provide a heuristic argument that how each of the parameters can be identified from a subset of the moments. The first set of moments include conditional moments for labor supply, i.e., fractions of women employed by marital and fertility status. These moments pin down the disutility of work for women. The second set of moments are the average homeownership rate and foreclosure rate, which pin down the extra utility from being homeowners and the cost of default. The third set of moments include marriage rate by age, divorce rate by age, and share of being ever married by age. These moments contribute to pinning down the variance of marriage shocks and the probability of meeting a partner.

Table 19: Model Fit

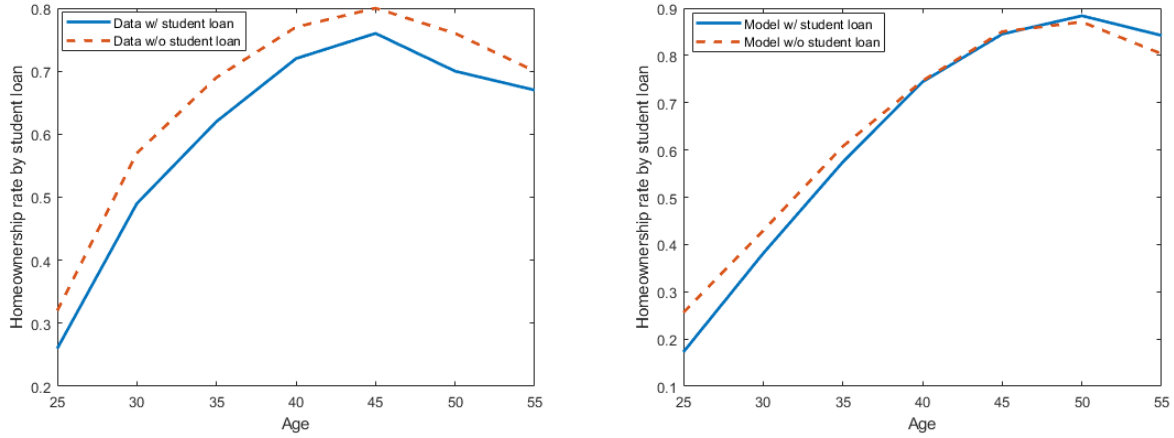
Moments	Data	Model
Homeownership rate	0.63	0.64
Employment for single women	0.81	0.83
Employment for married women w/ children	0.72	0.72
Employment for married women w/o children	0.85	0.85
Default rate	0.005	0.007

Figure 12: Marriage and Divorce By Age



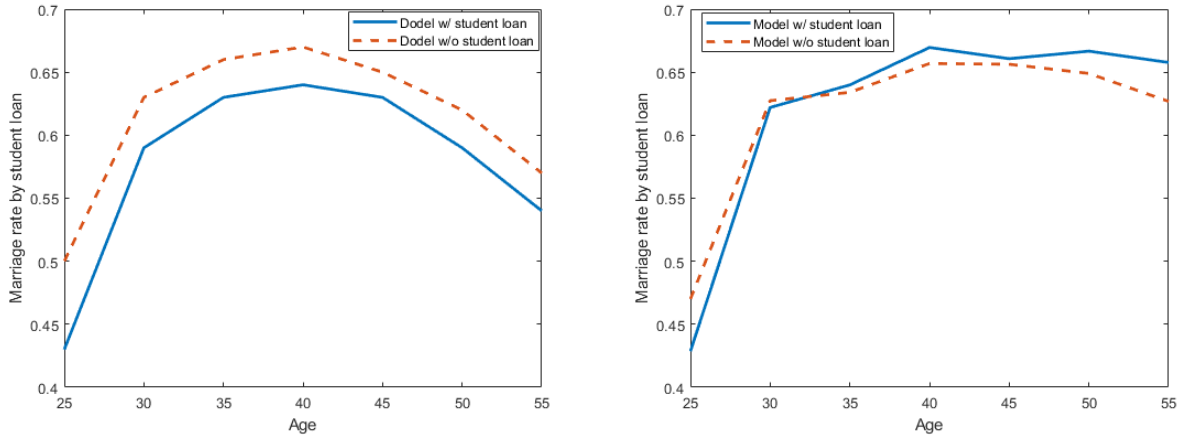
Note: The blue lines are the marriage and divorce rate by age calculated from NLSY79 data. The red lines are the marriage and divorce rate by age simulated from the model.

Figure 13: Homeownership By Student Loans



Note: The blue solid lines are the homeownership rates for graduates with student debt for the model and for the data. The red dotted lines are the homeownership rates for graduates without student debt for the model and for the data.

Figure 14: Marriage By Student Loans



Note: The blue solid lines are the marriage rates for graduates with student debt for the model and for the data. The red dotted lines are the marriage rates for graduates without student debt for the model and for the data.

3.4.6 Model Fit and Estimated Parameters

The model fit for homeownership, employment, and the default rate is shown in Table 19. The model fit for marriage and divorce rate by age is shown in Figure 12.[3] The model can replicate the targeted moments very well. In addition, the model can also reproduce statistics that were not targeted by the estimation procedure. An important set of nontargeted statistics are marriage and homeownership rates conditional on student loan status. Figure 13 and 14 show that the model can replicate the homeownership and marriage rate of the people with and without student loans.

Table 31 reports internally estimated parameters. The parameter governing the extra utility of being homeowners is estimated to be 1.01, implying that homeownership yields a higher utility flow. The variances of shocks to the initial marriage match and shocks to existing marriages are estimated to be 0.01 and 0.016. The probabilities of meeting someone at a young age, (25-35), middle-age (35-45), and old age (45+) are 0.55, 0.16, and 0.07. The disutility of working parameters helps match the employment patterns for single women and married women with or without children. The cost of default is estimated to be 0.01.

Table 20: Parameters Estimated Within The Model

Parameters	Description	Value
ω	extra utility from homeownership	1.01
$\sigma^2_{Q0}, \sigma^2_Q$	variance of marriage shock	0.01, 0.02
p_1, p_2, p_3	probability of meeting someone	0.6, 0.24, 0.1
ϕ_{SW}	disutility of working for single female	0.18
ϕ_{MW0}	disutility of working for married female w/o children	0.08
ϕ_{MW1}	disutility of working for married female w/ children	0.09
χ	cost of default	0.01

[3]The fraction of ever married by age is shown in Figure 19.

3.5 Understanding Changes in Homeownership and Marriage Over Time

The most important use of the model and structural estimates is to quantify the effect of each economic factor on marriage and homeownership changes between the two cohorts. We consider changes in student loans, housing prices, wage volatility, and downpayment. The goal of this section is to first quantify the explanatory power of each channel while controlling for other changes that affect marriage and housing decisions. We then examine the impact of the combination of changing the entire economic factors on marriage and homeownership.

21 presents the homeownership and marriage rates for NLSY 79 and NLSY 97 cohorts between age 25-35. Consistent with earlier stylized facts, both homeownership and marriage rates are much lower for the younger cohort. In particular, the homeownership rate for the younger cohort is 7 percentage points lower or 17% lower relative to that for the older cohort. The marriage rate is 5 percentage points or 9% lower when comparing the younger cohort to the older cohort.

Table 21: Difference Between NLSY79 And NLSY97

Moments (age 25-35)	NLSY 79	NLSY97	Difference (%)
Homeownership rate	0.49	0.42	17%
Marriage rate	0.57	0.52	9%

3.5.1 Student Loans

Wealth effect Student loans significantly affect marriage and homeownership. The fraction of college graduates with student debt and the average amount of debt starts to rocket after 2000. This is mostly due to the tuition and costs associated with the college is increasing (Lucca et al., 2018). The younger cohort thus has a much higher share and amount of student loans than the older cohort (Table 16), which will affect marriage and homeownership through an income effect.

Price effect The two college cohorts also face very different mortgage interest rates. Figure 15 shows the nominal and inflation-adjusted mortgage interest rates in the past

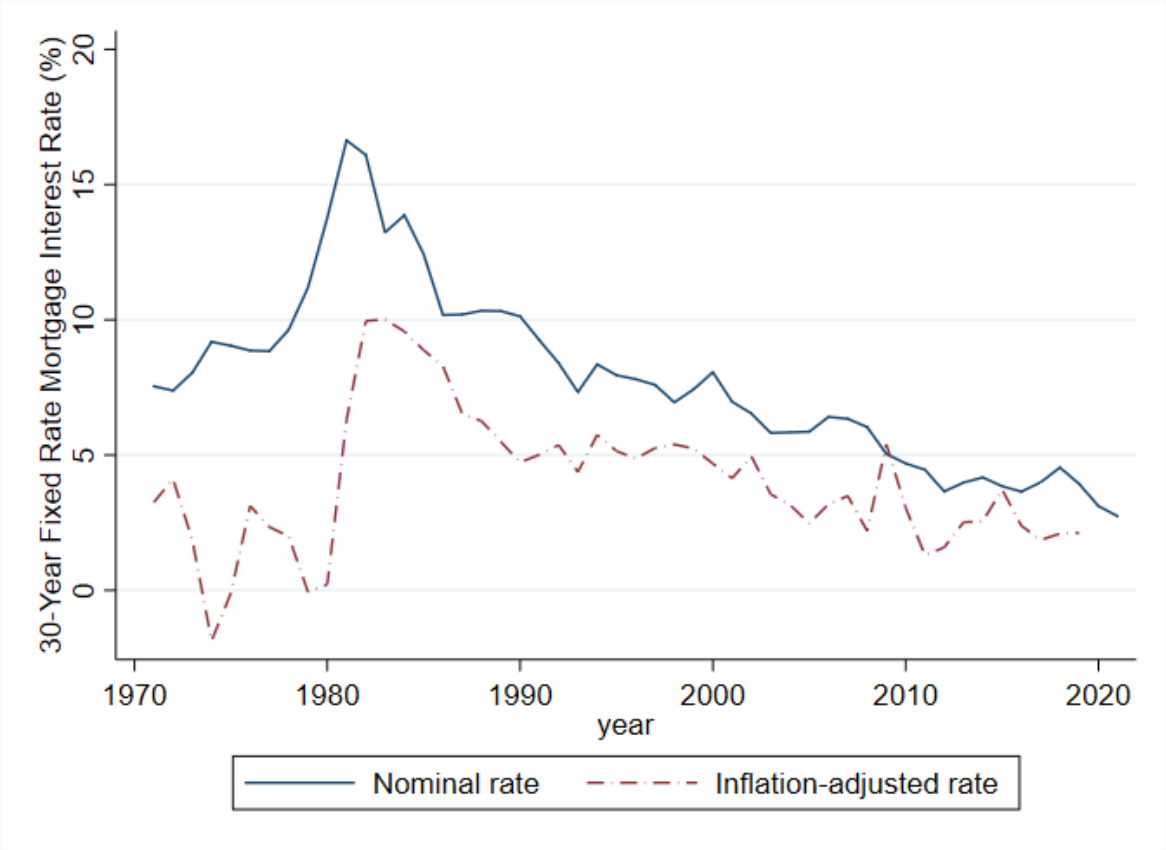
50 years. Starting with a low level in the 1970s, the mortgage interest rate reaches the historically high level in the 1980s and then steadily goes down over time. The older college cohort mostly buys their houses in the late 1980s and early 1990s and the younger cohort starts buying homes after the year 2010. Thus, giving all else being equal, the younger cohort faces a lower average mortgage interest, which will promote homeownership of the younger cohort relative to the older cohort.

However, it is important to mention that college graduates with student loans may have relatively lower credit scores and thereby facing a higher mortgage interest rate. More importantly, college graduates who default on student loans will subject to a larger penalty on credit scores and subsequently impact their mortgage interest rates. Since the younger cohort has much higher student loans and default rates on student loans, they may subject to a higher mortgage interest rate than the older cohort. The impact of student loans and default rates on mortgage interests is an empirical question. In Appendix X [notes from Stefania], we apply the credit file data from the Experian credit bureau to empirically estimate the impact of student loans, default risks, and age on credit scores and the mapping the credit scores into the mortgage interest rates.

Based on the empirical estimates, Table 22 reports the mortgage interest rate for the younger cohort and older cohort by student loan status.

The age of first-time homebuyers is between 30-35 for both younger and older cohorts. Older cohort college graduates tend to buy their first homes between the years 1990-1995 and younger cohort college graduates tend to buy their first homes between years 2010-2015. We calculate the average of real mortgage interest rates in the prime and sub-prime categories between years 1990-1995 for the older cohort and years 2010-2015 for the younger cohort. The NLSY79 college cohort with student loans has a mortgage interest of 0.055 throughout their lives, which is the sub-prime mortgage interest rate. The NLSY79 college cohort without student loans has sub-prime mortgage interest of 0.055 before age 40 and a prime mortgage interest rate of 0.052 after age 40. The decrease in mortgage interest rate is a result of the increase in credit scores as people become older. In contrast, the NLSY97 college cohort is not allowed to borrow mortgages before age 30 because of more student loans and higher student loan default risk. Though not everyone with a student loan

Figure 15: 30-Year Fixed Rate Mortgage Interest Rates (%)



Note: Freddie Mac 30-Year fixed rate mortgage interest rate (1970-2020).

Table 22: Mortgage Interest Rates

Age	NLSY 1979		NLSY 1997	
	w/ student loans	w/o student loans	w/ student loans	w/o student loans
25-29	0.055	0.055	N.A.	0.031
30-34	0.055	0.055	0.031	0.031
35-39	0.055	0.055	0.031	0.031
40-44	0.055	0.052	0.031	0.029
45-49	0.055	0.052	0.031	0.029
50-54	0.055	0.052	0.031	0.029
55-59	0.055	0.052	0.031	0.029

defaults on it, the default penalty on student loans tends to apply to every college graduate with student loans, which render them impossible to borrow a mortgage at an early age. As college graduates paying off their student loans after age 30, they are allowed to borrow mortgages and have mortgage interest of 0.031 throughout the rest of their lives, which is the sub-prime mortgage interest rate for the younger cohort. The NLSY97 college cohort without student loans has sub-prime mortgage interest of 0.031 before age 40 and a prime mortgage interest rate of 0.029 after age 40. The decrease in mortgage interest rate is a result of the increase in credit scores as people become older.

We report the effect of student debt on homeownership and marriage difference between the two cohorts in Figure 16 and Figure 17. Student debt can account for 33% of the homeownership difference and 17% of marriage difference between the two cohorts. Within the effect on homeownership, wealth effect accounts for 33% of the homeownership difference, while price effect does not account for much of the difference.

3.5.2 Housing Prices

The level of housing prices is important for understanding the changes in homeownership. Older cohort college graduates tend to buy their first homes between the years 1990-1995 and younger cohort college graduates tend to buy their first homes between years 2010-2015. Real house prices were higher in the 2010 decade compared to the 1990 decade. According to the Case Shiller Home Price, real housing price is 13% higher in the period 2010-2015 compared to period 1990-1995. The impact of rising housing prices on homeownership is ambiguous as rental prices are also rising along with housing prices. Thus, the costs for both renting and buying a house increase. The effect of price increase on homeownership will thus depend on household preferences for homeownership, household budgets, and the price-to-rent ratio.

3.5.3 Mean Wage and Wage Volatility

The increase in labor market volatility over time is widely documented in previous literature (Moffitt and Zhang, 2018; Santos and Weiss, 2016). College graduates are not an

exception. Table 28 shows that the mean earnings of college men for the younger cohort are similar to that for the older cohort. The mean earnings of college women for the younger cohort are higher than that for the older cohort. However, compared to the older cohort, the younger cohort has a larger standard deviation of earnings for both men and women, implying a higher income risk for the younger cohort.

Table 23: Mean And SD Of Wage

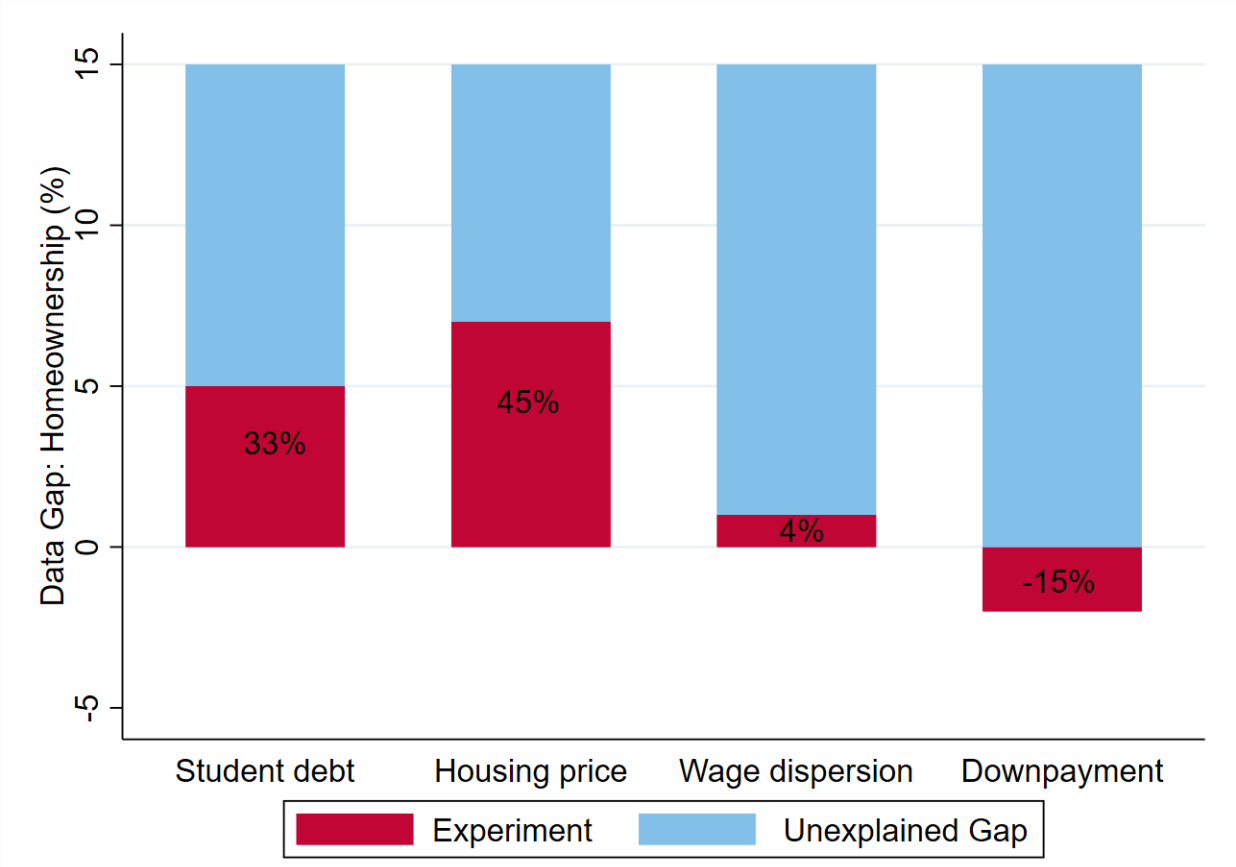
Age 25-35	Men		Women	
	Mean	SD	Mean	SD
NLSY79	52,398	29,919	38,249	21,242
NLSY97	51,357	33,567	41,998	25,092

The effect of increasing income volatility on homeownership is two folds. On the one hand, rising income risk cause households to delay homeownership. This is because higher-income risk will slow household asset accumulation and affect their ability to maintain long-term mortgage payments. On the other hand, an increase in income risk could also promote household precautionary saving. Ceteris paribus, higher wealth due to precautionary saving will increase homeownership.

3.5.4 Downpayment

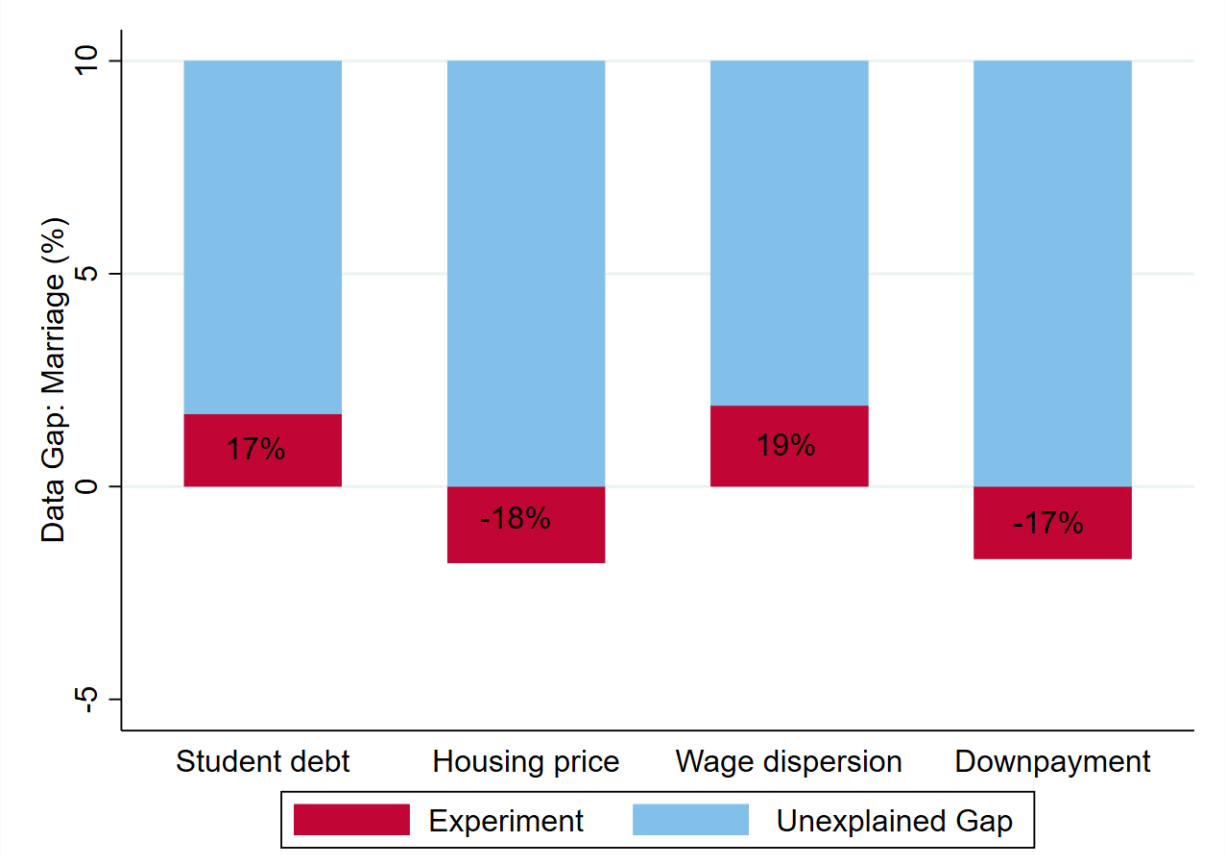
The downpayment constraint is one of the major constraints for households to buy a house. The downpayment constraint for the older cohort is 20%. If the average inflation-adjusted home price in the 1990s is $180,000 (The National Association of Realtors, The Federal Housing Finance Agency, Robert Shiller, and the U.S. Bureau of Labor Statistics), then the average downpayment for a homeowner is $36,000, which is the average annual wage of a college graduate at ages 27. With a looser downpayment constraint, households can buy a house with fewer assets. Data from the American Housing Survey (AHS) shows that the average downpayment after 2009 is 0.15, 25% lower than the downpayment applied to the older cohort. With a downpayment rate at 15% and all else being equal, the average downpayment for a home purchase is $27,000.

Figure 16: Role of Student Debt, Housing Price, and Wage Dispersion



Note: The overall gap between the two cohorts are based on the calculation from NLSY 79 and NLSY97.

Figure 17: Role of Student Debt, Housing Price, and Wage Dispersion



Note: The overall gap between the two cohorts are based on the calculation from NLSY 79 and NLSY97.

We report the effect of housing price, wage dispersion, and downpayment rates on homeownership and marriage difference between the two cohorts in Figure 16 and Figure 17. Among all of them, housing price and wage dispersion can account for 45% and 4% of the homeownership difference across the two college cohorts. In addition, wage dispersion can explain 19% of the marriage difference between the two cohorts. The downpayment rate, however, enlarges the gap of marriage and homeownership rates between the two cohorts.

3.5.5 Combining All the Economic Factors

We finally examine the combined effects of all the channels explored individually above. The combined channels may have a different impact than each individual channel because of offsetting interactions. The results from this combined experiment are shown in Table 24. The combined factors can explain 53% of the homeownership decline and 22% of the marriage rate decline between the two cohorts.

Table 24: Difference Between NLSY79 And NLSY97

Moments (age 25-35)	Difference (%)	Combined channels	Explanatory share
Homeownership rate	17%	9%	53%
Marriage rate	9%	2%	22%

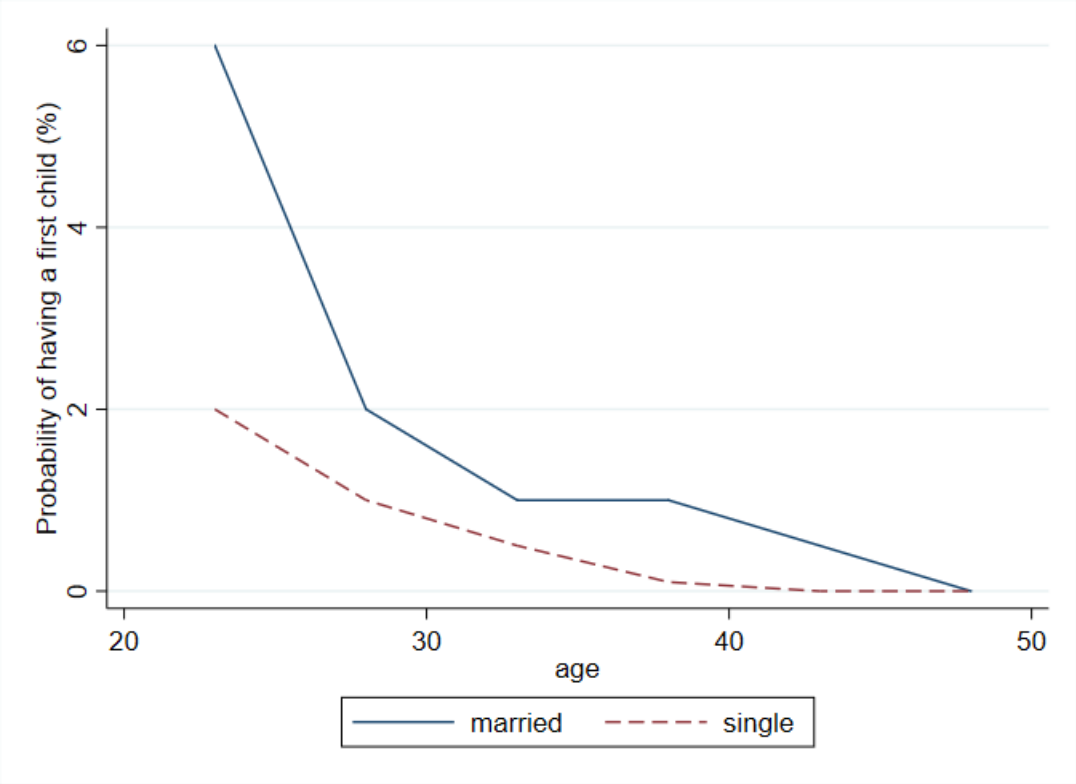
3.6 Conclusion

This paper first documents the increase in student debt and decline in homeownership and marriage rates for college graduates over time. We then study the effect of student debt on marriage and homeownership among college graduates. Using NLSY 79 and NLSY 97 data, we develop and estimate a lifecycle model to quantify the role of student debt in college graduates' marriage and homeownership patterns. We find that the increase in student debt over time can account for 46% of the difference in homeownership rates and 17% of the difference in marriage rates between NLSY 79 and NLSY 97 college cohorts. Student debt

negatively affect home purchase by reducing household asset accumulation (wealth effect) and by increasing the mortgage prices (price effect), where the wealth and price effects can each account for 30% and 16% of the homeownership difference, respectively. Beyond student debt, we also examine the role of housing prices, wage dispersion, and downpayment rates in accounting for the difference in homeownership and marriage rates. We find that housing price increase over time can account for 17% of the overall homeownership difference, and wage dispersion can explain 30% of the homeownership decline and 18% of the marriage decline when comparing the two cohorts.

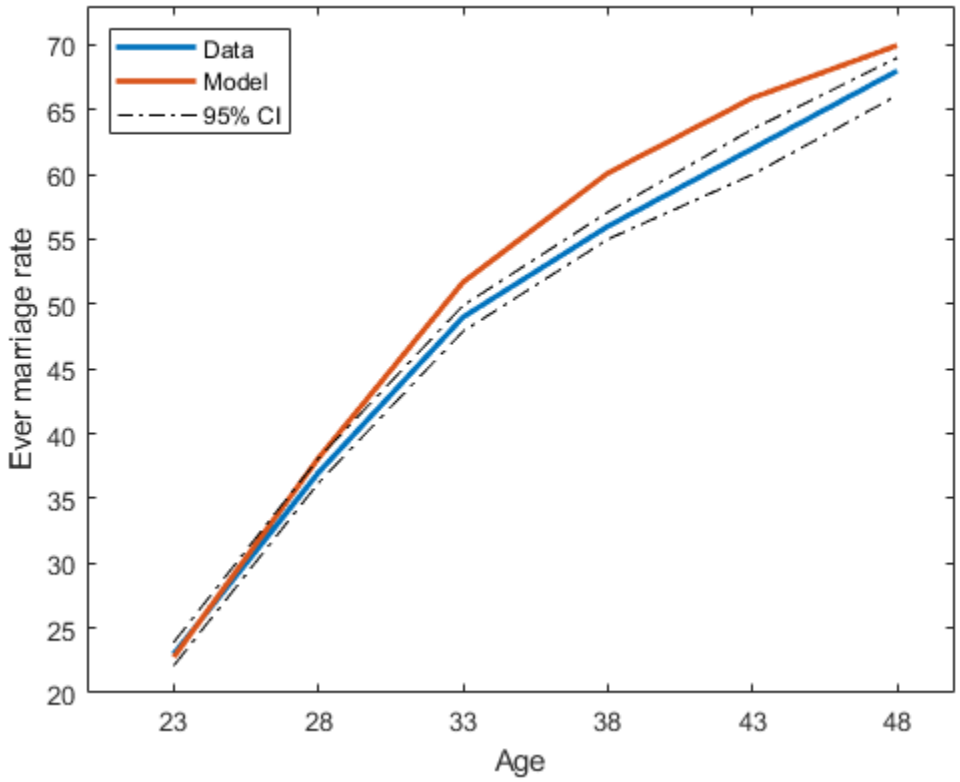
Appendix A First Chapter

Figure 18: Probability of Having the First Child by Woman's Age and Marital Status



Note: Data is drawn from the SIPP 1996, 2001, 2004, 2008 and 2014 panels.

Figure 19: Fraction Ever Married by Age (Percentage)



Note: The blue line is the share ever married by age calculated from the SIPP data. The red line is the share ever married by age simulated from the model. The dotted lines are the 95% confidence internal of fraction ever married.

Table 25: The Effect of Housing Vouchers: OLS Estimates

Variables	(1) Employed	(2) Homeowner	(3) Married	(4) Divorced
Housing Vouchers	-0.123***	-0.294***	-0.225***	0.043***
	(0.013)	(0.017)	(0.013)	(0.013)
Individual fixed effect	No	No	No	No
Mean of Dep. Var	0.46	0.33	0.39	0.19
Observations	146,480	146,480	146,480	146,480

Note: Data is drawn from the SIPP (1996, 2001, 2004, 2008 and 2014 Panel). All estimates control for gender, race, disability, age, education fixed effect, state fixed effect, year fixed effect and state specific time trend. Eligibility is inferred from state median income and metro status. Standard errors are clustered at state level. *** p¡0.01, ** p¡0.05, * p¡0.1

Table 26: Calibrated Parameters

Parameter	Description	Value	Source
σ	risk aversion	1.5	Attanasio et al. (2008)
β	discounting factor	0.98	Attanasio et al. (2008)
α	share of c in utility	0.8	Kaplan et al. (2017)
γ_e	economy of scale	0.7	Eckstein et al. (2019)
η	downpayment	20%	Freddie Mac LTV
(κ_b, κ_s)	transition cost	(0.025,0.07)	Yang (2009)
(r^L, r^H)	interest rate	(0.02,0.07)	Net interest margin of banks (FRED)

Table 27: The Effect of Welfare Benefits on Employment for Men and Women

Variables	Men Employment	Women Employment
Simulated Food Stamp Benefits ($100)	0.002	-0.023***
	(0.009)	(0.005)
Simulated TANF Benefits ($100)		-0.007
		(0.007)
Simulated EITC Benefits ($100)	0.098***	0.04***
	(0.021)	(0.013)
Simulated UI Benefits ($100)	0.107***	0.015
	(0.032)	(0.029)
F-statistics	52.41	16.35
Controls	Yes	Yes
Observations	52,650	93,830

Note: Data is drawn from the SIPP (1996, 2001, 2004, 2008 and 2014 Panel). All estimates control for age, state, and year fixed effect. Standard errors are clustered at state level. *** p¡0.01, ** p¡0.05, * p¡0.1

Table 28: Parameters Estimated Outside the Model

Parameters	Description	Value	SE
β_{0M}	life cycle profile of male earnings	8.73	2.13
β_{1M}	life cycle profile of male earnings	0.048	0.02
β_{2M}	life cycle profile of male earnings	-0.001	0
$\sigma^2_{\zeta^M}$	variance of male productivity shock	0.09	0.01
$\sigma^2_{\epsilon^M}$	variance of male measurement error	0.11	0.02
β_{0F}	life cycle profile of female earnings	8.66	2.11
β_{1F}	life cycle profile of female earnings	0.04	0.02
β_{2F}	life cycle profile of female earnings	-0.001	0
$\sigma^2_{\zeta^F}$	variance of female productivity shock	0.08	0.02
$\sigma^2_{\epsilon^F}$	varaince of female measurement error	0.06	0.01

Table 29: Moments Conditional on Voucher Users and Gender (Percentage)

	Model	Data	95% CI
Moments of voucher users			
Single male employment rate	14	17	(12, 24)
Married male employment rate	33	56	(46, 66)
Single female employment rate	35	41	(36, 52)
Married female employment rate	17	23	(18, 29)
Marriage rate	15	15	(13, 17)
Divorce rate	16	18	(16, 20)
Moments by gender			
Male homeownership	29	33	(31,35)
Female homeownership	26	24	(22, 26)
Male application rate	9	10	(8, 12)
Female application rate	22	20	(18, 22)

Table 30: The Effect of Housing Vouchers from Model Simulated Data

	(1)	(2)	(3)	(4)
Variables	Employed	Homeowner	Married	Divorced
Housing vouchers	-0.034***	-0.045***	-0.162***	0.159***
	(0.013)	(0.011)	(0.017)	(0.006)
Mean of Dep. Var	0.54	0.28	0.4	0.1
Observations	28,000	28,000	28,000	28,000
Number of Individuals	4,000	4,000	4,000	4,000

Note: Data is drawn from the model simulated data. The model simulated 2000 female and 1000 males born between 1968-1978. All estimates control for age, year and individual fixed effect. Standard errors are clustered at individual level. *** p¡0.01, ** p¡0.05, * p¡0.1

Table 31: Parameters Estimated Within the Model

Parameters	Description	Value	SE
ω	extra utility from being home owners	1.01	0.2
σ^2_{Q0}	variance of initial match quality	0.09	0.01
σ^2_{Q}	variance of existing match quality	0.14	0.03
λ_y, λ_m	prob. of meeting at young age	0.41	0.08
λ_y, λ_m	prob. of meeting at middle age	0.55	0.09
ϕ^{SM}	disutility of working for single men	0.28	0.07
ϕ^{MM}	disutility of working for married men	0.20	0.04
ϕ^{SW}	disutility of working for single women	0.08	0.02
ϕ_0^{MW}	disutility of working for single women w/ children	0.09	0.02
ϕ_1^{MW}	disutility of working for single women w/o children	0.19	0.06
ν	stigma cost of program participation	0.044	0.02
ξ	prob. of losing housing vouchers	0.22	0.04
$\gamma(.)$	conditional Prob. of receiving vouchers		
γ_{lm}, γ_{hm}	high-/low-income male	0.18, 0.2	0.07, 0.06
$\gamma_{lwc}, \gamma_{hwc}$	high-/low-income female w/ children	0.35, 0.45	0.11, 0.13
$\gamma_{lwnc}, \gamma_{hwnc}$	high-/low-income female w/o children	0.2, 0.2	0.06, 0.06

Note: I follow Eckstein and Lifshitz (2011) to calculate the asymptomatic standard errors.

Table 32: The Effect of Housing Vouchers on Prices

	Rental price
Panel A: Introducing housing vouchers	
No housing voucher:	1
Introducing housing voucher program:	
Inelastic housing supply (0.76) :	1.05
Elastic housing supply (1.5) :	1.02
More elastic housing supply (2.3) :	1
Panel B: Policies and supply elasticity 1.5	
Baseline:	1
Experiment 1: flat subsidies	1.01
Experiment 2: lower subsidy to all	1.02
Experiment 3: time limits	1
Experiment 4: home buying option	1

Note: Elasticity of housing supply is drawn from Saiz (2010). The calculation is based on the model predictions from Zhang (2020).

Table 33: More Experiments (Percentage)

Variables	baseline (1)	low-productivity (2)	females (3)	cash assistance (4)
Employment				
single male	58	59	60	57
married male	76	76	77	75
single female	53	53	52	52
married female w/o children	45	45	45	45
married female w/ children	36	36	35	35
Household formation				
marriage	40	40	40	40
divorce	9	9	9	9
homeownership	27	27	27	25
Program participation				
overall	18	12	18	31

Table 34: Percent Change in Welfare

Compensation Variation	All	Women	Men
Only to low-productivity households	+1.1	+0.8	+1.4
Only to female-headed households	+0.1	+1	-0.8
Cash assistance	+0.45	+0.38	+0.52

Note: The welfare in the current program (baseline) is normalized to 1.

Table 35: Parameters Estimated When Introducing Moving Costs

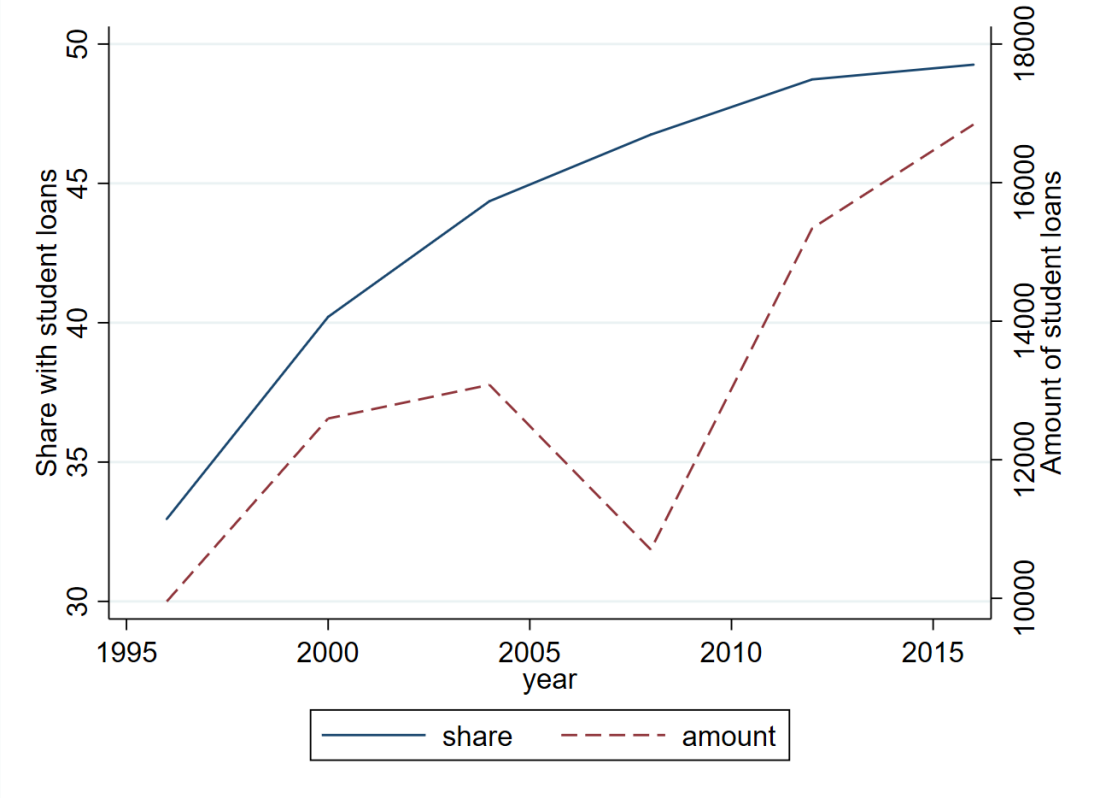
Parameters	Description	Value	SE
mc	moving costs	\$3100	\$950
ω	extra utility from being home owners	1.01	0.2
σ^2_{Q0}	variance of initial match quality	0.09	0.01
σ^2_{Q}	variance of existing match quality	0.14	0.03
λ_y, λ_m	prob. of meeting at young age	0.41	0.08
λ_y, λ_m	prob. of meeting at middle age	0.55	0.09
ϕ^{SM}	disutility of working for single men	0.28	0.07
ϕ^{MM}	disutility of working for married men	0.20	0.04
ϕ^{SW}	disutility of working for single women	0.08	0.02
ϕ_0^{MW}	disutility of working for single women w/ children	0.09	0.02
ϕ_1^{MW}	disutility of working for single women w/o children	0.19	0.06
ν	stigma cost of program participation	0.026	0.01
ξ	prob. of losing housing vouchers	0.22	0.04
$\gamma(.)$	conditional Prob. of receiving vouchers		
γ_{lm}, γ_{hm}	high-/low-income male	0.18, 0.2	0.07, 0.06
$\gamma_{lwc}, \gamma_{hwc}$	high-/low-income female w/ children	0.35, 0.45	0.11, 0.13
$\gamma_{lwnc}, \gamma_{hwnc}$	high-/low-income female w/o children	0.2, 0.2	0.06, 0.06

Table 36: Policy Experiments When Introducing Moving Costs (Percentage)

Variables	baseline	flat assistance	lower to all	time limits	home buying
	(1)	(2)	(3)	(4)	(5)
Employment					
single male	59	61	42	54	59
married male	77	77	76	77	76
single female	54	56	50	52	54
married female w/o kids	46	46	45	46	46
married female w/ kids	36	35	36	36	36
Household formation					
marriage	40	40	37	39	42
divorce	9	10	8	9	8
homeownership	28	28	22	27	34
Program participation					
overall	17	30	41	19	18
low-productivity	25	39	54	25	27
high-productivity	9	21	28	13	11

Appendix B Second Chapter

Figure 20: College Graduates Student Debt



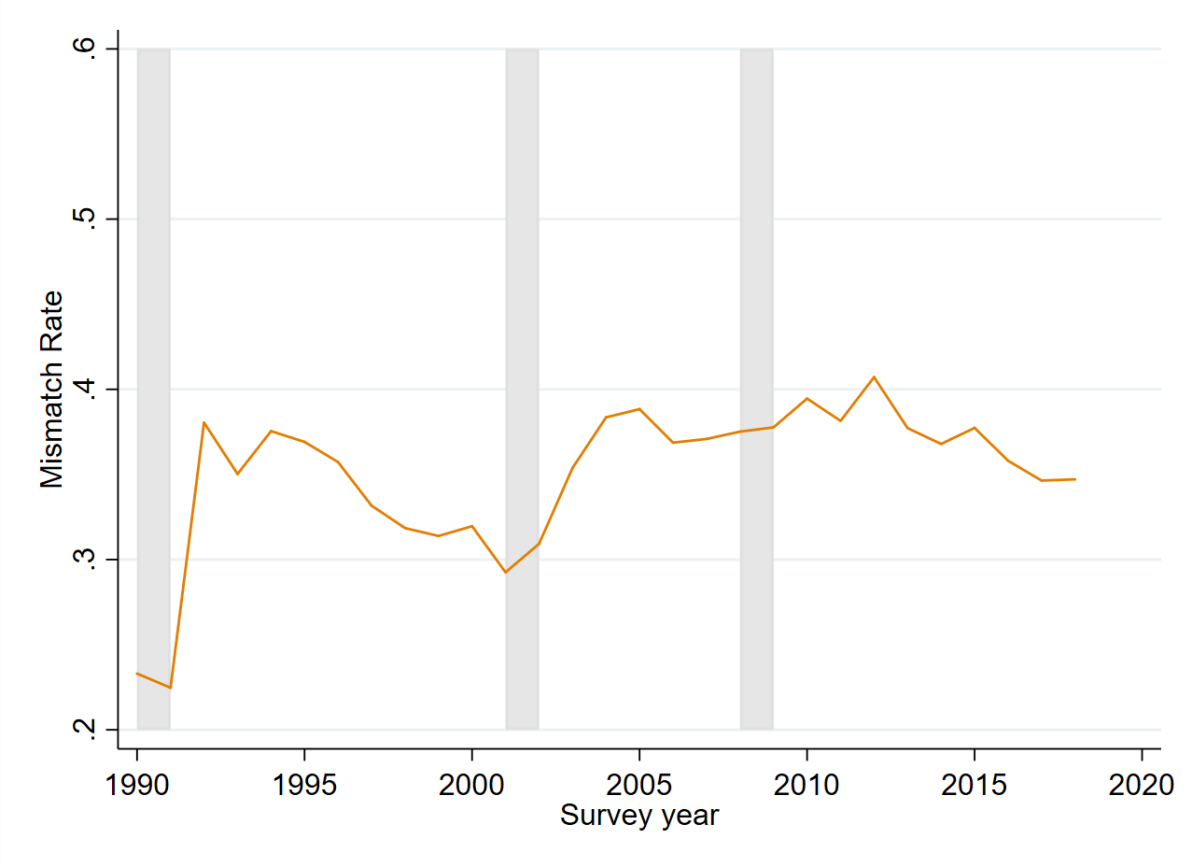
Note: U.S. Department of Education, National Center for Education Statistics, and 1993, 1996, 2000, 2004, 2008, 2012 National Postsecondary Student Aid Studies. The fraction is the percentage of undergraduates borrowing form both subsidized and unsubsidized from Stafford program. The average amount is the average conditional on those who are borrowing.

In this section, we discuss the construction of the main variables and several model choices.

B.1 Coresidence Variables

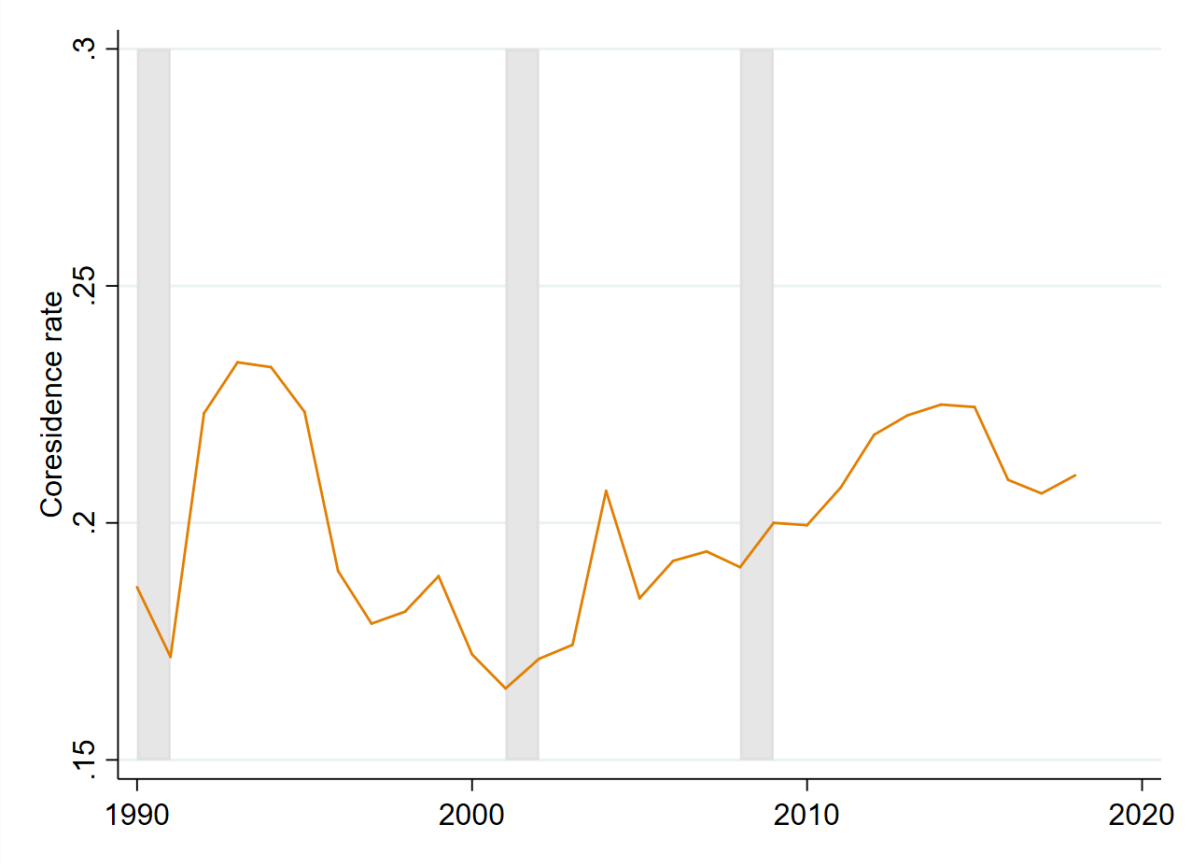
Information about living arrangements in SIPP can be attained in the following ways. Parents and the child are supposed to live together if the child's relation to the reference

Figure 21: College Graduates Job Mismatch Rate



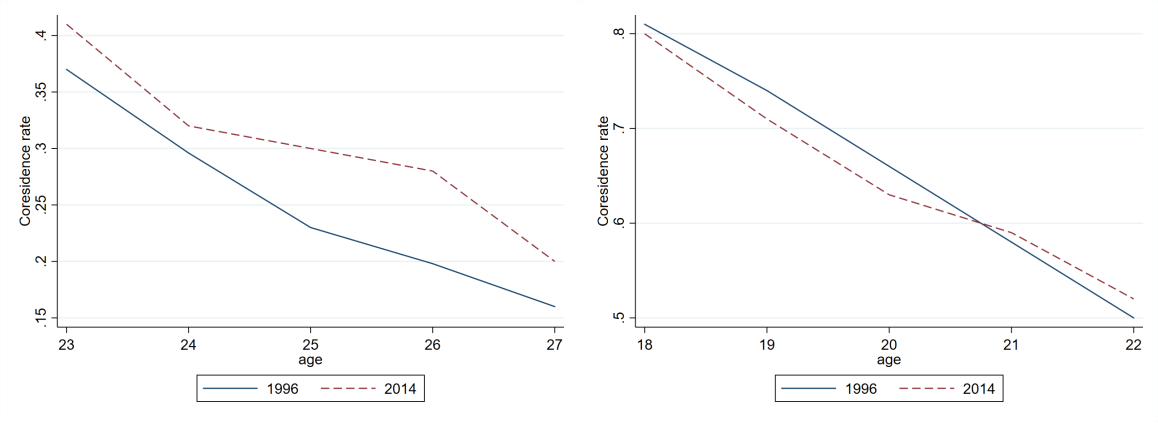
Note: U.S. Bureau of Labor Statistics, Current Population Survey, March Supplement. Young college graduates are those aged 21 to 28 with a bachelor's degree or higher. All figures exclude those currently enrolled in school. Shaded areas indicate periods designated recessions by the National Bureau of Economic Research.

Figure 22: College Graduates Coresidence Rate



Note: U.S. Bureau of Labor Statistics, Current Population Survey, March Supplement. Young college graduates are those aged 21 to 28 with a bachelor's degree or higher. All figures exclude those currently enrolled in school. Shaded areas indicate periods designated recessions by the National Bureau of Economic Research.

Figure 23: Coresidence of College and Non-college



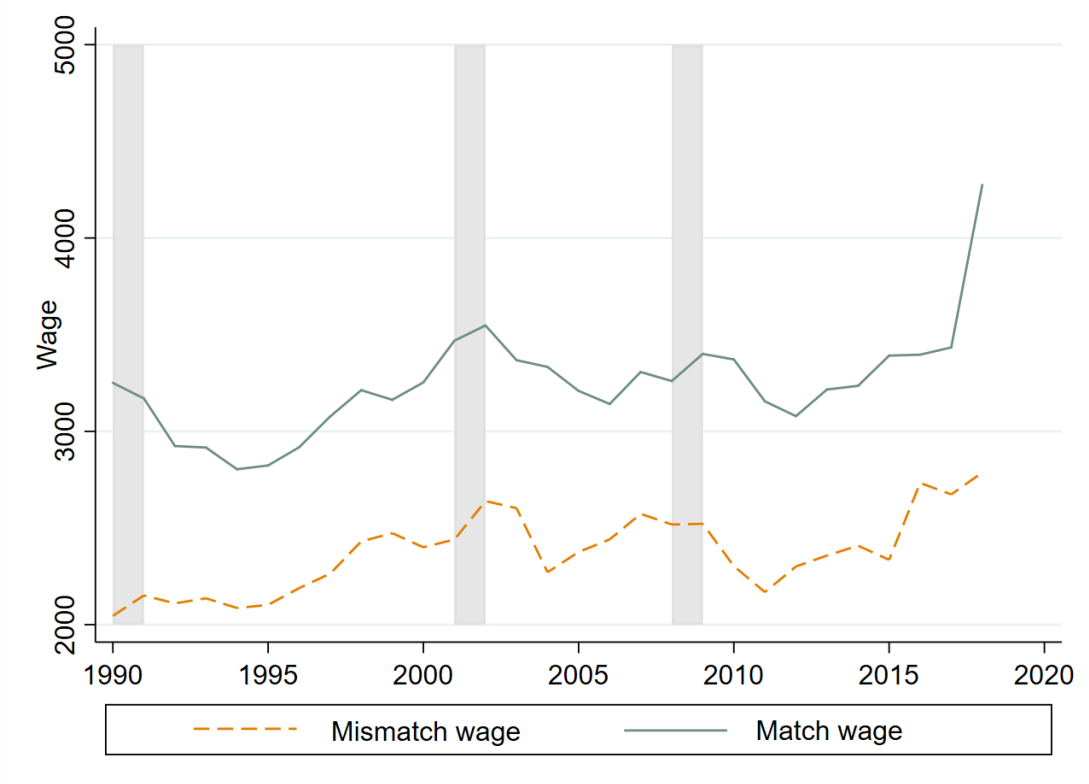
Note: Survey of Income and Program Participation (1996 and 2014) and Department of Labor, O*NET Education, Experience, Training. Note: Young college graduates are those aged 23 to 27 with a bachelor's degree. All figures exclude those currently enrolled in school.

person (household head) is "son" or "daughter" and there exists father's person number (EPNDAD) and/or mother's person (EPNMOM) number. If the parents don't live in the household, the father's person number and the mother's person number will be 9999. This information is recorded in the core microdata file for all months and all waves. We use this information to construct coresidence with parents variables.

B.2 Labor Market Variables

The SIPP Panel data includes detailed information about an individual's monthly labor market outcomes, i.e. employment status, wage and salary, and occupation for each job. Most of the employed college graduates (90%) has only one job. If the individual reports more than one job, we take the first one as his main job. We classified the college graduates' job as matched or mismatched job based on the occupation they work in. For unemployed individuals, the data set also includes the information on whether the person claims unemployment benefits and the amount of unemployment benefits.

Figure 24: College Graduates Wage Rate by Job Type



Note: U.S. Bureau of Labor Statistics, Current Population Survey, March Supplement; U.S. Department of Labor, O*NET. Young college graduates are those aged 21 to 28 with a bachelor's degree or higher. All figures exclude those currently enrolled in school. Shaded areas indicate periods designated recessions by the National Bureau of Economic Research.

Table 37: Sample Selection

	N. of observations	N. of individuals
SIPP 2014 and 2018 sample	2,923,967	144,342
keep youth born between 1990-1993	150,722	8,355
keep sample with a bachelor degree	32,217	2,452
keep sample without postgraduate study	28,339	2,169

Table 38: Moments

Moments	Data Value
Labor Market:	
Prob not working conditional on working in last period	0.04
Prob working in MA job conditional on unemployment in last period	0.52
Prob working in MI job conditional on unemployment in last period	0.43
Fraction of getting matched job	0.48
Mean MI log entry earnings	7.4
Variance MI log entry earnings	0.52
Variance MI log earnings conditional on working in consecutive periods	0.05
Growth mean MI log earnings	0.068
Mean MA log entry earnings	7.56
Variance MA log entry earnings	0.5
Variance MA log earnings conditional on working in consecutive periods	0.045
Growth mean MA log earnings	0.078
Average unemployment rate	0.12
Coresidence:	
Fraction living away	0.69
Growth fraction living away	0.05
Fraction ever move back	0.06
Autocorrelation of living away	0.87
Mean back home duration	4
Away home log earning difference	0.14
Assets and Transfers:	
Mean transfer	$6,058
Mean net assets	-$7,299

Matched vs mismatched job To determine whether college graduates get a mismatched job, we use the data from the U.S. Department of Labor Occupational Information Network (O*NET). O*NET has detailed descriptions of the work by job seekers, workforce development and HR professionals, students, researchers. It describes the features and characteristics of each occupation. We use the following question from the O*NET Education and Training Questionnaire to determine whether an occupation requires a college degree: "If someone were being hired to perform this job, indicate the level of education that would be required." We consider a college education to be a requirement for a given occupation if at least 50 percent of the respondents working in that occupation indicated that a bachelor's degree is necessary to perform the job. We then merged these data on the educational requirements for each occupation with the SIPP data.

Unemployment benefits The unemployment benefits are calculated based on the SIPP data for college graduates. The 2014 SIPP Panel surveys the amount of unemployment benefits for unemployed college graduates. The average amount of unemployment benefits for unemployed college graduates is around $600 per month during the years 2013 and 2017. The calculation of this number includes zeros because there are observations that receive no unemployment benefits when not working. This could be because unemployment benefits are time-limited. If I restrict the sample to nonzero unemployment benefits, the average unemployment benefits are $1,160 per month.

B.3 Parental Income and Transfers Variables

As the problem with most household survey data, we can only observe the characteristics of the parents if the parents live in the same household with the children at some time in the sample period. If the children always live independently in our sample period, we won't be able to know their parents' information. Due to this data limitation, we turn to the Health and Retirement Study (HRS) 1996-2000 and 2014-2018 Panel data to obtain parental income and transfer data. The University of Michigan Health and Retirement Study (HRS) is a longitudinal panel study that surveys a representative sample of approximately 20,000

elder people in America. The data set tracks the same sample every two years. It contains detailed information on an individual's income and transfer amount to own children. We apply the same sample restriction criteria with the SIPP data to the HRS data. We restrict the sample that their children must be college graduates and must be between age 23-27. The parents with young college graduates children are around 47-60 years old, most of which are still working. We get the parental income data from Section J EMPLOYMENT of HRS. It contains wage, salary, and self-employed income. We estimated the parental income as a four-point uniform distribution. Since in the data, the parental income doesn't change much during 2014-2018, we take the parental income as constant in the model. The transfer from parents to children is from Section E FAMILY STRUCTURE (CHILDREN) AND TRANSFERS (To Child) of HRS data. The survey question is stated as follows:

"About how much did that amount to for [that child/ [her /his /your] deceased child/, [her /his /your] deceased child/ each child/ each grandchild/ each child and grandchild/ [WHICH CHILDREN GAVE LGST AMT - SPECIFY]/[WHICH CHILD GIVEN LARGEST AMT - SPECIFY]/[WHICH CHILDREN GAVE SAME AMOUNT- [[since [Previous Wave Month], [PREV WAVE IW YEAR OF FAMILY R]/since [PREV WAVE IW YEAR OF FAMILY R]/in the last two years]])?"

Since the transfer data is surveyed for the past two years, we take the average to make it corresponds to per year. In other words, we only have annual transfer data.

B.4 Share of Public Consumption in Utility ϕ

The share of public consumption, ϕ, is from Kaplan (2012). Kaplan (2012) calibrates this parameter from household-equivalence scales, where he considers three scales: the OECD (Organization for Economic Cooperation and Development) equivalence scale, the OECD modified scale, and the square-root scale. For each equivalence scale, He computes the percentage increase in income needed by a household to keep welfare constant when moving from a household with two adults to a household with three adults. These three scales give values of 41%, 33%, and 22%, respectively. Kaplan (2012) applies a static version of his

model to map these values into the parameter ϕ, which implies values for ϕ ranging from 0.2 to 0.42. We took the average of this range, which is 0.3. We also experimented with other numbers like 2.5 or 3.5. The results are pretty robust.

B.5 Moving Cost κ

We calculate this number based on the following information.

a) The average moving cost from this website: https://www.moving.com/movers/moving-cost-calculator.asp. It measures the cost of hiring professionals for local and distanced moving. It says "The average cost of a local move is $1,250. The average cost of a distanced move is $4,890 (distance of 1,000 miles or more). These estimates are based on a 2-3 bedrooms move of approximately 7,500 pounds." We played with the calculator and found the estimates for 1 bedroom is about half of that price, which is $650 for local and $2400 for long distance.

b) We also refer to U-haul website to calculate the moving cost for a 1 2 bedroom. It ranges from $150 to $300 for a 200-500 miles move and $1,000 for more than 1,000 miles move.

Given that a lot of people don't hire professionals/trucks for moving, where the cost is much lower, we set the moving cost as half a month rent in the model.

B.6 Tax Function

We use a tax function that includes three types of tax: payroll, federal and state. There are two parts in payroll. First, social security tax of 6.2% of annual income up to $102,000. Second, a medicare levy of 1.5% of annual income with no limit. In terms of federal income tax, we calculate net income by gross income less a standard deduction of $6,200 and a personal exemption of $3,950. We then use the progressive tax rates for a single with no dependents for 2014 on the basis of the net income. We assume that state income taxes are

2.5% of gross income minus a deduction for federal taxes plus another $2,500. All calculation are based on annual income, by multiplying the monthly income by 12 and dividing the resulting tax by 12.

B.7 Numerical Methods

The model is solved by backward induction from the terminal value functions that are described in the main text. The asset choice is discretized into a 16 points exponentially spaced grids between the natural borrowing limit and the maximum asset. Similarly, the number of grid for wage offer is 10 and the number of grid for public consumption is 7. The distribution of the preference shocks, z_{it} is discretized into a 10 point stationary Markov chain using Tauchen method with parameters ρ_z and σ_z^2. Value functions and decisions are calculated based on the grids mentioned above. Values between grid points are calculate based on linear interpolation. The discrete choices like coresidence and labor supply are solved by interpolating the choice specific value function at the relevant stage of the game.

The estimation method is the Method of Simulated Moments (MSM), as proposed by McFadden (1989) and Pakes and Pollard (1989). The method involves finding the parameter vector Θ that minimizes the distance between the actual data and data simulated from our model. Let d_r denote a statistic from the actual data, and let $d_r^s(\Theta)$ be the corresponding statistic calculated in the simulated data, and assume we fit the model to $r = 1, 2, ..., R$ statistics. We then construct moments of the form:

$$m_r^s(\Theta) = [d_r - d_r^s(\Theta)] \quad for \quad r = [1, 2, ..., R]$$

The vector of simulated moments is given by $g'(\Theta) = [m_1^s(s), ..., m_R^s(s)]$. We minimize the objective function $G(\Theta) = g'(\Theta)Wg(\Theta)$, where the weighting matrix W is a diagonal matrix consisting of the inverse of the estimated variance of each moment (from a first step). We minimize $G(\Theta)$ with respect to Θ using the Simplex algorithm. We conduct our computation using H2P Cluster from Center for Research Computing, University of Pittsburgh.

To calculate standard errors, we follow Eckstein and Lifshitz (2011) to construct the asymptomatic standard error. To compute the numerical standard errors, we must first compute the numerical derivative of the objective function with respect to each of the parameter, Θ_p, use the five-point stencil formula with a long baseline.

$$f_{\Theta_p} = \frac{-f(\Theta_p + 2\epsilon_p) + f(\Theta_p + \epsilon_p) - 8f(\Theta_p - 8\epsilon_p) + f(\Theta_p - 2\epsilon_p)}{12\epsilon_p}$$

where f is a vector of the squared moments divided by their weights: $[d_r - d_r^s(\Theta)]^2/W_r$ and ϵ_p is equal to $0.01\Theta_p$. Given the numerical derivatives, we compute the covariance matrix using the outer product approximation to the Hessian.

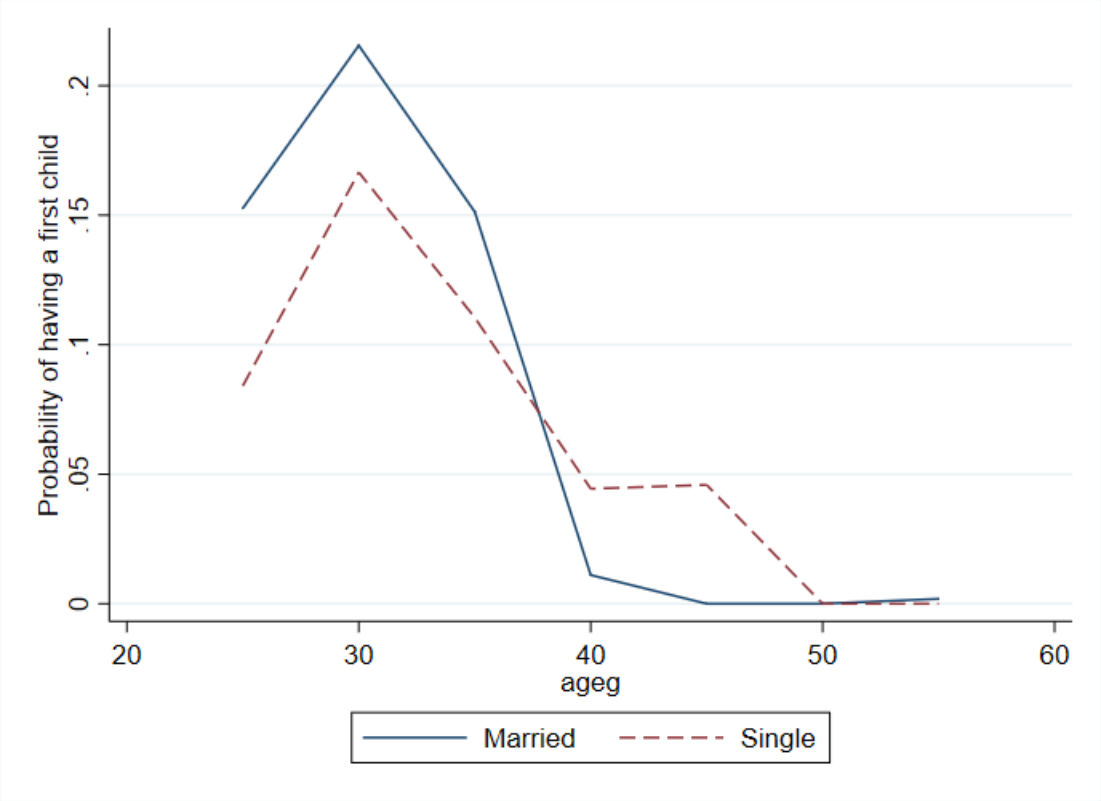
Appendix C Third Chapter

Table 39: The Effect of Divorce Law on Female Employment

Variables	(1) Employment	(2) Employment
Equitable distribution	0.093***	0.033
	(0.018)	(0.025)
Community property	0.019	-0.134***
	(0.018)	(0.028)
Unilateral × equitable distribution	-0.04***	-0.11***
	(0.014)	(0.012)
Unilateral × community property	0.03	-0.38***
	(0.027)	(0.009)
Unilateral × title-based	0.22***	0.072**
	(0.018)	(0.035)
F-statistics	132	844
Controls	No	Yes
Observations	5,298	5,298

Note: Data is drawn from NLSY79. The control variables include age fixed effect, state fixed effect, and year fixed effect. Standard errors are clustered at state level. "Equitable distribution" is the introduction of equitable distribution in mutual consent regimes. "Community property" is community property in mutual consent regimes. "Unilateral × equitable distribution" is introducing equitable distribution in unilateral divorce regimes. "Unilateral × community property" is the is introducing unilateral divorce in community property regimes. "Unilateral × title-based" is the introducing unilateral divorce in a title-based system. The excluded category is a title-based mutual consent system. *** p¡0.01, ** p¡0.05, * p¡0.1

Figure 25: Probability of Having the First Child by Woman's Age and Marital Status



Note: Data is drawn from the NLSY79. The blue solid line shows the probability of a married female giving birth to a child at each age period and the red dash line shows the probability of a single female giving birth to a child at each age period.

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