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In-kind Housing Transfers and Labor Supply: A Structural Approach

Ning Zhang

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Abstract

Policymakers continuously debate the current U.S. Housing Voucher Program, which features a high degree of rationing and decreasing subsidy amount as income increases. This paper studies the effect of the Housing Voucher Program on low-income household labor supply and welfare. Using several datasets, I estimate a dynamic lifecycle model to study the long-term impacts of housing vouchers on employment, and examine how a set of policy reforms affect household labor supply and well-being. I show that voucher usage (as opposed to no vouchers) decreases female labor supply by 17% and male labor supply by 7% in the long run. Compared to the current program, a proposed reform that provides every recipient with a flat-rate subsidy increases female labor supply by 4% and leads to higher welfare. Policies that offer a lower subsidy to a larger population decrease labor supply by 3-4% and increase household welfare. Time-limited subsidies increase female employment by 4% and improve overall welfare.

Keywords: housing vouchers, labor supply, welfare

*Department of Economics, University of Oxford. Email: ning.zhang@economics.ox.ac.uk. I would like to thank Stefania Albanesi, Rania Gihleb, Daniele Coen-Pirani, Robert Moffitt, James Ziliak, Hamish Low, Abi Adams-Prassl, Thomas H. Jørgensen, Petra Todd, Emily Nix, Kristiina Huttunen, Pietro Biroli, Osea Giuntella, Nezih Guner, Douglas Hanley, Karam Kang, Marla Ripoll, and seminar/conference participants at the University of Oxford, University of Pittsburgh, CMU, UCD, HKUST, SHUFE, Wuhan University, Jinan University, SOLE, SEHO, AASLE, EALE, and Econometric Society World Congress for their helpful comments and suggestions. I would also like to thank the European Research Council for their generous funding (ERC Grant Number 948070). All errors are my own.

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 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 its optimal structure and scope remain open to debate.¹ 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 long-term effects of the current program and major alternative reforms to the program on low-income household labor supply and welfare.

This paper contributes to our understanding of the long-run impacts of housing vouchers on household labor supply. Recent research has shown that the program has a significant negative effect on recipient labor supply, in the magnitude of 6-8% (Jacob and Ludwig, 2012; Mills et al., 2006). However, the policy might have longer term impacts on both labor supply and household formation that have not yet been considered. The dynamic labor supply effects may differ because housing assistance may promote household asset accumulation and thus negatively impact labor supply through lifetime wealth effect. Further, housing subsidies could alter the insurance value of marriage, affecting dynamic household formation and dissolution, which create their own labor supply incentives in the long run. In this paper, I apply a dynamic lifecycle model to understand the long-term impacts of housing vouchers. I show that my model can recover short-term impacts on labor supply consistent with the existing reduced form literature. I then use estimates from the model to study the long-term effects and decompose the underlying mechanisms.

This paper also contributes to our understanding of how changes in subsidy structure and degree of rationing influence household labor supply and well-being. Though policymakers

¹For instance, the Bush administration had proposed a “Flexible Voucher Plan” that would have reduced work disincentives and promoted self-sufficiency by introducing a time-limited subsidy and flat subsidy (Husock, 2004). In contrast, the Obama administration expanded the housing voucher program to assist more low-income families (King, 2015). The Trump administration, meanwhile, proposed large cuts to affordable housing programs and subsidy adjustments according to local conditions (Fischer, 2017). The current president, Joe Biden, has proposed universal housing vouchers to every qualified family (Yglesias, 2020).

and researchers continue to debate potential policy reforms regarding the structure and scope of vouchers, few studies have evaluated the effects of these reforms on household behavior and welfare (Keane and Moffitt, 1998; Olsen, 2003; Collinson et al., 2019). I apply a structural analysis to understand how policy reforms affect household behavior and welfare. In particular, I study three possible changes to the current program and how they would affect household labor supply and welfare. First, the current program features an inverse relationship between subsidies and recipients' income, which has the effect of discouraging labor supply (substitution effect channel) (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 subsidy amount. 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). I simulate two policy proposals that intend to expand the scope of households assisted by the program: one provides lower benefits to all voucher applicants and the other offers time-limited subsidies.

Beyond the contribution to evaluating long-term impacts and major program reforms, this paper also contributes to our understanding of the program's effects on multiple fronts. First, this paper contributes to the understanding of in-kind transfers such as housing vouchers on household labor supply and welfare. I explicitly model housing subsidies as an in-kind transfer by incorporating goods and housing consumption separately in the model, where housing vouchers only subsidize housing consumption. Second, in my model, households choose whether to participate in the voucher program. The data from the HUD survey of public housing agencies (PHA) allows me to estimate the key parameter governing household participation in the program. Other studies have to assume participation due to data limitations (Keane and Moffitt, 1998). Third, this paper contributes to our understanding of the effect of housing assistance on family formation (dissolution), whereas existing literature has limited evidence (Mills et al., 2006; Carlson et al., 2012).

I first establish stylized facts about the housing voucher program, which shows that vouchers are associated with lower employment. I then discuss the static and dynamic effects

of housing vouchers on labor supply. I also show that housing vouchers could affect labor supply indirectly through impacts on family formation because housing subsidies could alter the insurance value of marriage. Motivated by the stylized facts and the theoretical effects, I specify and estimate a structural lifecycle model to understand the mechanisms underlying the current program's effects on household labor supply and welfare. My model captures the main features of the current program as well as household decisions on labor supply and marriage. In addition, I model both goods and housing consumption, and endogenize voucher program participation. Conditional on 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 (divorce), and how much to save in each period.

Using household data from the Survey of Income and Program Participation (SIPP) and several data sets from HUD, I explore exogenous variations of the government voucher allocation system and heterogeneous rental prices to estimate the model parameters. I show that the model matches the targeted moments, such as employment, wages, marriage, and participation in the voucher program. The model also replicates the empirical estimates from existing papers that use randomized control trials (RCT), though these empirical estimates are not explicitly targeted by the estimation procedure.

One important use of the structural model is to study the long-term dynamic effect of the current housing voucher program on labor supply. By comparing employment outcomes in the baseline with housing vouchers and in the counterfactual scenario without vouchers, I find that housing vouchers negatively impact the labor supply for both men and women. Specifically, voucher usage (as opposed to no vouchers) reduces female employment by 10 percentage points (pp, 17% relative to the mean) in the long run and reduces male employment by 6pp (7% relative to the mean) in the long run. By decomposing the underlying mechanisms, I find that the substitution effect channel, as examined by the flat assistance policy experiment, accounts for a 2pp (4% relative to the mean) employment drop for women and a 3pp (4% relative to the mean) employment drop for men.

Housing is a public good that is shared by household members. By subsidizing housing, these vouchers can change the value of marriage relative to singlehood. I find that the current program has a meaningful negative impact on family formation. In particular, housing

voucher usage (as opposed to no vouchers) decreases marriage rates by 10pp in the long run and increases the divorce rate by 5pp in the long run. Since married women work less than single women on average, all else being equal, the household formation channel leads to an increase in overall female labor supply. A quantitative exercise that controls for other channels shows that the family formation channel can explain a 2pp (4% relative to the mean) female labor supply increase.

Another important use of the structural model is to explore the behavioral response and welfare implications of several program reforms. I consider three government-budget-neutral counterfactual policies and compare the employment effects of the three policy reforms to that of the current (baseline) program. In the first proposed reform, where every recipient household receives the same subsidy, households work more compared to the current program. The flat subsidy overcomes the disincentives generated by the current program toward labor supply by removing the inverse relationship between subsidy and income (substitution effect channel). In particular, this policy increases overall female employment by 2pp (4% relative to the mean) as opposed to the current program. By decomposing the overall effect into the composition effect and the treatment effect, I show that the treatment effect of removing the substitution channel can account for a 2pp (4% relative to the mean) employment increase for women and a 3pp (4% relative to the mean) employment increase for men. In addition, compared to the current program, the flat assistance program increases the marriage rate by 2pp and decreases the divorce rate by 2pp. Since married women work less than single women, the increase in the marriage rate induced by the experiment changes the composition of single vs. married women, thus resulting in a 1pp overall reduction in female labor supply.

The second policy experiment provides modest subsidies to all eligible applicants, where the subsidy amount remains inversely related to household income as in the current program. As a result, aggregate employment decreases in contrast to the current program because the negative effect on labor supply is spread over more households. Specifically, this policy causes overall male and female employment decreases by 2pp compared to the current program. The policy reform also creates significant disincentives for family formation because the expanded coverage raises the value of outside options for most households. Decomposition analysis shows that the overall decrease in employment is primarily driven by expanded coverage

induced by the policy reform rather than the difference in treatment or marriage effects for recipient households.

The third experiment, in which vouchers only last 5 years, has a positive effect on employment compared to the current program. Specifically, the time-limited subsidies increase female labor supply by 2pp and male labor supply by 1pp. Evidence suggests that housing vouchers reduce labor supply only during the first few years of receiving subsidies. Both male- and female-headed households are forward-looking and increase labor supply before running out of time-limited subsidies. Moreover, the time-limited subsidies positively impact marriage, i.e., increase the marriage rate by 1pp compared to the current program, due to the worsening of outside options for marriage. The positive effect on marriage induced by the time-limited subsidies suggests a negative impact on female labor supply.

I also evaluate the effect of the policy reforms on household welfare. Compared to the current program, the first policy that provides the same amount of subsidy to every recipient household increases male welfare but decreases female welfare as a result of shifting subsidies across households. The second 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 and redistributing the subsidies to needy families that are hit by negative income shocks.

When considering the robustness of the results, I discuss the evidence of the housing voucher program's effect on rental prices from the existing literature, and provide suggestive evidence of the general equilibrium effect on my results. I find that the impact of each policy on rental prices is limited, assuming that the elasticity of housing supply is at the national median level. I also show that the results are robust when relaxing the model assumption about application rates. Finally, I show that the main results are robust to several alternative specifications.

The rest of the paper is structured as follows. Section II reviews the background of the Housing Voucher Program and related literature. Section III describes the data sets and stylized facts. Section IV specifies the lifecycle model and discusses the households' problem. Section V discusses the estimation of structural parameters and the model's internal and

external fit. Section VI presents the long-term dynamic impact of housing vouchers on labor supply. Section VII shows the policy experiments and reports the effects on household labor supply and welfare of potential program reforms. The last section concludes this paper and discusses policy implications.

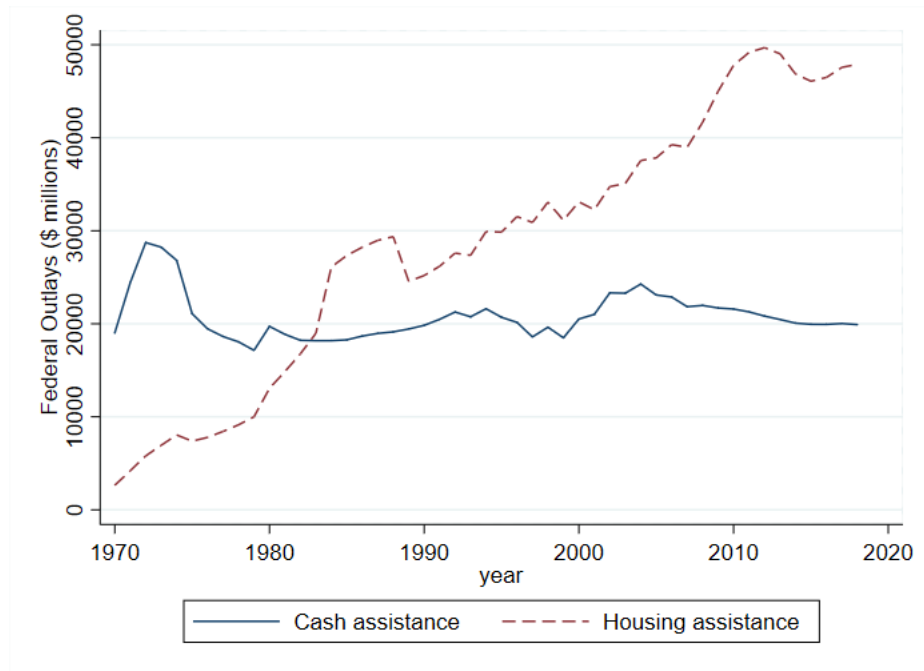
2 The Housing Voucher Program and Related Literature

In this section, I briefly review the Housing Voucher Program (Section 8). The national shortage of affordable housing for low-income households was 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, households on average pay more than 30% of their income for rent (American Housing Survey, 2017), 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 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).

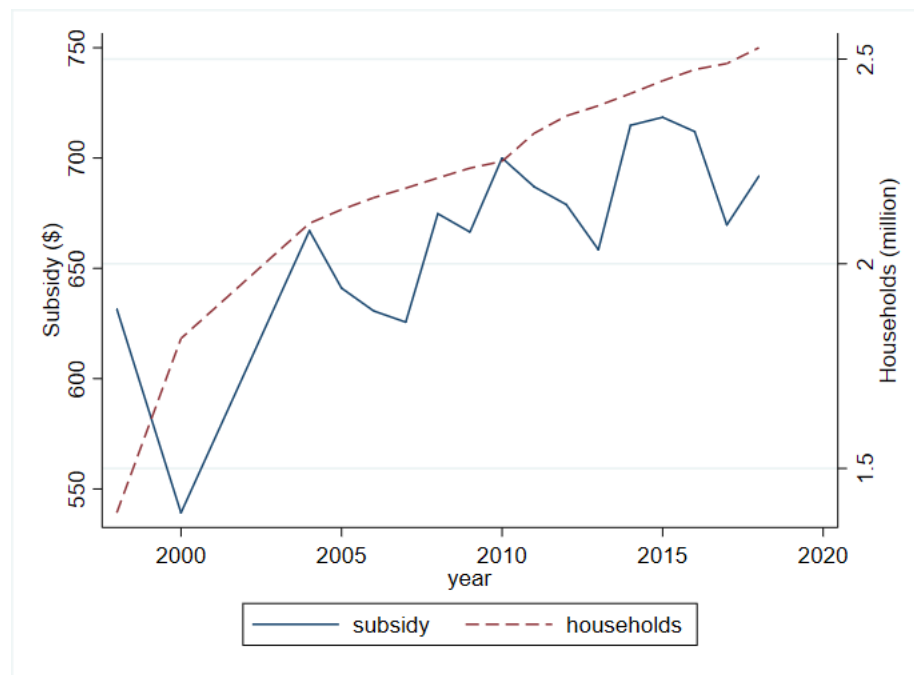
Housing vouchers are means-tested. Eligibility for the housing voucher program depends on family size and income. To be eligible, a four-person family's gross income may not exceed 50% of the local Metropolitan Statistical Area (MSA) median income. The income

Figure 1: Federal Outlays for Housing and Cash Assistance Programs



Notes: This figure displays the federal outlays for housing and cash assistance programs over time. The blue solid line describes the outlays for cash assistance and the red dash line for housing assistance. Cash assistance includes 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. Source: Outlays reported by the US Office of Management and Budget represented in 2010 dollars, deflated using Consumer Price Index.

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



Notes: This figure displays the number of households covered by the housing voucher program and the monthly subsidy amount per household over time. The red dash line is the number of households receiving housing vouchers from 1998-2018 and the blue solid line is the average monthly subsidy amount per household in real terms (take 2010 as the base year). Source: Department of Housing and Urban Development's (HUD's) Office of Policy Development and Research (PDR).

cut-offs differ by family size.² Although roughly 25 million households qualify for federal rental assistance based on their income, a calculation based on the Current Population Survey (CPS) shows that only 8% of eligible families receive vouchers. Housing vouchers are administered locally by public housing agencies (PHAs). 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, PHAs put applicants on a waiting list. Housing authorities (PHAs) organize waiting lists in three ways: 1) first come, first served; 2) random lottery; and 3) local preferences (Been et al., 2018).³ Due to high demand, waiting periods are lengthy, averaging as long as two years (HUD Picture of Subsidized Households, 2004-2018). Some housing authorities may close their waiting lists when they cannot assist more families in a given period of time.

Voucher recipients are responsible for finding suitable units that landlords agree to rent under the program. The maximum subsidy available to families, essentially equal to the fortieth to the fiftieth percentile of the local private-market rent distribution (minus household contribution), is governed by 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 (2004-2018), the average housing voucher subsidy for a family is nearly \$8,000 per year, equivalent to the annual salary of a minimum wage part-time worker.

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

²Source: <https://www.huduser.gov/portal/datasets/il/fmr99/sect82.html>

³For 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.”

form papers that estimate the effects of the current program on individual outcomes such as labor supply, earnings, residential location, children’s outcomes, rental prices, housing and neighborhood quality;⁴ (b) papers that estimate structural models to evaluate the counterfactual consequences of the program (Keane and Moffitt, 1998; Mansur et al., 2002; Leung et al., 2012; Galiani et al., 2015; Davis et al., 2021); and (c) papers that summarize the housing assistance programs and related research (Olsen, 2003; Collinson et al., 2015, 2019; Chan and Moffitt, 2018). The existing literature enhances our understanding of affordable housing programs and inspires more research including my paper. Note that another strand of literature discusses the impact of transfers in-kind vs. transfers in-cash (Moffitt and Kosar, 2020). My paper focuses on the policy reforms within the transfer in-kind subsidies. The discussion between transfer in-kind vs. in-cash is left for future study.

3 Data and Stylized Facts about Housing Vouchers

3.1 Data

The main data set comes from the Survey of Income and Program Participation (SIPP) 2001, 2004, 2008, 2014, and 2018 panels. The data set contains detailed information on household demographics. In particular, it includes information on whether a household is granted a housing voucher through the Section 8 program.⁵ I focus on the working-age (18-60) sample with a high school education or below. I also exclude homeowners and households who live in public housing, as they are not the target of the housing voucher program.⁶ The sample includes 29,071 individuals with 137,081 observations. I use this sample to provide a series of stylized facts about the housing voucher receivers and non-receivers. When estimating

⁴See Jacob and Ludwig (2012); Jacob et al. (2015); Collinson and Ganong (2018); Kling et al. (2005); Eriksen and Ross (2015); Chetty et al. (2016) for more details. Note that most of the literature that studies the residential location and neighborhood effect use the Moving to Opportunity (MTO) program data, rather than the general housing voucher program data.

⁵For 2001-2008 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 each wave for each household. For the 2014 and 2018 panels, respondents are interviewed annually rather than three times per year; the reference period covered in each interview is the previous 12 months.

⁶In the rest of the paper, the sample selected is referred to as “low-income” households for ease of illustration.

the lifecycle model, I control the cohort effect by further restricting the sample to a single cohort, i.e., the cohort born between 1970 and 1980. With this restriction, the final sample ends up with 8,904 individuals and 44,872 observations.

It is worth mentioning that the sample selection criterion is not based on the household eligibility status for the housing voucher program, but on a more general selection of low-income households. This is because households could endogenously change their eligibility status by reducing their employment and earnings. The endogenous selection into the program is especially important when we consider different policy experiments, where households' incentives to become eligible might be altered. By using a more general sample that is both actual eligible and potentially eligible, I am able to estimate a model to account for the endogenous selection into and out of the program.

In addition, 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 one. To obtain the program participation information for my selected sample, I turned to the HUD PHA Homeless Preferences: Web Census Survey Data, which asked all U.S. PHAs in 2012 about how many households were on the waiting list.⁷ The data shows that overall 4.9 Million households are on the waiting list for housing vouchers. This could provide a numerator for calculating the application rate of housing vouchers for the selected SIPP sample. The denominator should be the total number of unassisted renter households satisfying the sample selection criterion applied to SIPP data. I use the 2012 SIPP to estimate the denominator, which is 16.9 million.⁸ This calculation suggests that the aggregate application rate for housing vouchers in my selected SIPP sample is 29%.⁹ This aggregate application rate could

⁷Throughout the paper, household participation in the program means that households apply for a voucher. Participation does not imply that households will receive the subsidy because vouchers are rationed among applicants.

⁸In particular, I calculate the share of the total number of unassisted renter households satisfying the sample selection criterion over the total number of households in SIPP, which is 14%. Then I multiply this share by the total number of households in the U.S. in 2012, which is 121.08 million to calculate the denominator as 16.9 million.

⁹The application data is only available for 2012. In Appendix B, I explore more information from the growth of households receiving vouchers each year to infer the application rates between 2004-2018, showing that the average application rate is close to 29%. In addition, I test the robustness of the main results with respect to a range of application rates in [20%, 40%], and find that results are robust.

help us pin down the parameter that governs aggregate application for housing vouchers.¹⁰

3.2 Stylized Facts

In this section, I present two stylized facts about the housing voucher program: 1) housing voucher recipients have lower socioeconomic status; 2) housing vouchers are negatively associated with individual employment and marital status.

I present summary statistics of the sample from the SIPP data in Table 1. Column (1) reports the characteristics for the full sample. The statistics for voucher recipients and non-recipients 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 non-recipients. Specifically, the employment rate for male (female) recipients is 0.35 (0.38), while that for male (female) non-recipients is 0.74 (0.56). Average monthly earnings are \$1,578 and \$1,888 for individuals with or without vouchers. Voucher recipients have a lower marriage rate (23%) and a higher divorce rate (19%).¹¹ The percentages of observations that are presumably eligible for housing vouchers are 62% and 60% for the full sample and estimation sample, respectively. The percentages that received a voucher are 6% and 7%, respectively. Most of the sample, particularly voucher users, consists of female-headed households and households with children. The summary statistics suggest that voucher recipients have lower socioeconomic status, and housing vouchers are negatively associated with individual employment and family formation.

¹⁰However, it may fail to pin down the heterogeneous preferences of households selecting into the program, i.e., heterogeneous stigma costs of program participation. To address this concern, in the model I allow government allocation of housing vouchers to be heterogeneous across different demographic groups, which will generate heterogeneity of voucher recipients that matches the data. For more details, see the housing assistance subsection in Section 4.2.

¹¹Note that it is only legal marital status that matters. The eligibility for the housing voucher program depends on family composition (size) and total family income. In particular, PHAs verify family composition using marriage certificates (for more details, see https://www.hud.gov/sites/documents/DOC_35767.PDF). Thus, I only consider legal marital status in the paper, without further distinguishing marriage vs. cohabiting but unmarried couples. It's also worth noting that in the data, unmarried cohabitating couples comprise only a minimal share of the sample (4% of the low-income sample and 1% of the voucher recipient sample).

Table 1: Summary Statistics (SIPP)

Variables	All sample (1)	Receiving housing vouchers (2)	Not receiving housing vouchers (3)	Estimation sample (4)
<u>Employment</u>				
Male employment rate	0.72	0.35	0.74	0.81
Female employment rate	0.55	0.38	0.56	0.56
Monthly earnings (\$)	1,877	1,578	1,888	1,927
<u>Household formation</u>				
Married	0.46	0.23	0.48	0.53
Divorced	0.16	0.19	0.16	0.10
Share with children	0.55	0.63	0.55	0.74
<u>Vouchers</u>				
% eligible	61.93	100	0	60.41
% w/ vouchers	6.37	100	0	6.78
<u>Demographics</u>				
Age	39	41	38	32
Male	0.42	0.24	0.44	0.42
White	0.69	0.48	0.71	0.72
N. of obs	137,081	8,734	128,347	44,872
N. of individuals	29,071	3,114	25,957	8,904

Notes: This table shows the summary statistics of key variables from the SIPP data. Column (1) presents the statistics for the full sample, which consists of the working-age (18-60) unassisted renters with high school education or below. Columns (2) and (3) show the statistics for voucher recipients and non-recipients. Column (4) presents the statistics for the estimation sample, which consists of the cohort aged 20-30 in 2000 (born between 1970 and 1980). Employment is defined as usual hours worked greater than or equal to 20 hours per week. Earnings are defined as labor income, including wages and salaries. Earnings are in real terms (take 2010 as the base year). Eligibility for the program is inferred based on the family's total income and the income cut-off for the state and metro areas. Source: Data is drawn from the SIPP (2001, 2004, 2008, 2014, and 2018 Panels).

4 A Model Demonstrating Household Decisions

Economic theory documents several channels through which housing vouchers could affect individual labor supply. In addition to providing generous subsidies, the amount of rent paid by the program is inversely related to family income. A static labor supply theory implies a negative effect on labor supply through both income and substitution effects ([Jacob and](#)

Ludwig, 2012).¹²

In addition to the static effect, housing assistance may also have a dynamic impact on household labor supply. First, vouchers are associated with long-term benefits, which increase lifetime wealth (assets), thus affecting household labor supply through the lifetime income effect. Second, once households receive vouchers, they can keep receiving the benefits as long as they are program eligible. Therefore, if voucher recipients experience positive income shocks after receiving vouchers, they may strategically choose not to work in the following periods to maintain program eligibility. Third, housing vouchers could also indirectly affect labor supply through their dynamic impact on marriage. In particular, if marriage works as private insurance for individuals, housing assistance may crowd out private insurance by increasing the value of marriage outside options. Given that marriage interacts with labor supply nontrivially (especially for women), housing vouchers also indirectly affect labor supply through family formation. Since vouchers have both static and dynamic effects on labor supply, a dynamic model is needed to study the impact of housing vouchers on household labor supply and welfare.¹³

Motivated by the stylized facts and economic theory, I thus develop a dynamic lifecycle model to study the effect of housing vouchers on labor supply. The model captures the static income and substitution effects and the dynamic lifetime income effect. The model could also capture the indirect effect on labor supply through marriage. Admittedly, the model does not feature spatial locations so it cannot capture the channel that the program may incentivize families to change their residential choices and employment opportunities. However, the literature that focuses on the residential choices and neighborhood effect uses data from the Moving to Opportunity (MTO) program, rather than the general housing voucher program (Kling et al., 2007; Chetty et al., 2016; Galiani et al., 2015). It is important to note that MTO is very different from the general housing voucher program because the treated families of MTO could only use vouchers in low-poverty areas for specific periods, and

¹²To be more precise, we have two types of goods in this context, consumption and leisure. Within consumption, we have housing and non-housing consumption. The substitution effect referred here is the substitution between consumption (housing plus non-housing) and leisure.

¹³Other than the static and dynamic effects, the program could also affect labor supply through other channels. For example, housing and non-housing goods could be complementary. If receiving a housing voucher increases housing consumption, households could also work more to maintain a certain level of non-housing consumption.

they get counseling for moving. Thus, the moving channel is important for studying the MTO program. In contrast, the general housing voucher program does not require vouchers to be used in low-poverty areas, nor has counseling for moving. Therefore, whether the moving channel is important for studying the housing voucher program is an empirical question. Specifically, my calculation from the SIPP data shows that about 70% of households do not move after receiving a voucher. Consistent with the SIPP data, both [Jacob and Ludwig \(2012\)](#) and [Schwartz et al. \(2017\)](#) find no impacts of housing vouchers on household moving. This evidence suggests that the re-location of voucher users is not a channel that affects most households. Even if the moving channel can play a role in affecting labor supply, it is likely that households with vouchers will move to a better neighborhood with higher employment opportunities, thus improving household labor supply. By abstracting from this possibly positive effect channel, the estimate from this paper therefore provides a lower bound on the negative impact of housing vouchers.

In the model, agents work from period $t \in \{1, 2, \dots, T\}$, after which they retire. Each period in the model corresponds to 1 year in real life. Households obtain utility from two forms of consumption: goods and housing, where housing comes from renting. In addition to consumption, people suffer from the disutility of working and the stigma cost of participating in the housing voucher program. Individuals are heterogeneous in labor productivity. At the beginning of each period, men's (M) and women's (W) labor productivity are realized. Depending on their marital status and age, women know whether they have a child. There is a probability of single people (S) meeting a potential partner randomly drawn from the distribution of remaining singles. Given a random initial love shock and individual-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 at the beginning of each period and decide whether to remain married or not. Single or married households also decide whether to apply for a voucher in each period.

Households who applied for housing vouchers may get a voucher depending on gender, the number of children, and household income. The government rationing system determines the probability of receiving a housing voucher. If the applicant receives a voucher, they will receive subsidized rental housing, for which they contribute a sum equal to 30% of their

household income. Besides housing assistance, they may also receive welfare benefits from TANF, Food Stamps, and EITC, which are exogenously given and depend on household characteristics. In all cases, households decide whether to work, how much to save, and how much to consume. The housing voucher program affects households' labor supply through its impact on budget constraints and subsidies for housing consumption.

4.1 Preference

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

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

where $c_{it} > 0$ is goods consumption and $h_{it} > 0$ is housing consumption. Goods consumption is continuous while housing consumption is discretized as $h_{it} \in [h_{min}, \dots, h_{max}]$, which is referred to as housing size below. Goods and housing consumption take a Cobb-Douglas function form, and α ($1-\alpha$) is the share of goods (housing) consumption. In addition, the term e stands for the exponential operator. The term $l_{it} \in \{0, 1\}$ stands for extensive margin labor supply;¹⁴ the term $\phi^{Sg}(N)$ captures the disutility of working, which is gender specific and depends on the number of children (N). The disutility of working term changes the marginal utility of consumption if working $l_{it} = 1$. The term $B_{it} \in \{0, 1\}$ is the decision to participate in the housing voucher program, and ν is the stigma cost associated with program participation.¹⁵

Married (M) men's and women's utilities are denoted by

$$u_{it}^{Mg}(c, h, l, B) = \frac{(((\gamma_e c_{it})^\alpha h_{it}^{1-\alpha})e^{(\phi^{Mg}(N)l_{it})})^{1-\sigma}}{1-\sigma} - \nu B_{it} + Q_{it}$$

¹⁴For computational ease, I do not consider the intensive margin of labor supply nor distinguish between part-time and full-time employment. The latter one is not a major concern since the share of households working part-time, defined as usual weekly working hours between 20 and 30, is only 5.7%. By ignoring the intensive margin, the results on the effect of housing vouchers on labor supply could be seen as a lower bound.

¹⁵For the general applicant households, who could fail to receive vouchers due to rationing, ν could be better described as the time/hassle of completing the application, rather than as the stigma cost. For the voucher recipients, this would be the stigma costs of using the subsidies. For ease of illustration, I refer to them as stigma costs throughout the rest of the paper.

where $c_{it} > 0$ and $h_{it} > 0$ are joint total goods and housing consumption. Housing is a public good for a married household, so the economy of scale is 1 for h_{it} . The parameter $\gamma_e \in (0.5, 1)$ captures the economy of scale within non housing goods c . Married men's and women's utilities depend on the disutility of working $\phi^{Mg}(N)l_{it}$, the stigma cost of housing voucher application νB_{it} , and match quality Q_{it} (love shock).

4.2 Shocks to Households

Households face three sources of shock: earnings, marriage and fertility, and housing vouchers due to rationing.

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

$$\log w_{it}^g = \beta_0^g + \beta_1^g \text{age} + \beta_2^g \text{age}^2 + z_i^g + \epsilon_{it}^g$$

where z_i^g is the individual productivity or permanent income component that does not vary over time, which is drawn from a normal distribution $N(0, \sigma_{z^g}^2)$; the term ϵ_{it}^g is the income shocks, which is i.i.d and normally distributed as $N(0, \sigma_{\epsilon^g}^2)$. Because selection into work is an issue and earnings are only observed for employed people, I internally estimate the earnings parameters in the structural model.

Marriage and fertility In each period, there is a probability λ_t that a single agent will meet with a potential spouse (of the same age group), who is characterized by a certain level of labor productivity and assets. The potential couple then draws an initial match quality $Q_0 \sim N(0, \sigma_Q^2)$. If they decide to marry, their match quality follows a random walk with innovations ξ_Q :

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

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

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

For simplicity, I assume each woman only has one child. Note that a child will only affect a man when married to a woman.

Housing assistance Households decide to apply for a housing voucher in each period. Each applicant household has a probability of receiving a voucher. Since PHAs cannot accommodate all demand for housing subsidies of applicant households, they will allocate vouchers by random lottery or based on priorities. Therefore, the probability of receiving a voucher is not purely random. I model the probability of receiving vouchers as a function of gender (female-headed or male-headed), household income in the previous period ($I_{i,t-1}$, binary variable equal to 1 if household income in the previous period is below 30% of local MSA median income and 0 otherwise), and for female-headed households with and without minors (binary variable equal to 1 if having a minor and 0 otherwise), and denote the probability as $\gamma(g, N_{it}, I_{i,t-1})$. Thus, the gamma function takes a total of 6 values for six categories: 1) male-headed households with income between 30-50% of local median income; 2) male-headed households with income less than 30% of local median income; 3) female-headed households without children with income between 30-50% of local median income; 4) female-headed households without children and with income below 30% of local median income; 5) female-headed households with children and with income between 30-50% of local median income; 6) female-headed households with children and with income below 30% of local median income. This specification is motivated by the fact that PHAs may prioritize households based on such observables and categories (Been et al., 2018; HUD, 2012).¹⁶ Once they receive a voucher, households can keep receiving subsidies as long as they are program eligible.¹⁷

It's worth noting that in the current model setup local governments establish their pref-

¹⁶Note that in the model, some households with income higher than the exogenously assigned eligibility income cut-offs are not eligible for housing assistance, so their probability of receiving a voucher is 0. The eligibility income cut-offs are heterogeneous to mimic the reality that there is regional variations in income cut-offs.

¹⁷In reality, voucher receivers may lose vouchers due to two sources of risk: 1) households may fail to find a landlord that agreed to use the vouchers within 90 days after the issue of vouchers; 2) existing voucher users may lose it because their landlords refuse to renew the lease. I cannot observe the loss of vouchers due to the first risk in the SIPP data, thus the first risk is not empirically distinguishable from the case that the government does not allocate a voucher to the household. For the second risk, SIPP data shows that only 4% of households lose a voucher after receiving the benefits for a while. Given that the second risk is quantitatively small, the model abstracts from this risk and takes the voucher receiving as an absorbing state.

erence for applicants, and people have a uniform marginal cost of program participation (stigma costs). Alternatively, the stigma costs could be heterogeneous and differ by income, gender, fertility, etc. Both government priorities and individual-specific stigma costs would introduce heterogeneity into the group of people participating in the program and receiving vouchers. Given that the available data is the aggregate application rate, rather than micro-level data on applicants, I cannot separately identify government priorities from the heterogeneous stigma costs. Therefore, I combine both into the government priorities, leaving the stigma cost homogeneous. To further justify this specification, official evidence has supported that PHAs have certain priorities for allocating housing vouchers based on household characteristics.¹⁸ However, there is no clear evidence showing that households have heterogeneous stigma costs of participating in the housing voucher program. Moreover, the specification of a homogeneous stigma cost has the advantage of capturing the economic factors that explain different types of households participating in the program, rather than attributing it to heterogeneous preferences.

Rental prices P^R are heterogeneous across households. Prices are i.i.d and are exogenously drawn from rental price distributions, which are allowed to vary across regions. For more details on the estimation of rental prices (rental rate and housing size), see Section 5.3 below and Appendix C.

In addition to housing assistance, low-income households receive other welfare benefits, e.g., Food Stamps, TANF, and EITC. The targeting of TANF and EITC is mainly toward female-headed households. Since it is complex to model multiple welfare take-up and benefits endogenously, I estimate take-ups and benefits of Food Stamps, TANF, and EITC using the SIPP data outside the model.¹⁹ For Food Stamps, I estimate the welfare benefit as a linear function of marital status, number of children, and labor income for both men and women. For TANF and EITC, I only estimate them for female-headed households: TANF is estimated as a linear function of marital status, number of children, and labor income; EITC benefits

¹⁸See HUD PHA Homeless Preferences: Web Census Survey Data (2012); HUD Section Housing Vouchers: https://www.hud.gov/topics/housing_choice_voucher_program_section_8; Been et al. (2018)

¹⁹Admittedly, housing vouchers could affect the receipt of other welfare programs and therefore affect household behavior indirectly. For example, Jacob and Ludwig (2012) found that receiving a housing voucher has a positive effect on participation in TANF. If TANF has a negative effect on household labor supply, then the result in my paper yields a lower bound on the effect of housing vouchers on labor supply.

are calculated based on marital status, number of children, and labor income according to the IRS EITC calculator.²⁰

4.3 Household Problems

4.3.1 Single Women

At each time t , a single female-headed household decides whether to work, whether to apply for a housing voucher, and how much to consume and save. At the beginning of a period, labor market and marriage shocks occur, and agents decide to marry (or divorce) by comparing their realized status quo value with outside options. Given marital decisions, agents then decide whether to apply for a housing voucher by trading off the expected value of receiving a subsidy based on rationing probability versus the stigma costs of applying. After the realization of vouchers, households decide on labor supply, savings, goods and housing consumption.

If a woman receives a voucher, her budget constraint is:

$$c_{it} + a_{i,t+1} + 0.3[w_{it}l_{it} + b_{it}(1 - l_{it}) + \text{tanf}_{it}] = w_{it}l_{it} + b_{it}(1 - l_{it}) + \text{tanf}_{it} + fs_{it} + \text{eitc}_{it} + (1 + r)a_{it} \quad (1)$$

where $a_{it} \geq 0$ is savings (assets, no borrowing allowed), w_{it} is the wage rate, and b_{it} is unemployment benefits which capture any formal or informal insurance during unemployment. The terms tanf_{it} , fs_{it} , and eitc_{it} represent benefits from TANF, Food Stamps, and EITC.²¹ When households receive a housing voucher, they contribute 30% of their income $w_{it}l_{it} + b_{it}(1 - l_{it}) + \text{tanf}_{it}$ for rent.²² Denote P_{it}^R as rental prices, then the subsidy amount is $P_{it}^R h_{it} - 0.3(w_{it}l_{it} + b_{it}(1 - l_{it}) + \text{tanf}_{it})$. The subsidy is in-kind rather than in-cash given that

²⁰<https://www.irs.gov/credits-deductions/individuals/earned-income-tax-credit/use-the-eitc-assistant>

²¹The welfare and unemployment benefits will ensure households have a minimum subsistence level even when not working.

²²The HUD rent calculations exclude certain benefits but include others in the determination of income. Benefits that count toward income and rent calculations include: Unemployment Insurance (UI), Social Security Disability Insurance (SSDI), Supplemental Security Income (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, Low Income Home Energy Assistance Program (LIHEAP), earnings from or payments from participation in Workforce Investment Act (WIA) programs, and EITC refunds in the income calculation (Collinson et al., 2015).

it increases with housing consumption h_{it} . In addition, the subsidy is decreasing in income with a marginal tax rate of 0.3. Thus, the household has an incentive to reduce labor supply l_{it} and increase housing consumption h_{it} when they receive a housing subsidy.

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

$$c_{it} + a_{i,t+1} + P_{it}^R h_{it} = w_{it} l_{it} + b_{it}(1 - l_{it}) + \tan f_{it} + f s_{it} + e i t c_{it} + (1 + r) a_{it}, \quad (2)$$

In the case where she receives no vouchers, she has to pay the full rent $P_{it}^R h_{it}$.

The state vector for a single woman is $\Omega_{it}^{SW} = \{z_i^W, N_{it}^{SW}, a_{it}^{SW}, v8_{it}^{SW}\}$, which is composed of labor productivity, fertility, assets, and housing vouchers. With probability λ_t , a single woman meets a man with characteristics $\{\widetilde{z}_i, \widetilde{a}_{it}, \widetilde{v8}_{it}\}$, 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 they decide to marry, 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 equation (1) or equation (2).

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

4.3.2 Single Men

A single male-headed household also decides whether to work, whether to apply for a housing voucher, and how much to consume and save in each period. The state space for a single man is $\Omega_{it}^{SM} = \{z_i^M, a_{it}^{SM}, v8_{it}^{SM}\}$.

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

$$c_{it} + a_{i,t+1} + 0.3[w_{it} l_{it} + b_{it}(1 - l_{it})] = w_{it} l_{it} + b_{it}(1 - l_{it}) + f s_{it} + (1 + r) a_{it} \quad (3)$$

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

$$c_{it} + a_{it+1} + P_{it}^R h_{it} = w_{it} l_{it} + b_{it}(1 - l_{it}) + f s_{it} + (1 + r) a_{it} \quad (4)$$

A single man is only eligible for unemployment and 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. equation (3) or equation (4).

$$V_{it}^{SM}(\Omega_{it}^{SM}) = \max_{\{c, h, a', l, B\}} u_{it}^{SM}(c, h, l, B) +$$

$$\beta E[\lambda_{t+1}[(1 - M_{i,t+1})V_{it+1}^{SM}(\Omega_{it+1}^{SM}) + M_{i,t+1}V_{it+1}^{MM}(\Omega_{it+1}^{MM})] + (1 - \lambda_{t+1})V_{it+1}^{SM}(\Omega_{it+1}^{SM})]$$

4.3.3 Married Couples

When a man and a woman get married, they make decisions on labor supply, program participation, consumption, and savings to maximize the joint household value.

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

$$c_{it} + a_{it+1} + 0.3[w_{it}^M l_{it}^M + w_{it}^W l_{it}^W + b_{it}(1 - l_{it}^M) + b_{it}(1 - l_{it}^W) + \tan f_{it}] =$$

$$[w_{it}^M l_{it}^M + w_{it}^W l_{it}^W + b_{it}(1 - l_{it}^M) + b_{it}(1 - l_{it}^W) + \tan f_{it}] + f s_{it} + e_{it} c_{it} + (1 + r) a_{it} \quad (5)$$

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

$$c_{it} + a_{it+1} + P_{it}^R h_{it} = w_{it}^M l_{it}^M + w_{it}^W l_{it}^W + b_{it}(1 - l_{it}^M) + b_{it}(1 - l_{it}^W) + \tan f_{it} + f s_{it} + e_{it} c_{it} + (1 + r) a_{it} \quad (6)$$

The state space for a couple is $\Omega_{it}^M = \{z_i^W, z_i^M, N_{it}^M, Q_{it}, a_{it}^M, v_{it}^M\}$. Let $V_{it}^M(\Omega_{it}^M)$ be the joint value function of a married couple. Denote the Pareto weight for husband as θ . Then the problem of a household is to maximize the following value function s.t equation (5) or equation (6).

$$V_{it}^M(\Omega_{it}^M) = \max_{\{c, h, a', l^M, l^W, B\}} (\theta u_{it}^{MM}(c, h, l^M, B) + (1 - \theta) u_{it}^{MW}(c, h, l^W, B)) +$$

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

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

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

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

are value functions of married women and men, respectively.

The marriage and divorce specification adopted in this paper is a special case of the limited-commitment intertemporal collective model ([Mazzocco, 2007](#); [Chiappori and Mazzocco, 2017](#)). In particular, married men and women pool their income together, and both spouses will benefit from an increase in overall household consumption. In this sense, the model inherits the unitary model characteristics in terms of goods and housing consumption. However, each spouse has their own value of leisure (or disutility of working), and they do not care about the other partner's leisure. Therefore, each spouse faces a trade-off between maximizing joint household consumption and increasing their own leisure. In this sense, the model has the collective model characteristics that individuals have distinct utilities.

The justification for specifying the consumption component as unitary rather than collective is as follows. First, the housing voucher is a household-based transfer that subsidizes the household's public goods (housing). It is not particularly targeting any specific member within a household. Second, the likelihood of receiving a voucher depends on the total household income and characteristics, rather than a particular spouse's income or characteristics. Third, this paper focuses on the effect of housing vouchers on labor supply, rather than intrahousehold resources allocation. More specifically, the intent to include marriage

is to capture the indirect effect of housing vouchers on labor supply through family formation (dissolution). Marriage in the model works as private insurance. Housing assistance (public insurance) could crowd out private insurance such as marriage to affect individual labor supply. Thus, a unitary model in consumption is sufficient to capture the channel of housing vouchers on labor supply through marriage. In addition, I allow spouses to have distinct utilities due to different private values of leisure to introduce the trade-off between aggregate household consumption and individual leisure (labor supply). This specification is more flexible to capture the individual response of employment to housing subsidies within marriage.

Another special case in the marriage model is that each partner has a constant preassigned Pareto weight rather than a Pareto weight determined by bargaining in every period. The justification is that the purpose of introducing the Pareto weights is to define the joint household optimization objective, but rather to examine intrahousehold resources allocation, which is important but out of the scope of this paper. Furthermore, to properly estimate the Pareto weights, we need distribution factors as well as an accurate description of marriage outside options. However, the division of vouchers upon divorce is complex and case-dependent, challenging the precise evaluation of outside options.²³ Thus, instead of estimating the Pareto weights internally from the model, I follow [Eckstein et al. \(2019\)](#) to specify a constant Pareto weight for both spouses.

5 Estimation

The estimation is based on the 1970s cohort of low-income renter households. I estimate the model parameters in three steps. First, I calibrate some parameters outside the model. Second, I estimate the fertility process, the distribution of potential spouses, the

²³When two people get married, if one of the spouses has a voucher already, then the couple can keep using the voucher if the newly formed household is still eligible based on total household income. However, if a family breaks up, the housing authority has the discretion to determine which members of the family would continue to receive assistance. In reality, several factors could determine who remains on the program, such as domestic/dating violence; stalking; the interest of minor children or of ill, elderly, or disabled household members; and any additional considerations that the housing authority may identify. For computational tractability, the model abstracts from these factors and assumes that women will continue to receive assistance after divorce. For more details, see <https://hcr.ny.gov/system/files/documents/2019/02/adminplansection120determiningassistanceifafamilybreaksup.pdf>

distribution of unemployment benefits, and the distribution of rental prices directly from the data without imposing the model structure. Finally, I explore the exogenous variations in rental prices, and the government allocation system of housing vouchers to estimate the remaining parameters internally by the Method of Simulated Moments (MSM). These parameters include earnings parameters $(\beta_0^g, \beta_1^g, \beta_2^g, \sigma_{\zeta^g}, \sigma_{\epsilon^g})$, preference parameters $(\alpha, \phi^{SM}, \phi^{MM}, \phi_0^{SW}, \phi_1^{SW}, \phi_0^{MW}, \phi_1^{MW}, \nu)$, those governing marriage dynamics (σ_Q^2, λ_t) , and policy parameters related to the uncertainty around receiving a voucher, $\gamma(\cdot)$. I simulate the theoretical moments and minimize the difference between simulated moments and data moments.

5.1 Initial Conditions

I first specify the initial conditions of the model. In the model, people start at age 20. By that age, only a small share of men and women had gotten married and given birth. Therefore, the proportions of married men and women, and the proportion of women with children (separately for married and single women) at age 20 are all set to zero. Initial labor productivity is heterogeneous and drawn from 5-grid discrete sets $[-2\sigma_{\zeta^g}, -\sigma_{\zeta^g}, 0, \sigma_{\zeta^g}, 2\sigma_{\zeta^g}]$ for men and women separately.

5.2 Externally Calibrated Parameters

The values and references of the externally calibrated parameters are reported in Table A.1. Agents are assumed to have a constant risk aversion coefficient of $\gamma = 1.5$. The annual discount factor is $\beta = 0.96$. Following Voena (2015), the economy of scale is set to 0.61.²⁴ The annual interest rate for assets (savings) is 2%, set to match the risk-free interest rates. The husband Pareto weights $\theta = 0.5$ is drawn from Eckstein et al. (2019).²⁵ The rental housing sizes h are calibrated from Zillow and set to be 3 discrete values $[0.7, 1, 1.5]$. Note that there is an FMR cap for voucher rented housing, so the rental housing size is discretized

²⁴The results are robust with respect to a range of economies of scale in $[0.5, 0.7]$.

²⁵The model results are robust with respect to a range of husband Pareto weights in $[0.5, 0.7]$, which is consistent with the estimates of Pareto weights from the existing literature (see (Low et al., 2018) and the references therein).

for housing below the national median rental housing size. For more details on the calibration of housing size, see Appendix C.

5.3 Externally Estimated Parameters

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. The estimated transition probabilities are in Figure A.1. The distribution of characteristics of single men and women comes 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.

The unemployment benefit b is drawn from the unemployment benefit distribution from the SIPP data. The mean and standard deviation of unemployment benefits are \$650 and \$700 respectively.²⁶

To capture the heterogeneity in eligibility income cut-offs and rental prices (rental subsidies) across different regions, I classify all the MSAs by the income cut-offs into five groups (quantiles) using the empirical distribution of income cut-offs.²⁷ I then take the mean of the income cut-offs within each group. Accordingly, the model classifies all the simulated households into five groups. Each household is assigned an exogenous income eligibility cut-off based on their assigned group. For example, if a simulated household is assigned to group 1, then its income eligibility cut-off will be the mean of the income eligibility cut-off in group 1 from the data. Similarly, for households in groups 2, 3, 4, and 5, their income eligibility cut-offs will be the mean of the income eligibility cut-offs in groups 2, 3, 4, and 5, respectively. In addition, for each household in the model, the rental prices P^R are drawn from a distribution with mean μ_{PR} and variance σ_{PR} . The mean and variance are allowed to vary across the five groups. In particular, based on the group of MSAs classified above, the mean and variances of the rental prices for each group are estimated from the American Community Survey (2001-2017). Thus, rental prices (as well as the associated subsidy

²⁶Admittedly, unemployment benefits depend on unemployment spells and previous employed wages. In this model I introduce unconditional heterogeneous unemployment benefits in order to capture any formal or informal insurance households would get during unemployment.

²⁷<https://www.huduser.gov/portal/datasets/il.html>

amount) have both across region (group of MSAs) variations and within region variations.

5.4 Internally Estimated Parameters

I apply the 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 parameters in the earnings equation for men and women separately $(\beta_0^g, \beta_1^g, \beta_2^g, \sigma_{\zeta^g}, \sigma_{\epsilon^g})$; share of goods/housing in total consumption $(\alpha/1 - \alpha)$; the variance of initial match quality (σ_{Q0}^2) and the variance of shocks to existing marriage (σ_Q^2) ; the probability of meeting someone at young (age 20-30), middle (age 31-40), and old age (age 41+) $(\lambda_y, \lambda_m, \lambda_o)$; the disutility of working for single men (ϕ^{SM}) and for married men (ϕ^{MM}) , the disutility of working for single women with or without children $(\phi_0^{SW}, \phi_1^{SW})$, for married women with or without children $(\phi_0^{MW}, \phi_1^{MW})$; the stigma cost of participating in the program (ν) and the probability of receiving a voucher for men and women with income above or below 30% of local median income, and for women with or without children $\gamma(\cdot)$.

Empirical moments ϕ_{data} are calculated from the 1970s birth cohort of low-income renters from 2001-2017. To reduce the moment dimensionality and facilitate computation speed, I group the sample into 5-year age groups: 20-24, 25-29, 30-34, 35-39, and 40-44. The mean and standard deviations of earnings by gender and 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 .

Though it is not straightforward to prove identification under this full structure framework, I provide an intuition for how I explore the exogenous variations in government allocation of vouchers and rental prices for identification. In particular, I explore the variation conditional on household application decisions and demographics (i.e., income, fertility, and

gender); whether a household receives a housing voucher is random.²⁸ Specifically, the treated group comprises households that apply for housing vouchers and receive a voucher. In contrast, the control group comprises those that apply for housing vouchers but do not receive one due to government rationing. The treatment and control groups are both based on endogenous program take-up to control for selection into the program. The identification mainly comes from the fact that, conditional on endogenous program take-up, whether a household can get a voucher depends on the observed household characteristics and random lotteries. For example, consider two identical households: both applied for housing vouchers; however, one received a voucher but the other did not due to rationing. Then the difference in their labor supply behavior will be the sources of variation in the model to identify the parameters. The quasi-random allocation system affects household behavior through budget constraints but does not correlate with individual preferences, acting as an exclusion restriction. Similarly, market-level rental prices will affect household budget constraints but not correlate with preferences, thus acting as exclusion restrictions. Admittedly, the rental price for a specific unit depends on idiosyncratic factors. However, the model's rental price captures the market price determined by overall regional supply and demand, and a household is assumed to be a price taker. The rental rate would introduce heterogeneity in budget constraints for two similar households that live in different regions and thus face different rental prices. These variations are explored to explain differences in labor supply of otherwise identical individuals, attributing the employment difference to voucher use, or exogenous variations in rental prices.

Furthermore, 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. Although all of the moments are used to estimate all of the parameters, some moments are especially important in identifying certain parameters. The first set of moments includes conditional moments for labor supply, i.e., proportions of men employed by marital status and 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

²⁸This identification assumption is valid given that most PHAs first give priorities to certain demographic groups, and then adopt either random lottery or first come first served system to allocate vouchers among applicants.

applied for a housing voucher and the proportions of low-income households 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 pin down the probability of getting a voucher for different demographics. The third set of moments contains the ratio of housing spending over income, which helps determine the weight of housing and goods consumption in the utility function. The fourth set of moments includes the mean and variance of logarithm wages by gender and age group. These moments help determine the male and female earnings parameters. The last set of moments is marriage and divorce rates by age group, which contribute to pinning down the variance of marriage shocks and the probability of meeting a partner.

5.5 Model Fit, Validation using RCTs, and Estimated Parameters

The model fit for the moments is shown in Table 2, and the ones for the evolution of mean and variance of wages, marriage and divorce rates by age group are displayed in Figure 3. The model can replicate the targeted moments. In addition to validating targeted moments (internal validity), I have compared estimates of the model simulated data to the estimates from the existing studies that use RCTs. The model can reproduce reduced-form estimates on the effects of housing vouchers on labor supply (external validity). Specifically, I simulate the model for men and women over a 30-year period. I then use the simulated data to run regressions and estimate the effects of housing vouchers on labor supply. I compare my estimates from model-simulated data with estimates from [Jacob and Ludwig \(2012\)](#) and [Mills et al. \(2006\)](#). It is worth noting that [Jacob and Ludwig \(2012\)](#) estimates the short-run effects of housing vouchers on labor supply (within 5 years of receiving a voucher). Thus, to make the estimates comparable, I also use the model simulated data to estimate short-run effects, though my model is able to estimate the long-run effects, which is presented after the validation exercise. In addition, [Jacob and Ludwig \(2012\)](#) explore an RCT using a random lottery among voucher applicants and compare voucher recipients vs. non-recipients to estimate the effects of housing vouchers. Similarly, I explore the random allocation of vouchers by the government conditional on household characteristics among simulated voucher applicants to estimate the effects of housing vouchers. In particular, I

estimate the following regression using the simulated voucher applicant subsample:

$$Y_{it} = \delta \text{voucher}_{it} + \text{age}_{it} + \text{age}_{it}^2 + \text{price}_{it} + \text{child}_{it} + \text{gender}_i + \text{productivity}_i + \gamma_t + \epsilon_{it} \quad (7)$$

where voucher_{it} is a dummy variable equal to 1 if the individual i has a voucher in time t . In addition, I also control for age, age squared (age_{it}^2), rental prices (price_{it}), gender (gender_i), productivity (productivity_i), children (child_{it}), and time fixed effects (γ_t).

Table 3 presents the results. The first and second rows show the coefficients and their magnitude relative to the sample mean from the existing literature. In particular, [Jacob and Ludwig \(2012\)](#) found that housing vouchers reduce labor supply by 4pp (6% relative to the mean). Similarly, [Mills et al. \(2006\)](#) found that housing vouchers reduced the employment rate by 4pp (8% of the mean). The last row shows the estimates from my model-simulated data, which are quantitatively similar to the findings from the existing evidence in the literature. Altogether, the evidence suggests that the model is valid to produce aggregate household behaviors, and micro-level estimates (regression coefficients).

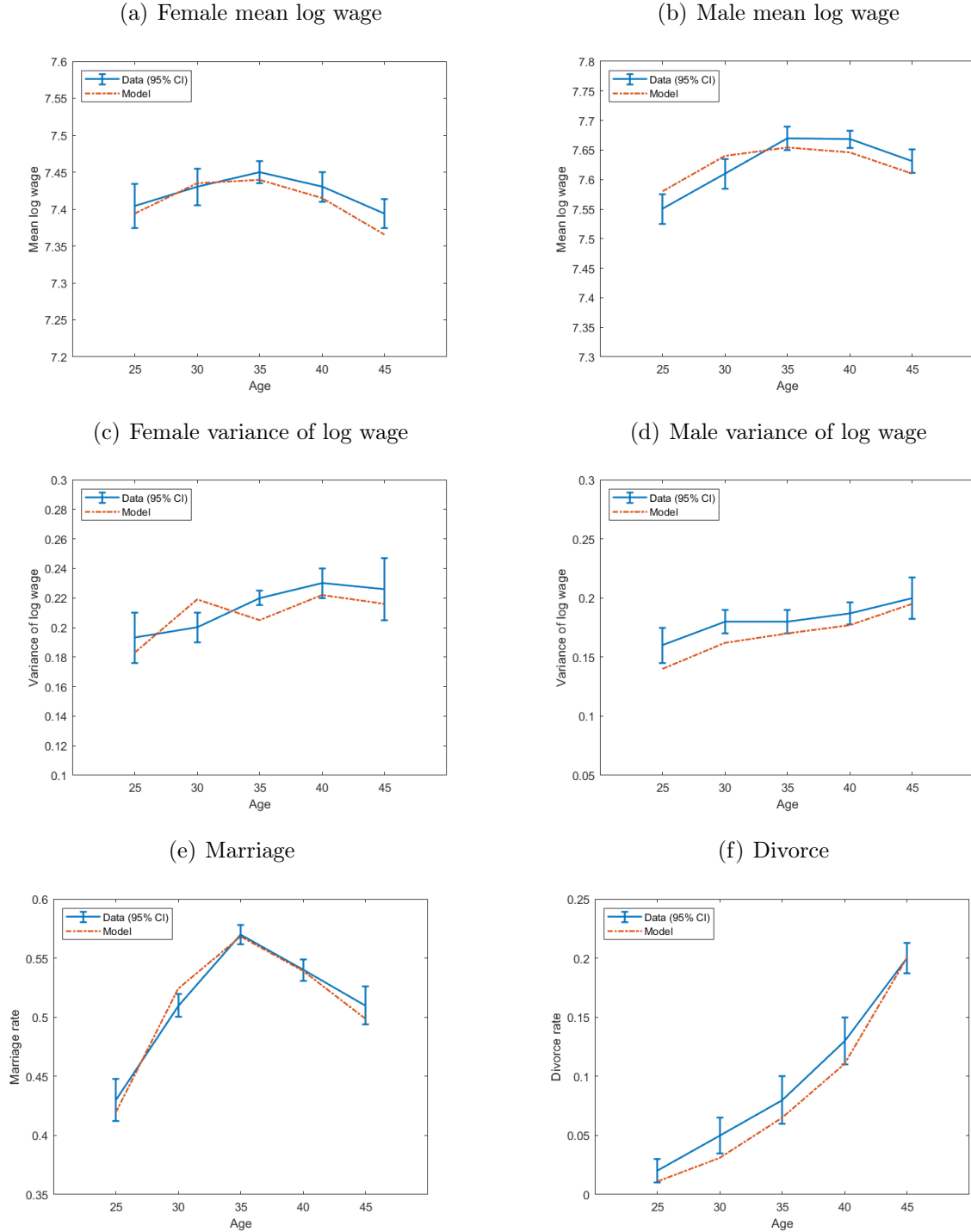
Table 2: Model Fit: Targeted moments

	Model	Data	95% CI
Employment rate			
Single male	0.78	0.78	(0.77, 0.79)
Married male	0.85	0.84	(0.83, 0.85)
Single female w/o children	0.74	0.74	(0.73, 0.75)
Single female w children	0.66	0.66	(0.64, 0.67)
Married female w/o children	0.52	0.50	(0.48, 0.52)
Married female w/ children	0.42	0.42	(0.41, 0.43)
Housing			
Voucher application rate	0.29	0.29	n.a.
Share of housing spending over income	0.42	0.43	(0.41, 0.45)

Notes: This table compares the model simulated moments to their data counterparts. Employment rates and their 95% confidence intervals (CI) are calculated from the SIPP. The voucher application is calculated from the HUD PHA Homeless Preferences: Web Census Survey Data (2012). The share of housing spending over income is calculated from the American Housing Survey (2001-2017).

Table A.2 reports internally estimated parameters and their standard errors. The earn-

Figure 3: Model Fit: Targeted Moments by Age



Notes: This figure compares the model simulated wages, marriage, and divorce profiles to their data counterparts. The solid blue lines are the moments and their 95% CI by age group calculated from the SIPP data. The dashed red lines are the model simulated counterparts. Panel (a) and (b) display the mean log monthly earnings for women and men separately. Panel (c) and (d) show the variances of monthly log earnings for women and men, respectively. Panel (e) and (f) depict the marriage and divorce rates by age group.

Table 3: The Effect of Housing Vouchers from Model Simulated Data

	Estimates	Relative to the mean
Jacob and Ludwig (2012)	-0.04	6%
Mills et al. (2006)	-0.04	8%
This model's simulation	-0.05	7.5%

Notes: This table compares the estimates from the existing reduced form papers and my model simulation. The model simulated 5000 female-headed households and 5000 male-headed households born between 1970-1980.

ings parameters are estimated for men and women separately. Both men and women have a concave wage profile, captured by a positive coefficient of age and a negative coefficient of age square. The variance of male productivity is estimated to be 0.044 and that for female productivity shock is estimated to be 0.04. The variances of income shocks for men and women are estimated to be 0.04 and 0.043, respectively. The combination of the variances of productivity and measurement errors can produce the large dispersion in earnings that we observed in the data.

Single men have a higher disutility of working in absolute value than married men, which is consistent with the fact that single men work less than married men. The disutility of working is higher in absolute value for married women than that for single women and the disutility of working for women with children is higher than that for women without children. These parameters help us match women's employment patterns by marital and fertility status.

The variances of the shock to the initial marriage match and to existing marriages is estimated to be 0.18. The annual probabilities of meeting someone at a young age (20-30), middle age (31-40), and old age (41+) are 0.08, 0.04, and 0.035, respectively. The larger meeting probability for young people suggests that individuals are more likely to get married at an early age.

The share of goods (housing) consumption in the utility function is $\alpha = 0.6(0.4)$. The stigma cost of voucher program participation is estimated at 0.015, which is identified by the share of 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 $\tau = 5\%$.

The conditional probabilities of households receiving vouchers are reported for male-headed households with income above or below 30% of local median income ($\gamma_{lm} = 0.02$, $\gamma_{hm} = 0.04$), female-headed households with income above or below 30% of local median income with children ($\gamma_{lwc} = 0.05$, $\gamma_{hwc} = 0.09$) or without children ($\gamma_{lwn} = 0.04$, $\gamma_{hwn} = 0.04$). The parameters imply that relatively low-income households have a higher chance of receiving vouchers; 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. These estimates are consistent with the characteristics of voucher recipients as shown in Table 1.

6 Long-run effects of housing vouchers

In this section, I use the model to examine the long-run dynamic effects of housing vouchers on labor supply by gender. All else being equal (i.e., shocks, household characteristics, etc.), I conduct a counterfactual exercise in which there are no housing subsidies. Then I compare the employment outcomes for the same household in the baseline with vouchers and in the counterfactual exercise without vouchers to estimate the effect of housing subsidies on labor supply. I focus on the effects within 10 years after households receive vouchers. In particular, I run the following event-study analysis:

$$Y_{itr} = \sum_{j=-5}^{10} \delta_j \text{voucher}_{i,t-j,r} + \alpha_{it} + \epsilon_{itr} \quad (8)$$

where i indexes an individual, t indexes a year, and r represents a regime, i.e., baseline or counterfactual. The term Y_{itr} is a dummy variable equal to 1 if the individual i works in time t under regime r . The term $\text{voucher}_{i,t-j,r}$ is the treatment of whether the individual receives a voucher in year $t - j$ in regime r . The term δ_j is the coefficient of interest, which measures the effect of housing vouchers on labor supply in years j since receiving a voucher. I also include the individual by time fixed effects (α_{it}), which indicates that we compare the outcomes for the same person in the same year but in different regimes. I run the event-study analysis by gender separately.

The long-term effects of housing vouchers on employment are reported in Figure 4. Panel (a) displays the coefficients from the event study analysis for women. It shows that housing vouchers have a persistent negative effect on female labor supply at 10pp (17% relative to the mean) from the first year that households receive vouchers. Panel (b) displays the long-run effects of housing vouchers on employment for men. Voucher usage reduces male employment by 6pp (7% relative to the mean) in both short run and long run. The heterogeneity effect by gender suggests that men and women have different labor supply responses to housing benefits. Specifically, women’s labor supply is more elastic with respect to housing assistance.

It is worth noting that the short-run effects are similar to the long-run effects. That is, the estimates of housing vouchers on individual labor supply are persistent over time. This suggests that the composition of the dynamic effect channels is quantitatively small in affecting long-term labor supply. Remember that the three dynamic effect channels are: lifetime wealth channel through asset accumulation, strategic motive channel to maintain program eligibility when experiencing positive income shocks, and family formation channel.

To investigate the quantitative effect of each dynamic channel, I first find that housing benefits do not play a significant role in promoting low-income household asset accumulation, thus the lifetime wealth effect channel is limited in affecting long-run household labor supply.²⁹ I then find that most of voucher receipts tend to be low-productivity households (as shown in Column (1) of Panel C in Table 4), who are still eligible if experiencing positive income shocks and working.³⁰ Therefore, very few recipient households will face the trade-off between losing the voucher benefits if working and maintaining voucher benefits if not working. In this sense, the strategic motive channel of reducing labor supply to maintain program eligibility is limited in affecting long-run labor supply as well.

Furthermore, I examine the family formation channel. I first show the long-term dynamic effect of vouchers on marriage and divorce by estimating Equation (8) on a dummy variable

²⁹Note that vouchers are generally not limited due to assets levels. In cases where a family receives net income from assets, the net income will be counted into family annual income when determining program eligibility. For more details, see https://www.hud.gov/sites/documents/DOC_35701.PDF

³⁰Low- Median- and High-productivity households are defined by individual labor productivity z in the model. Since labor productivity in the model is discretized into 5 grids $[-2\sigma_{\zeta^g}, -\sigma_{\zeta^g}, 0, \sigma_{\zeta^g}, 2\sigma_{\zeta^g}]$, low productivity is defined as households with labor productivity less than 0, median productivity is defined as households with labor productivity 0, and high productivity is defined as households with labor productivity greater than 0.

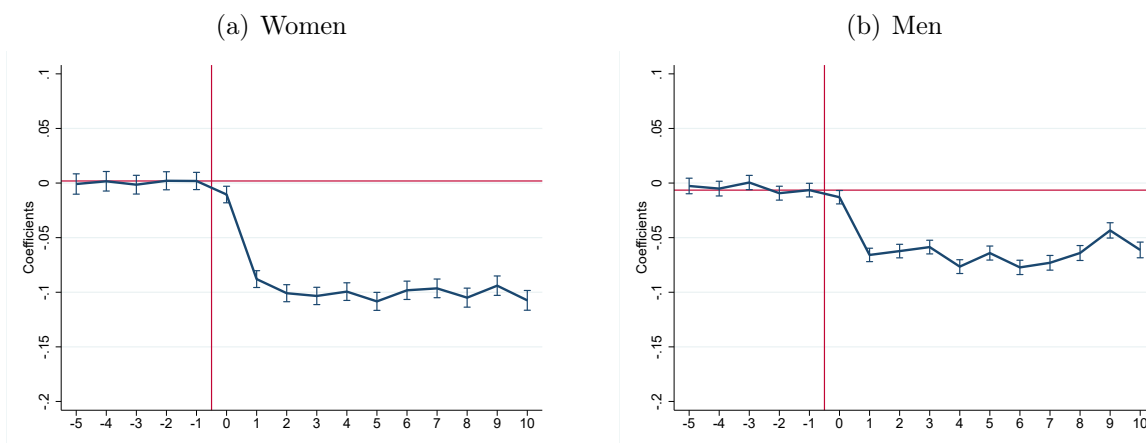
of being married and a dummy variable of being divorced. Figure 5 shows that housing subsidies have a long-term negative effect on marriage and a positive effect on divorce. Specifically, voucher usage gradually reduces the share of individuals being married by 1pp annually. The negative impact on the share of married individuals suggests that housing subsidies improve the outside options for marriage thereby reducing the relative benefits of marriage. To further examine whether this is driven by more married couples getting divorced or fewer single people getting married, Panel (b) displays the event-study analysis of vouchers on the share of individuals getting divorced. It shows that housing assistance has a positive effect on divorce. In particular, the divorce rate gradually increases from 2pp in the short run to 5pp in the long run. This suggests that housing subsidies improve the outside options for marriage and lead to a higher divorce rate in existing couples. The magnitude of the effects on marriage (10pp in the long run) and on divorce (5pp in the long run) implies that housing vouchers lead to more married couples getting divorced and fewer single people getting married.

Compared to other welfare programs (e.g., TANF and Food stamps), the effects of housing vouchers on marriage and divorce in the long run are substantial for the following reasons. First, the housing voucher program subsidy is much more generous than other popular welfare programs in the U.S. For example, the average monthly benefit of TANF is \$315, and the average monthly benefit from Food Stamps is \$360 (SIPP 2001-2018, inflation adjusted by CPI). In contrast, the average monthly benefit of the housing voucher program is as much as \$750 for all voucher recipients, and in large MSAs with high rental prices or for households with extremely low incomes, the average monthly benefit could be as much as \$1,200-1,500 (HUD). A large amount of housing subsidies implies a high value of public insurance that could crowd out private insurance such as marriage, thus suggesting a more substantial impact on family formation given its high stakes. Second, unlike other welfare programs, the housing voucher program aims to subsidize housing, which is a public good in the household. Subsidies for public goods presumably have a larger impact on family formation than subsidies on private goods (or cash subsidies on both private and public goods) because the primary economic incentive for an individual to form a family is to take advantage of economies of scale in terms of public goods. For this reason, we would expect

that subsidies for public goods are more likely to have a larger impact on marriage and divorce than cash assistance or subsidies for private goods.

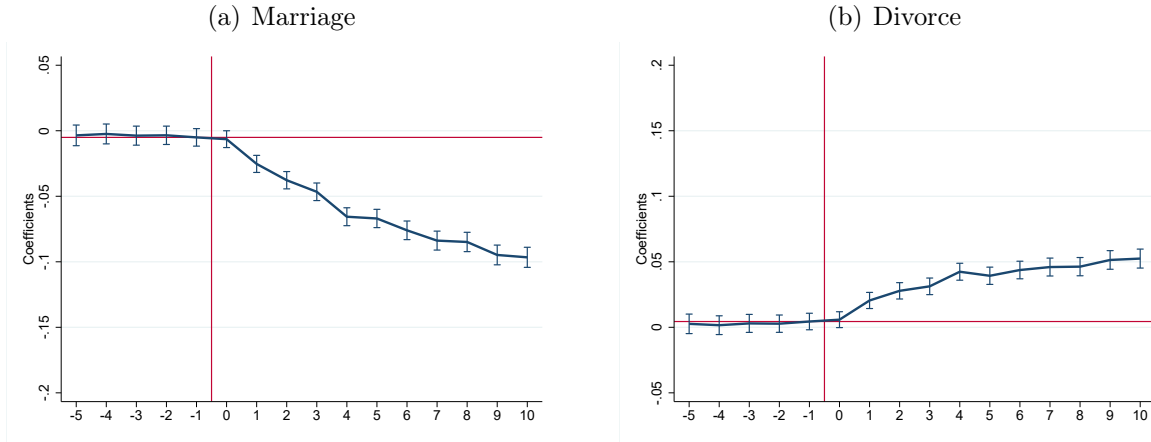
To control for the effect of housing vouchers on labor supply through marriage, I fix the individual marital status as the (counterfactual) scenario where there are no housing subsidies, then I introduce the current housing voucher program and examine how it would affect labor supply. The comparison between the baseline case (where marital status can adjust due to vouchers) and the counterfactual case (where marital status cannot adjust due to vouchers) sheds light on the employment effect through marriage. As shown in Figure 6, the negative effect of vouchers on female labor supply becomes larger if we control for marital status. This is because vouchers have a negative effect on marital status and women work more when being single compared to being married. Thus, the interaction between housing subsidies and marital status generates a positive effect on female labor supply. However, the positive effect is quantitatively small (1pp in the short run and 2pp in the long run). The small quantitative effect could be because the major recipients of vouchers, i.e., 77% according to column (2) of Table 1 are single-headed households. On the other hand, I do not find a significant interaction effect between housing subsidies and marriage on male employment. This is because single and married men do not have a big difference in employment behavior. Even if housing assistance affects men's marital status, it's implausible to generate a significant effect on men's employment.

Figure 4: The Long-run Effects of Vouchers on Employment by Gender



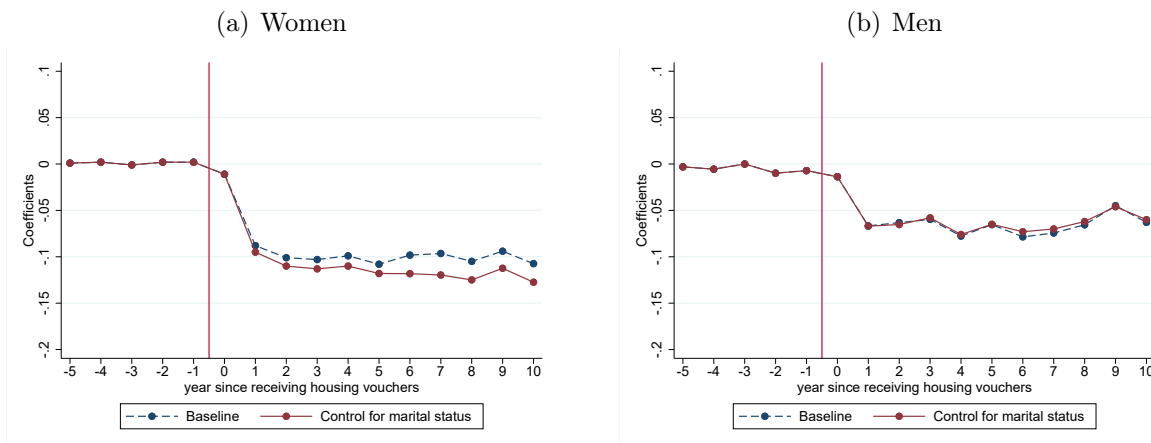
Notes: This figure displays the long-run effects of housing vouchers on employment rate by gender. Time 0 is when the household receives a housing voucher.

Figure 5: The Long-run Effects of Vouchers on Marriage and Divorce



Notes: This figure displays the long-run effects of housing vouchers on marital status. Time 0 is when the household receives a housing voucher.

Figure 6: The Long-run Effects of Vouchers on Employment by Controlling for Marital Status



Notes: This figure displays the long-run effects of housing vouchers on labor by controlling for marital status. The solid blue line is the estimates in the baseline without controlling for marital status; the dashed red line is the estimates by controlling for marital status in a counterfactual exercise. Time 0 is when the household receives a housing voucher.

After examining each dynamic effect channel, the next step is to quantitatively decompose the impact of the two static channels: substitution effect and income effect in explaining the employment drop (in both the short and long run). I explicitly examine the quantitative impact of the substitution channel through the flat assistance counterfactual experiment in the policy experiment section below. In addition, I use the percent income change induced by a HUD tax rate change to calculate the labor supply elasticity. In the current baseline model, the HUD tax is 30%. To calculate the labor supply elasticity (at the participation margin), I simulate a one-time change in the HUD tax from 30% to 20% at age 35. Using this one-time change in the HUD tax rate and its associated labor supply change, I calculate the labor supply elasticity at the extensive margin for voucher recipients, which are 0.14 and 0.16 for men and women, respectively.³¹ With the substitution effect channel, the income effect channel is the residual channel that can be inferred from the difference between the overall effect and the substitution effect.

7 Policy Experiments

The most important use of the model and structural estimates is to study the effects of potential reforms on household labor supply and welfare. I consider three 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, which sheds light on the quantitative effects of the substitution channel. 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 voucher users can only receive assistance for a maximum of 5 years. The intent behind the second and third reforms is to mitigate the problem of rationing. It is worth noting that for all the policy changes, I not only examine the effect of the policy change on low-income households who are always eligible for the program but also examine

³¹I also follow French (2005) to calculate the Frisch labor supply elasticity, which captures the sum of the substitution elasticity and measures people's willingness to trade off work and consumption over time. I simulate a 10% wage change for individuals at age 35 and calculate the percent change in labor supply. The Frisch labor supply elasticity at the participation margin for men and women are 0.24 and 0.53, respectively.

the impact of selection into the program by households who may initially be ineligible but endogenously reduce labor supply for eligibility. Allowing households to select into and out of the program will help us thoroughly understand each of the policy experiments on household behavior.

For each policy, I show the implications for low-income household labor supply, marriage and divorce rates, program participation, as well as 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 at 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 8](#), I will discuss the program’s effect on rental prices and provide suggestive evidence of the housing market equilibrium effect on my results.

7.1 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. [Figure A.2](#) depicts the subsidy structure for the baseline and the experiment. The flat amount (\$650) is set such that government expenditure on the program in the experiment is equal to that in the baseline. Note that the new policy environment also adopts the baseline administrative constraints such as government allocation rules (rationing).

The flat assistance policy removes the negative substitution effect so it can gauge the quantitative effects of the substitution channel on labor supply. In addition, the new policy shifts resources from relatively lower-income households to relatively higher-income households: in the baseline 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.³² One consequence of shifting the resources is that some high-income (ineligible) households would strategically reduce their employment and earnings in order to receive benefits from the new policy. I examine this endogenous selection into the program by calculating the share of ineligible households in the baseline that participate in the program in the policy experiment.

The first two columns in Table 4 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 the female labor supply. In particular, the employment rate for women increases by 2pp (4% increase relative to the baseline mean). At the same time, the policy has a positive (negative) impact on marriage (divorce). Specifically, the marriage rate increases from 51pp to 53pp and the divorce rate decreases from 8pp to 6pp. The proportion of people receiving housing vouchers is 0.12 and 0.13 in the baseline and the policy experiment, respectively.

The aggregate increase in employment could be a result of multiple channels. First, flat assistance removes the negative substitution effect and thus promotes household labor supply (treatment effect). Second, it could result from a compositional change of households selecting into the program (composition effect). For example, it is possible that the households applying for vouchers in the baseline are relatively low-income households, while those in the new policy are relatively high-income households. Third, the new policy affects family formation, thus generating an indirect effect on labor supply. To examine the quantitative contribution of the three channels in accounting for the aggregate change, I first document the compositional change of households participating in the program. I then explicitly estimate the treatment and marriage effects, leaving the compositional effect as the residual channel.

To document the compositional change of households participating in the program, Column (2) of Panel C in Table 4 shows the application rates for overall households and the application rates by productivity and gender. The overall participation rate increases from 29% in the baseline to 30% in the counterfactual. A further decomposition by productivity

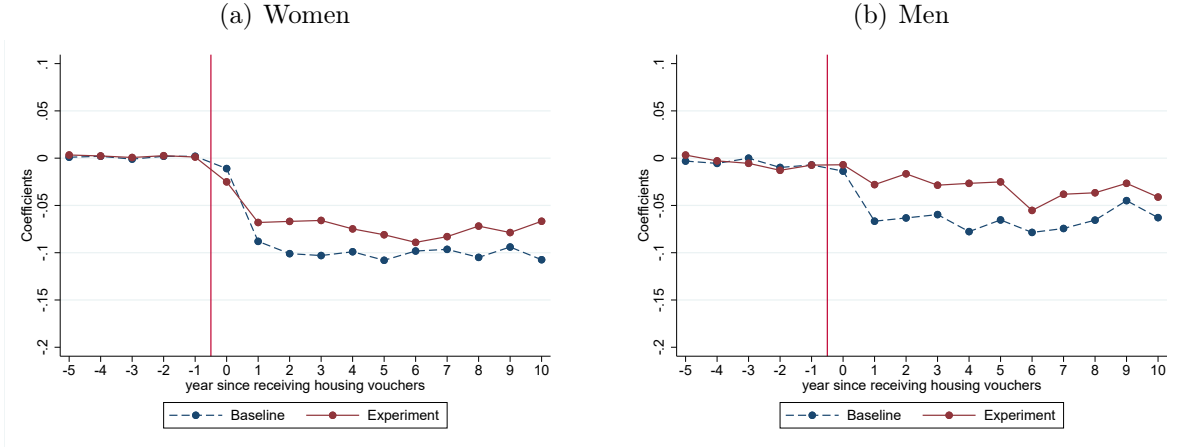
³²The sample for all the policy experiments is still the low-income households that are eligible for the voucher program. "Low-income households" here refer to the extremely low-income households while "high-income households" refer to the low-income households that are relatively rich.

shows that low productivity households decrease their application by 2pp (5% relative to the baseline), while median and high productivity households increase their application by 3pp (11% relative to the baseline) and 2pp (13% relative to the baseline). The increase for median and high productivity households is consistent with the fact that resources shift to relatively high-income households in the policy experiment. In addition, male-headed households increase their application more than female-headed households, because male-headed households on average have higher income and relative high-income households benefit from the policy change. Moreover, the share of ineligible households in the baseline who become eligible in the experiment and select into the program is 4%. The low share suggests that the incentives from the increase in benefits are not strong enough to change household behavior on the eligibility margin, probably because of low chances for high-income households to receive a voucher due to rationing.

To quantify the treatment effect of the policy change, I estimate the dynamic treatment effect (Equation (8)) using the simulated data in the policy experiment. I then compare the estimated coefficients with the estimates from the baseline and present the results in Figure 7. The red solid line shows the estimates of voucher usage on labor supply using the simulated data from the flat assistance experiment. Compared to the baseline estimates, flat assistance has a smaller treatment effect on employment for both men and women. Specifically, the treatment effect of flat assistance on women’s employment is on average 2pp smaller than that of the baseline. On the other hand, the treatment effect of flat assistance on men’s employment is on average 3pp smaller than the estimates from the baseline. The comparison between the estimates from the baseline and the policy experiment suggests that removing the negative substitution channel account for a 2pp (4% relative to the baseline mean) employment increase for women and a 3pp (4% relative to the baseline mean) employment increase for men.

To gauge the employment effect through marriage, I impose the individual marital status in the experiment the same as that in the baseline and compare the employment change. The labor supply of female-headed households under this exercise further increases by 1pp compared to the baseline. That is, the employment rate for women increases from 0.56 in the baseline to 0.59 in this counterfactual exercise. This evidence suggests that the interaction

Figure 7: The Long-run Effects of Flat Assistance on Employment by Gender



Notes: This figure displays the long-run effects of flat assistance on employment rate by gender. Time 0 is when the household receives a housing voucher.

between flat assistance and marriage generates a negative impact on labor supply that goes against the overall increase in aggregate employment for women. Altogether, the overall increase in employment for women, i.e., the majority of voucher recipients in the baseline and policy experiment, is primarily driven by the treatment effect of removing the substitution channel. The policy also has a positive treatment effect on men's employment. However, this positive effect does not significantly drive up overall men's employment because men are not the majority of voucher recipients in both the baseline and policy experiment.

7.2 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 offers substantial subsidies for only a few families, aiming to address the problem of low permanent income. However, the current program might be suboptimal because the more money provided to the same households, the lower the marginal benefits. 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, every family who applies for a voucher will be granted one, though the subsidy is less generous. Thus, it eliminates the adminis-

Table 4: Policy Experiments

Variables	Baseline (1)	Flat assistance (2)	Lower to all (3)	Time limits (4)
<u>Panel A: Employment</u>				
Men	0.81	0.81	0.79	0.82
Women	0.56	0.58	0.54	0.58
<u>Panel B: Family formation</u>				
Proportion married	0.51	0.53	0.46	0.52
Proportion divorced	0.08	0.06	0.10	0.08
<u>Panel C: Participation</u>	0.29	0.30	0.42	0.31
<i><u>By productivity</u></i>				
Low productivity	0.45	0.43	0.73	0.44
Median productivity	0.27	0.30	0.32	0.31
High productivity	0.16	0.18	0.05	0.18
<i><u>By gender</u></i>				
Male	0.22	0.26	0.32	0.24
Female	0.34	0.33	0.47	0.36
<i><u>Ineligibles in baseline</u></i>	0	0.04	0.01	0.06
<u>Panel D: Prop. w/ vouchers</u>	0.12	0.13	0.42	0.14

Notes: This table reports the key statistics from the model simulated baseline and policy experiments. Column (1) reports the moments for the baseline (current program); column (2) reports the statistics for the first experiment in which every voucher recipient receives the same amount of subsidy; column (3) shows the moments from the second experiment in which government provides lower benefits to all households that apply for vouchers; column (4) presents the moments from the third experiment in which subsidies are time-limited. Participation in the program refers to applying for a housing voucher, but not necessarily receiving one. Low- Median- and High-productivity households are defined by individual labor productivity z in the model. Since labor productivity in the model is discretized into 5 grids $[-2\sigma_{\zeta^g}, -\sigma_{\zeta^g}, 0, \sigma_{\zeta^g}, 2\sigma_{\zeta^g}]$, low productivity is defined as households with labor productivity less than 0, median productivity is defined as households with labor productivity 0, and high productivity is defined as households with labor productivity greater than 0.

trative constraints of rationing. To keep the 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 36% lower such that the government budget is the same as the baseline.³³ The same marginal tax rate and the less generous subsidy in the policy experiment imply that the substitution effect channel is preserved to be the same as the baseline, but the income effect is mitigated as a result of lower benefits. Eliminating rationing implies that it will substantially change the volume and composition of households participating in the program.

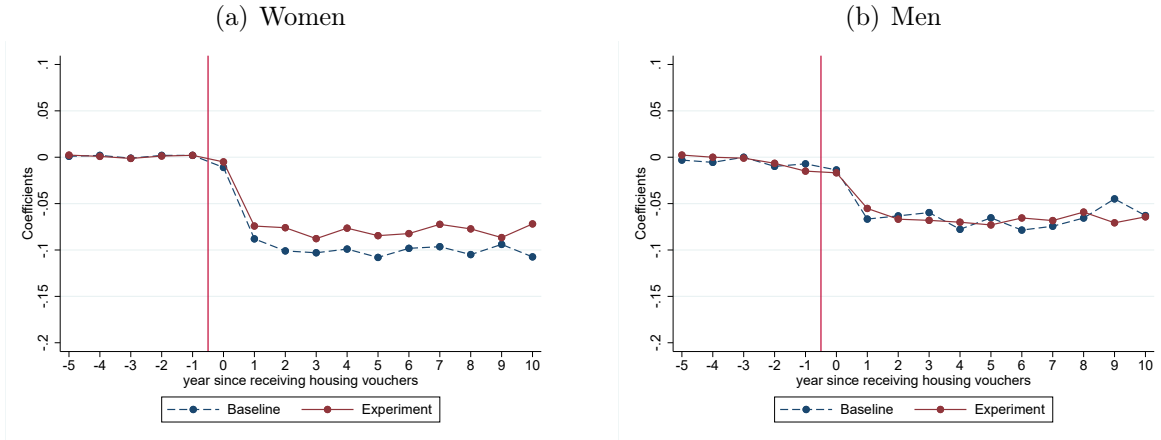
Column (3) in Table 4 presents the result of the policy change on household behavior. Providing lower benefits for all applicants has a negative impact on both men’s and women’s employment. In particular, the policy change reduces men’s employment by 2pp (3% relative to the mean) and women’s employment by 2pp (4% relative to the mean), respectively. In addition, the policy change also has a negative impact on family formation. It reduces the marriage rate by 5pp (10% relative to the mean) and increases the divorce rate by 2pp (25% relative to the mean). This is because the relative insurance value of marriage decreases, and the outside option of marriage increases due to expanded benefits without rationing. Specifically, in the baseline, where vouchers are highly rationed, the insurance value of vouchers is limited. For this reason, more people are likely to form a family with a partner to obtain the economy of scale of housing. In contrast, the counterfactual policy eliminates rationing and allows every applicant household to receive a housing subsidy, though the value of the subsidy is much lower. In this case, single people could afford to live independently with non-rationing housing vouchers; thus, the insurance value of family formation is relatively reduced. This policy has a pronounced effect on marriage and divorce because expanded excess policy impacts a substantial share of households in the population, namely all households eligible for housing vouchers. Since there is no rationing in the policy experiment, the proportion of people receiving vouchers is the same as that of people participating in the

³³Alternatively, we could fix the fair market rent to the baseline rate and require households contribute more than 30% of their income for rent. However, this alternative design will not yield enough demand for housing vouchers to match the government spending in the baseline because lots of households would prefer not to join the program due to a higher share of income contribution.

program (applying for housing vouchers).

To examine the household behavior in program participation, column (3) in Panel C of Table 4 shows that providing lower benefits to all applicants substantially increases the program participation rate from 29pp to 42pp because it is certain that households will receive a voucher if they apply (the new policy removes the uncertainty of the rationing process). In particular, low productivity households increase their application for housing vouchers from 45pp to 73pp, and median productivity households increase their application from 27pp to 32pp. The application rate of male-headed households increases from 22pp to 32pp and that of female-headed households increases from 34pp to 47pp. However, both the share of high productivity households participating in the program and the share of ineligible households in the baseline that select into participating in the program is small because the housing benefits from this policy are much lower.

Figure 8: The Long-run Effects of Lower Benefits to All on Employment by Gender



Notes: This figure displays the long-run effects of lower benefits to all on the employment rate by gender. Time 0 is when the household receives a housing voucher.

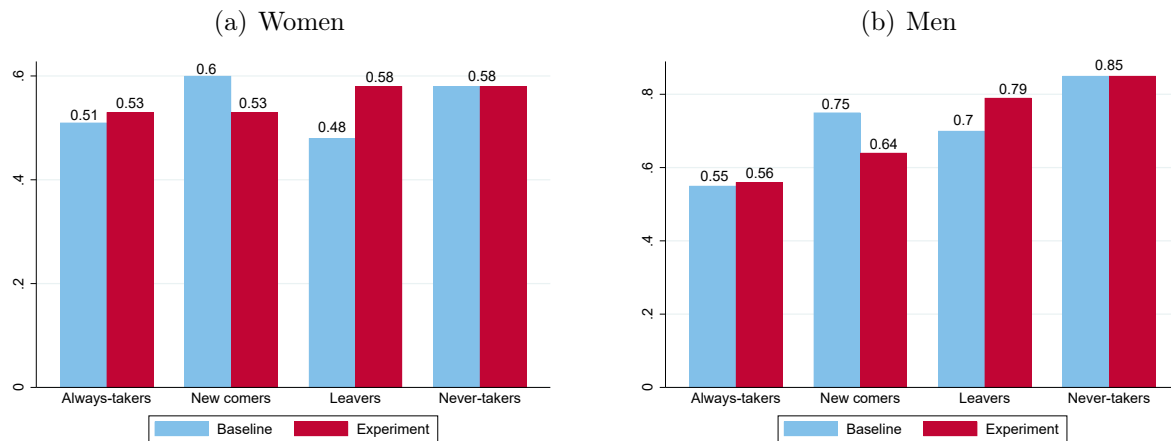
To shed light on the long-term dynamic impact on labor supply, I estimate equation (8) using the simulated data in this policy experiment and compare the coefficients to the baseline estimates. It is worth noting that the discussion of the treatment effect in the policy experiment is all relative to the treatment effect in the baseline (or the current housing voucher program). Figure 8 shows that compared to the baseline (current program) treatment effect, the treatment effect of the policy that gives lower benefits to all applicants is smaller in magnitude for female employment. In particular, the treatment effect in the pol-

icy experiment is on average 2pp lower than that in the baseline. On the other hand, the treatment effect on male labor supply in the experiment is similar to that in the baseline.

To explore why the treatment effect on female labor supply is smaller in the policy experiment, I dig into the three channels that affect the treatment effect and compare them in the baseline and policy regime. The three channels that affect the treatment effects are 1) substitution effect (HUD tax); 2) income effect (how generous the subsidies are); and 3) marriage effect. First, as noted above, the HUD marginal tax rate is both 30% in the policy experiment and the baseline program, thus the substitution effect channel is the same in both regimes and will not contribute to the difference in treatment effects. Second, compared to the baseline program, the housing benefits in the policy experiment are much lower, suggesting a smaller income effect on labor supply in the policy experiment, which contributes to a smaller treatment effect for women (who are the majority of voucher recipients in the baseline). Third, since the policy experiment reduces marriage compared to the baseline program, housing subsidies could also interact with marriage to positively affect employment. To control the marriage effect channel, I impose the marital status in the policy experiment as the baseline. I find that women's labor supply decreases by 1pp (change from 54pp to 53pp), suggesting that the marriage effect channel positively affects female labor supply. Thus the marriage channel also contributes to the treatment effect difference between the baseline program and the policy experiment. Altogether, the smaller treatment effect for women in the policy experiment is due to a smaller income effect and a positive marriage effect on labor supply. However, these two channels do not significantly affect men's labor supply across the two policy regimes. This is because the share of men receiving vouchers is still much lower than women (32% vs. 47% in the policy experiment), and men's employment behavior is not responsive to marital status change.

Since the treatment effect predicts an increase in female employment and no change in male employment, the major channel in driving the aggregate employment drop for both men and women is the volume and compositional change of households participating in the program. To be specific, as more people receive assistance from the program, the negative impacts of vouchers on labor supply will apply to a larger population and yield a decrease in overall employment (compositional effect). To further validate the compositional effect, I

Figure 9: The Effects of Lower Benefits to All Applicants on Employment by Voucher Receiving Status



Notes: This figure displays the effects of the lower to all experiment on employment rate by voucher receiving status in the baseline and flat assistance policy experiment. Among female-headed households, 15% of them are always-takers, 32% of them are newcomers, 5% of them are leavers, and 48% of them are never-takers. Among male-headed households, 7% of them are always-takers, 25% of them are newcomers, 2% of them are leavers, and 66% of them are never-takers.

divide the households into four categories and compare their employment behavior across the two regimes. The first category is composed of the households that receive vouchers both in the baseline and the experiment (always-takers); the second category includes the households that receive vouchers in the baseline but not the experiment (leavers due to policy change); the third group is composed of the households that receive vouchers in the experiment but not the baseline (newcomers due to policy change); the last group includes the households that neither receive vouchers in both circumstances (never-takers). The employment rates for the four groups by gender in both scenarios are reported in Figure 9.

The employment rate for always-takers increases due to a reduction in benefits, i.e., a smaller negative income effect. The employment rate for female newcomers decreases from 60pp to 53pp and for male newcomers decreases from 75pp to 64pp. The employment rate for leavers increases as a result of non-housing subsidies. Because the number of newcomers far exceeds the number of always-takers and leavers (more than 60% of voucher recipients in the policy experiment are newcomers), the former effect (more people receiving assistance) dominates the latter (less generous for the original recipients), yielding an overall negative impact on labor supply.

7.3 Time-limited Subsidies

Rather than providing subsidies for an indefinite period, the third policy considers imposing time limits on receiving housing assistance. 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, however. First, it may discourage voucher users from working, as increasing their income will probably render them ineligible for the program. Second, apart from the impacts on voucher users, it will affect households that need vouchers but cannot get one. When negative income shocks hit the households, 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 of benefits. The subsidy amount that a household can receive within the 5 years is the same as the baseline, which is the difference between rent and 30% of the family income. Accordingly, applicants' probability of receiving a voucher will increase to maintain the same government budget as the baseline. As a result of an increase in the likelihood of receiving a voucher, more families in need can access housing benefits, but for a limited time. The new policy aims to address the problem of income volatility rather than low permanent income.

Introducing time limits would introduce an extra state variable indicating how many periods the households have been subsidized, through which time limits will dynamically affect household labor supply. Specifically, the law of motion for time limits is that:

$$TS_{it} = TS_{it-1} + I_{Voucher_{it}}$$

where TS_{it} is the total number of years that the household i has been subsidized by housing vouchers until period t . It equals the total number of years that housing vouchers have subsidized the household until period $t-1$ plus an indicator variable equal to 1 if the household receives a housing subsidy in period t . Each household can only receive a maximum of 5 years of housing subsidies. Since households are forward-looking, they are more likely to use vouchers when facing adverse income shocks. Thus, households are “banking” the

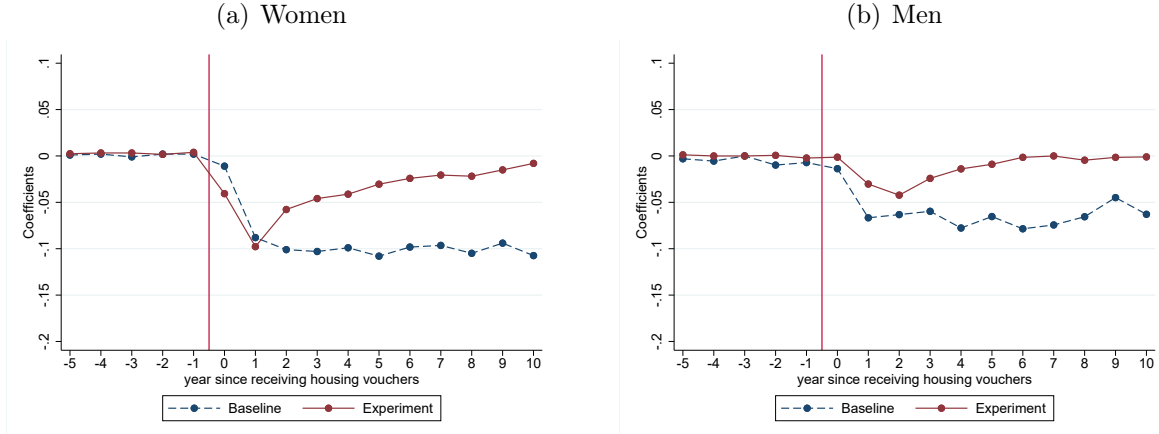
benefits for future use when there are no adverse income shocks.

I present the effect of introducing time limits in column (4) of Table 4. This policy has a positive impact on male and female employment. In particular, time-limited subsidies increase male employment by 1pp and female employment by 2pp. This is because the time-limited subsidies reduced the expected long-term benefits, motivating households to work more. In addition, I find there is a small positive impact (1pp) of the policy on marriage. This is because the relative insurance value of marriage increases, and the outside option of marriage decreases due to decreased (time-limited) benefits. The decreasing value of public insurance (housing assistance) crowds in private insurance (marriage). If we control the individual marital response to the policy change, the female labor supply will increase more (from 56pp to 59pp). This suggests that marriage interacts with the time-limited subsidies to negatively affect female labor supply.

Column (4) in Panel C of Table 4 presents the application rates by productivity and gender. The application of median and high-productivity households increases as they have a higher chance of receiving housing assistance than baseline. I find that median and high productivity households are more likely to apply for a voucher when negative income shocks hit them. In addition, the time-limited subsidies incentivize more originally ineligible households (6%) to apply for vouchers, especially when they experience adverse income shocks. The proportion of people receiving housing vouchers in the policy experiment is 0.14. Though it is similar to the baseline program, the composition of households receiving housing vouchers differs. In the baseline program, few households receive vouchers for the long term. In the policy experiment, however, more households receive vouchers for a short period.

The dynamic effect is especially important in this policy setting because when a subsidy is time-limited, households will consider the intertemporal trade-off between applying for subsidies in one period vs. the other. To examine the dynamic effect of housing vouchers on labor supply, I estimate equation (8) using the simulated data in this time-limited subsidy experiment, and compare the coefficients with the ones estimated from baseline. Figure 10 shows that households reduce their labor supply when they just receive housing vouchers. However, their employment gradually increases after 2 years of receiving the benefits and the negative effects of vouchers on labor supply almost disappear after 5 years of initially

Figure 10: The Dynamic Effects of Time-limited Subsidies on Employment by Gender



Notes: This figure displays the long-run effects of time-limited subsidies on employment rate by gender. Time 0 is when the household receives a housing voucher.

receiving the benefits. The bouncing back of employment before running out of the time limits suggests that households are forward-looking and preemptively increase their labor supply in the expectation of losing future benefits. In particular, households “bank” their benefits for future use in case of negative income shocks. To further show the household’s forward-looking behavior, I plot the distribution of household total years of housing benefits used in Figure A.3, which shows that 30% of the households do not use up all of the 5 years of benefits. Altogether, the evidence suggests that time-limited subsidies only have a negative impact on employment in the first few years of receiving subsidies, and households gradually increase their employment before running out of benefits.

7.4 Household Welfare

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

For each scenario, the benefits (costs) to household welfare for all low-income people and

Table 5: Percent Change in Welfare

Compensation Variation	Overall	Women	Men
Policy 1: flat assistance	+0.77	-0.60	+2.14
Policy 2: lower subsidy to all	+1.05	+0.58	+1.52
Policy 3: time-limited subsidy	+2.65	+3.49	+1.81

Notes: This table reports the household welfare across the three experiments. Household welfare is calculated by compensation variation for the overall low-income households and for male- and female-headed households separately. The household welfare for the current program (baseline) is normalized to 1.

men and women are presented separately in Table 5. Compared to the baseline, the first policy of changing housing assistance into a flat subsidy increases overall welfare. Male-headed households drive this increase in welfare. Female-headed households suffer from welfare loss in this policy experiment. The gender difference is because men have higher incomes than women, and the policy change shifts resources from relatively low-income to relatively high-income households. To test how behavior change, i.e., labor supply and marriage increase contributes to the welfare change, I conduct an exercise in which household labor supply and marital status are not allowed to adjust to the new policy. I find that in this exercise, women’s welfare will further decrease, and men’s welfare will decrease slightly. Thus, the increased incentives for working and marriage mitigate the negative impact of redistributing resources on women’s welfare and help improve men’s welfare.

Providing lower benefits to all eligible applicants improves overall welfare for both men and women (second row of Table 5). At baseline, the government provides continued substantial 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 new policy because the policy substantially increases their incidence of receiving vouchers. On the other hand, time-limited subsidies substantially increase overall welfare, especially for women. Both the latter two policies promote overall welfare by mitigating the rationing problem. However, the higher welfare increase in the time-limited subsidies is also a result of household behavior change, i.e., an increase in employment and marriage. In contrast, the welfare gain for the lower to all experiment stems from the fact that the benefits extend to more families with higher marginal utility at lower subsidy levels.

Finally, it is worth noting that the welfare effect does not engage with the consequences of how each policy reform affects homelessness, eviction, and the number of people living in a shelter. [Abramson \(2021\)](#) has shown how various housing assistance policies could affect welfare by affecting homelessness, eviction, and the number of people living in a shelter. Compared to the current housing voucher program, if the alternative policy reform reduces homelessness, eviction, and the number of people living in a shelter, then the welfare effect reported in Table 5 yields a lower bound. For instance, the lower-to-all experiment provides a subsidy to every needy family, and time-limited subsidies benefit more eligible households. Compared to the current welfare program, they are likely to reduce the homeless and eviction rate, and the number of people in shelters. Thus, the welfare effect of the policy experiment provides a lower bound of the true welfare effect. If, on the other hand, the alternative policy experiment increases homelessness, eviction, and the number of people in a shelter, then the welfare effect would yield an upper bound.

7.5 Robustness checks

In this subsection, I summarize the robustness of my main results with respect to some model assumptions and data limitations. I first consider the general equilibrium effects of housing vouchers on rental prices and how that will affect my main results. I gather evidence from the existing literature and a general equilibrium model to show that housing vouchers have minimal impact on overall rental prices across the nation, though it may have a meaningful impact on rental prices in regions with low housing supply elasticity. I show my results are robust to incorporating the effects of housing vouchers on rental prices. Second, we only have one year of information on the household application rate for vouchers. To deal with this data limitation, I explore the growth rate of households receiving housing vouchers from the annual HUD Picture of Subsidized Households between 2004 and 2018 to infer the average application rate between 2004-2018. I find that the average application rate inferred from this data is also around 29%. To further show the robustness of my results with respect to the application rate, I test my main results with respect to targeting a range of application rates between [20%, 40%], and find the main results are robust. Third, I discuss why low-income households are reluctant to move and justify that the counterfactual results are credible if

we abstract from household moving. Forth, I find my results are robust when comparing the rationing implied waiting periods in the model to the empirical data. Fifth, I examine an alternative counterfactual by allocating the voucher to males and females with equal probabilities when the family dissolves. Finally, I show that the main results are robust to alternative function forms and calibrated parameters. The details of each robustness check are presented in Appendix B.

8 Conclusion and Discussion

The economic theory yields ambiguous predictions of the housing voucher program’s effect on labor supply. Existing evidence of the program’s effects, especially long-run effects, on household behavior and welfare is limited. Until now, no study has employed a national sample or 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 have taken advantage of the welfare program take-up data and household socioeconomic status data from the SIPP and HUD to construct a structural model to study the program’s long-term effect. I decompose the underlying mechanisms driving the negative effect of housing vouchers on labor supply and quantify each channel. This paper also shows the behavioral response and welfare implication of some stylized program reforms and provides a rigorous framework to examine any possible policy reforms. In addition to 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. This study is relevant to 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 about the trade-off between the program’s disincentives and benefits (McClure, 2008). The flat housing assistance experiment shows that the negative substitution effect distorts household labor supply decisions. My findings also provide rigorous evidence against a high degree of rationing. This debate centers around the advantages and disadvantages of: 1) providing modest subsidies to an increased number of households; and 2) time-limited subsidies (Collinson et al., 2015, 2019). The policy experiments show that

providing lower subsidies to more households will improve overall household welfare because the program will assist more households. However, expanded access to housing vouchers decreases overall employment and marriage because the disincentives generated by the program apply to a much larger share of the population. In contrast, time-limited subsidies also aim to mitigate the problem of rationing. Instead of decreasing overall employment and marriage, this policy has the extra benefit of promoting employment and marriage. In this sense, the time-limited subsidies can both mitigate the rationing problem and mediate disincentives to working and family formation. If the policymakers' goals are to: 1) both mitigate program disincentives and improve household welfare; and 2) address the problem of temporal income shocks rather than permanent income shocks, then time-limited subsidies could be a promising direction for future policy reforms.

References

- Abramson, B., 2021. The welfare effects of eviction and homelessness policies .
- Attanasio, O., Low, H., Sánchez-Marcos, V., 2008. Explaining changes in female labor supply in a life-cycle model. *American Economic Review* 98, 1517–52.
- Been, V., O'Regan, K., Waldinger, D., Center, N.F., 2018. Allocation of the limited subsidies for affordable housing. *New York Times* .
- Bergman, P., Chetty, R., DeLuca, S., Hendren, N., Katz, L.F., Palmer, C., 2019. Creating moves to opportunity: Experimental evidence on barriers to neighborhood choice. Technical Report. National Bureau of Economic Research.
- Carlson, D., Haveman, R., Kaplan, T., Wolfe, B., 2012. Long-term effects of public low-income housing vouchers on neighborhood quality and household composition. *Journal of Housing Economics* 21, 101–120.
- Chan, M.K., Moffitt, R., 2018. Welfare reform and the labor market. *Annual Review of Economics* 10, 347–381.
- Chetty, R., Hendren, N., Katz, L.F., 2016. The effects of exposure to better neighborhoods on children: New evidence from the moving to opportunity experiment. *American Economic Review* 106, 855–902.
- Chiappori, P.A., Mazzocco, M., 2017. Static and intertemporal household decisions. *Journal of Economic Literature* 55, 985–1045.
- Cho, Y., Zhang, N., 2021. The general equilibrium effect of affordable housing policies. Working paper .
- Collinson, R., Ellen, I.G., Ludwig, J., 2015. Low-income housing policy, in: *Economics of Means-Tested Transfer Programs in the United States, Volume 2*. University of Chicago Press, pp. 59–126.

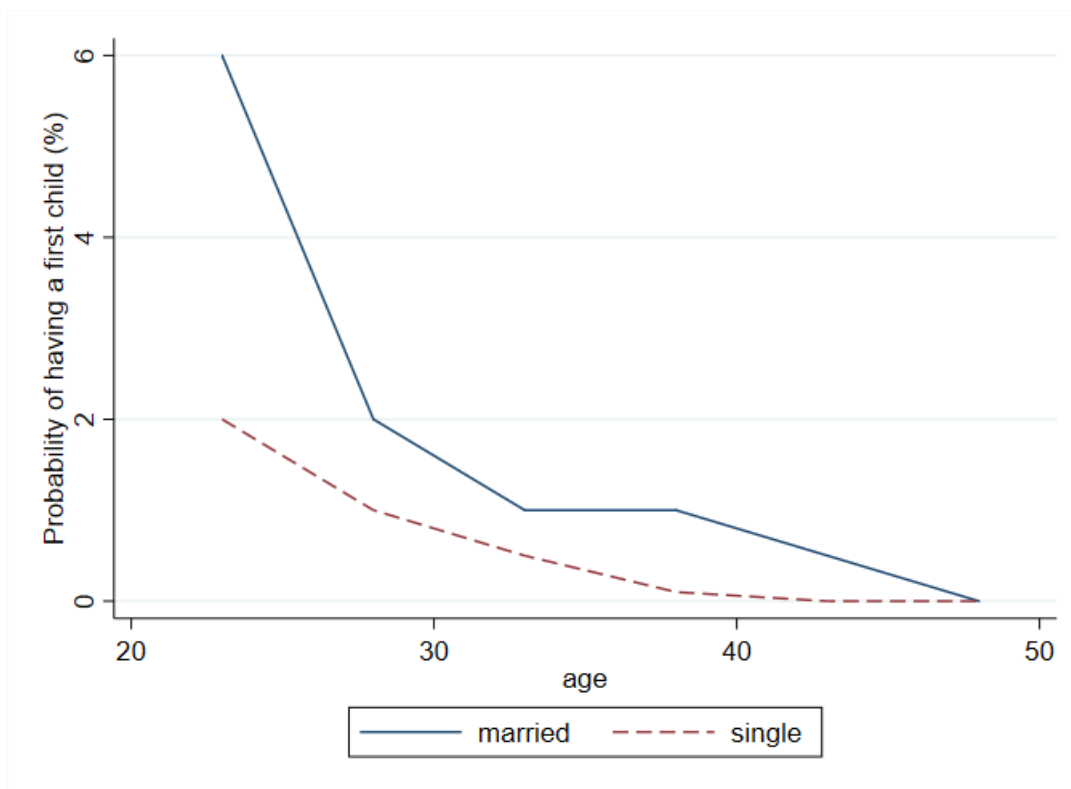
- Collinson, R., Ellen, I.G., Ludwig, J., 2019. Reforming housing assistance. *The Annals of the American Academy of Political and Social Science* 686, 250–285.
- Collinson, R., Ganong, P., 2018. How do changes in housing voucher design affect rent and neighborhood quality? *American Economic Journal: Economic Policy* 10, 62–89.
- Davis, M.A., Gregory, J., Hartley, D.A., Tan, K.T., 2021. Neighborhood effects and housing vouchers. *Quantitative Economics* 12, 1307–1346.
- Eckstein, Z., Keane, M., Lifshitz, O., 2019. Career and family decisions: Cohorts born 1935–1975. *Econometrica* 87, 217–253.
- Eckstein, Z., Lifshitz, O., 2011. Dynamic female labor supply. *Econometrica* 79, 1675–1726.
- Eriksen, M.D., Ross, A., 2015. Housing vouchers and the price of rental housing. *American Economic Journal: Economic Policy* 7, 154–76.
- Fischer, W., 2017. Trump administration blocks housing voucher policy that would expand opportunity and reduce costs. Report from Center on Budget and Policy Priorities .
- Galiani, S., Murphy, A., Pantano, J., 2015. Estimating neighborhood choice models: Lessons from a housing assistance experiment. *American Economic Review* 105, 3385–3415.
- Glaeser, E.L., Luttmer, E.F., 2003. The misallocation of housing under rent control. *American Economic Review* 93, 1027–1046.
- HUD, 2012. PHA Homeless Preferences: Web Census Survey Data. Technical Report. U.S. Department of Housing and Urban Development.
- Husock, H., 2004. The housing reform that backfired" section 8" vouchers were supposed to revolutionize subsidized housing-but only expanded it. *City Journal* 14, 81–87.
- Jacob, B.A., Kapustin, M., Ludwig, J., 2015. The impact of housing assistance on child outcomes: Evidence from a randomized housing lottery. *The Quarterly Journal of Economics* 130, 465–506.

- Jacob, B.A., Ludwig, J., 2012. The effects of housing assistance on labor supply: Evidence from a voucher lottery. *American Economic Review* 102, 272–304.
- Keane, M., Moffitt, R., 1998. A structural model of multiple welfare program participation and labor supply. *International economic review* , 553–589.
- King, R., 2015. The obama administration’s vision for housing: A look at the fy 2016 budget request. *National Housing Conference* .
- Kling, J.R., Liebman, J.B., Katz, L.F., 2007. Experimental analysis of neighborhood effects. *Econometrica* 75, 83–119.
- Kling, J.R., Ludwig, J., Katz, L.F., 2005. Neighborhood effects on crime for female and male youth: Evidence from a randomized housing voucher experiment. *The Quarterly Journal of Economics* 120, 87–130.
- Leung, C.K.Y., Sarpca, S., Yilmaz, K., 2012. Public housing units vs. housing vouchers: Accessibility, local public goods, and welfare. *Journal of Housing Economics* 21, 310–321.
- Low, H., Meghir, C., Pistaferri, L., Voena, A., 2018. Marriage, labor supply and the dynamics of the social safety net. *Technical Report. National Bureau of Economic Research*.
- Mansur, E.T., Quigley, J.M., Raphael, S., Smolensky, E., 2002. Examining policies to reduce homelessness using a general equilibrium model of the housing market. *Journal of Urban Economics* 52, 316–340.
- Mazzocco, M., 2007. Household intertemporal behaviour: A collective characterization and a test of commitment. *The Review of Economic Studies* 74, 857–895.
- McClure, K., 2008. Deconcentrating poverty with housing programs. *Journal of the American Planning Association* 74, 90–99.
- McFadden, D., 1989. A method of simulated moments for estimation of discrete response models without numerical integration. *Econometrica: Journal of the Econometric Society* , 995–1026.

- Mills, G., Gubits, D., Orr, L., Long, D., Feins, J., Kaul, B., Wood, M., Jones, A., 2006. The effects of housing vouchers on welfare families. Washington, DC: US Department of Housing and Urban Development, Office of Policy Development and Research .
- Moffitt, R., Kosar, G., 2020. In-kind transfers, incomplete program take-up, and labor supply: A structural econometric model. Working paper .
- Olsen, E.O., 2003. Housing programs for low-income households, in: Means-tested transfer programs in the United States. University of Chicago Press, pp. 365–442.
- Saiz, A., 2010. The geographic determinants of housing supply. *The Quarterly Journal of Economics* 125, 1253–1296.
- Schwartz, H.L., Mihaly, K., Gala, B., 2017. Encouraging residential moves to opportunity neighborhoods: An experiment testing incentives offered to housing voucher recipients. *Housing Policy Debate* 27, 230–260.
- Susin, S., 2002. Rent vouchers and the price of low-income housing. *Journal of Public Economics* 83, 109–152.
- Voena, A., 2015. Yours, mine, and ours: Do divorce laws affect the intertemporal behavior of married couples? *American Economic Review* 105, 2295–2332.
- Yglesias, M., 2020. Joe Biden’s surprisingly visionary housing plan, explained. *VOX* .

Appendix A: Supplemental Figures and Tables

Figure A.1: Probability of Having the First Child by Women's Age and Marital Status



Notes: This figure shows the probability of having the first child by women's age and marital status. The solid blue line shows the probabilities for married women by age, and the dashed red line shows the probabilities for single women by age. Source: Data is drawn from the SIPP 2001, 2004, 2008, 2014, and 2018 panels.

Table A.1: Calibrated Parameters

Parameter	Description	Value	Source
σ	Risk aversion	1.5	Attanasio et al. (2008)
β	Discounting factor	0.98	Attanasio et al. (2008)
γ_e	Economy of scale	0.61	Voena (2015)
r	Interest rate	0.02	Risk-free interest rates
θ	Husband Pareto weight	0.5	Eckstein et al. (2019)
h	Discrete rental housing sizes	[0.7, 1, 1.5]	Zillow

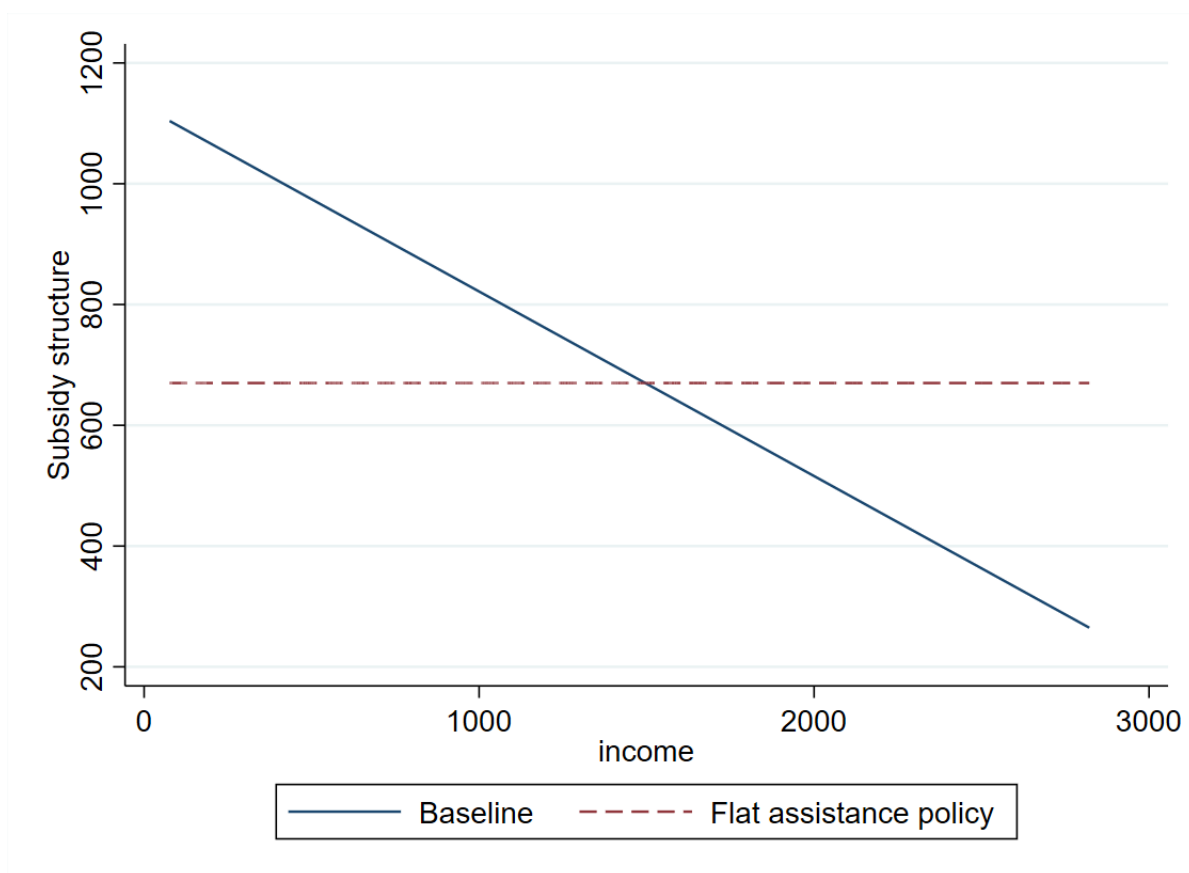
Notes: This table reports the values and sources of parameters calibrated outside the model.

Table A.2: Parameters Estimated Within the Model

Parameters	Description	Value	SE
Earnings			
β_{0M}	Constant in male earnings	9.48	2.13
β_{1M}	Coeff. of age in male earnings	0.036	0.01
β_{2M}	Coeff. of age square in male earnings	-0.0005	0
$\sigma_{\zeta M}^2$	Var. of male productivity	0.044	0.01
$\sigma_{\epsilon M}^2$	Var. of male income shocks	0.04	0.02
β_{0F}	Constant in female earnings	9.35	2.11
β_{1F}	Coeff. of age in female earnings	0.034	0.02
β_{2F}	Coeff. of age square in female earnings	-0.0006	0
$\sigma_{\zeta F}^2$	Var. of female productivity	0.04	0.02
$\sigma_{\epsilon F}^2$	Var. of female income shocks	0.043	0.01
Disutility of working			
ϕ^{SM}	Single men	-0.19	0.07
ϕ^{MM}	Married men	-0.10	0.04
ϕ_0^{SW}	Single women w/o children	-0.07	0.02
ϕ_1^{SW}	Single women w/ children	-0.26	0.04
ϕ_0^{MW}	Married women w/o children	-0.33	0.05
ϕ_1^{MW}	Married women w/ children	-0.44	0.07
Marriage			
σ_Q^2	Var. of match quality	0.18	0.04
λ_y	Prob. of meeting at young age	0.08	0.02
λ_m	Prob. of meeting at middle age	0.04	0.01
λ_o	Prob. of meeting at old age	0.035	0.01
Housing and Vouchers			
α	share of c in utility	0.6	0.18
ν	stigma cost of program participation	0.015	0.005
Conditional Prob. of Receiving Vouchers			
γ_{lm}, γ_{hm}	male above/below 30% local median	0.02, 0.04	0, 0.01
$\gamma_{lwc}, \gamma_{hwc}$	female above/below 30% local median w/o children	0.04, 0.04	0.02, 0.01
$\gamma_{lwnc}, \gamma_{hwnc}$	female above/below 30% local median w/ children	0.05, 0.09	0.02, 0.03

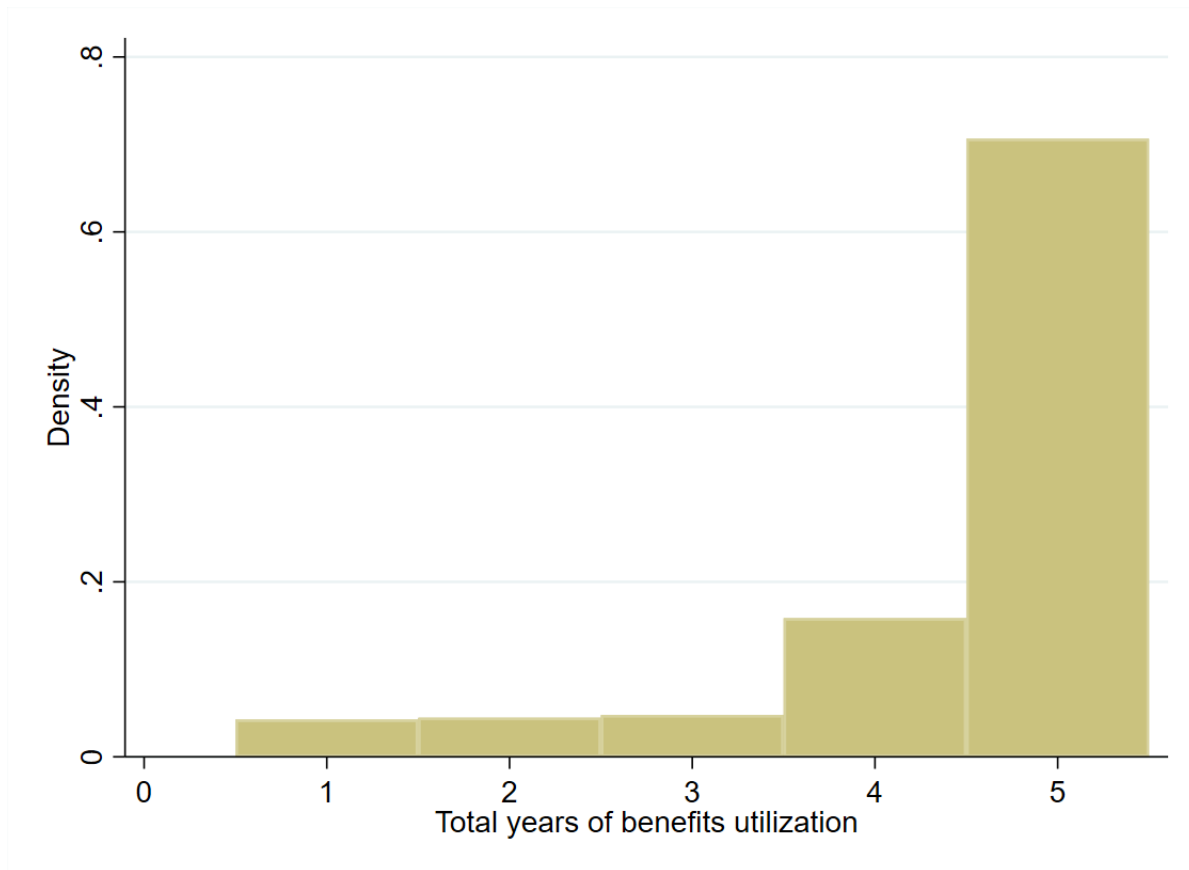
Notes: This table reports the values and standard errors (SE) of the parameters estimated within the model. I follow [Eckstein and Lifshitz \(2011\)](#) to calculate the asymptomatic standard errors.

Figure A.2: The relationship between income and subsidy amount



Notes: This figure displays the relationship between monthly income and subsidy amount in the baseline and flat assistance policy experiment. The solid blue line is the fitted line of the subsidy amount and income from the simulated data in the baseline. The dashed red line shows the subsidy amount and income in the policy experiment.

Figure A.3: Distribution of Total Years of Housing Voucher Utilization



Notes: This figure displays the total years of housing voucher utilization distribution in the time-limited subsidy policy experiment.

Appendix B: Robustness Check

In this section, I provide more details regarding each of the robustness checks.

General Equilibrium Effects of Housing Vouchers on Rental Prices

The model in this paper is a partial equilibrium model. It does not consider housing market equilibrium, marriage market equilibrium, or labor market equilibrium. In this session, I discuss the effects of housing market equilibrium on my results.

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 the elasticity of housing and rental unit supply. [Susin \(2002\)](#) uses the 90 biggest metropolitan areas in the U.S. and finds that vouchers have raised the rent by 16% 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 the overall price of rental units. 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 rent increase is below \$70 a year. It 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 the housing supply. To provide more suggestive evidence of the voucher program's effect on rental prices, we have developed a separate framework ([Cho and Zhang, 2021](#)) and applied it to each scenario.³⁴ The framework builds a stationary equilibrium model to study the general equilibrium effect of introducing housing vouchers and various public policies related to housing. Since the elasticity of the housing supply is critical to determining the effect of housing vouchers on rental prices, I experiment with various supply elasticity values to examine the current program's effect on rental prices. I then apply the national median elasticity of housing supply to investigate the effect of each policy change

³⁴For space concern, the draft of the general equilibrium framework is available upon request.

on rental prices. The results are presented in Table B.1.

Panel A of Table B.1 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 the 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, the current program barely affects prices.

Panel B of Table B.1 shows the effect of the three 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 \$780 (during the sample period), a 2% increase in rent implies that rent will increase by \$16 per month, which is small. When I apply the increase in rental prices in the baseline and the experiments, the main results are robust regarding the price change. This is consistent with the existing evidence that housing vouchers have no impact on rental prices when using a 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.

Table B.1: The Effect of Housing Vouchers on Prices

	Rental price
<u>Panel A: Introducing housing vouchers</u>	
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
<u>Panel B: Policies and supply elasticity 1.5</u>	
Baseline	1
Experiment 1: flat subsidies	1.01
Experiment 2: lower subsidy to all	1.02
Experiment 3: time limits	1

Notes: This table reports the effects of housing vouchers on rental prices. Panel A reports the effects of housing vouchers on rental prices across different housing supply elasticity cases. The rental price in the case with no housing vouchers is normalized to 1. Panel B reports the effects of housing vouchers on rental prices across the baseline and policy experiments when the housing supply elasticity is fixed at the national median level (1.5). The rental price in the baseline is normalized to 1. The elasticity of housing supply is drawn from [Saiz \(2010\)](#). The calculation is based on the model predictions from [Cho and Zhang \(2021\)](#).

Robustness with respect to Application Rates

Due to data limitations, the application information from the HUD PHA Homeless Preferences: Web Census Survey Data is only available in 2012. In this robustness check section, I apply the annual growth rate of the number of households receiving housing vouchers from the HUD Picture of Subsidized Households (2004-2018) and assume that the growth of the application rate is equal to the growth of households receiving vouchers over time. [Figure 2](#) shows that the voucher receiving rate grew smoothly from 2004 to 2018. In particular, the receiving rate has been growing by 2% annually. Assuming the growth of receiving rate is proportional to the growth of the application rate, then using the 2012 application rate as a benchmark would infer that the average application rate between 2004-2018 is 28%, which is similar to the 29% I use as a moment target in the model.

However, some readers may find the assumption that the growth of the application rate is equal to that of households receiving vouchers over time noxious. To reassure the readers, I tested my main results concerning targeting a range of application rates between [20%, 40%], and found the main results are robust. Admittedly, changing the targeted application rate would affect the estimates of stigma cost and the estimates of the probabilities that applicant households receive vouchers. In particular, stigma costs would be higher if the targeted application rate is lower and vice versa. The probability of receiving housing vouchers for each demographic group is higher if the targeted application rate is lower and vice versa. However, the relative change in these estimates will not fundamentally affect the quantitative implication of the model and the evaluation of alternative policy reforms.

Robustness with respect to Moving

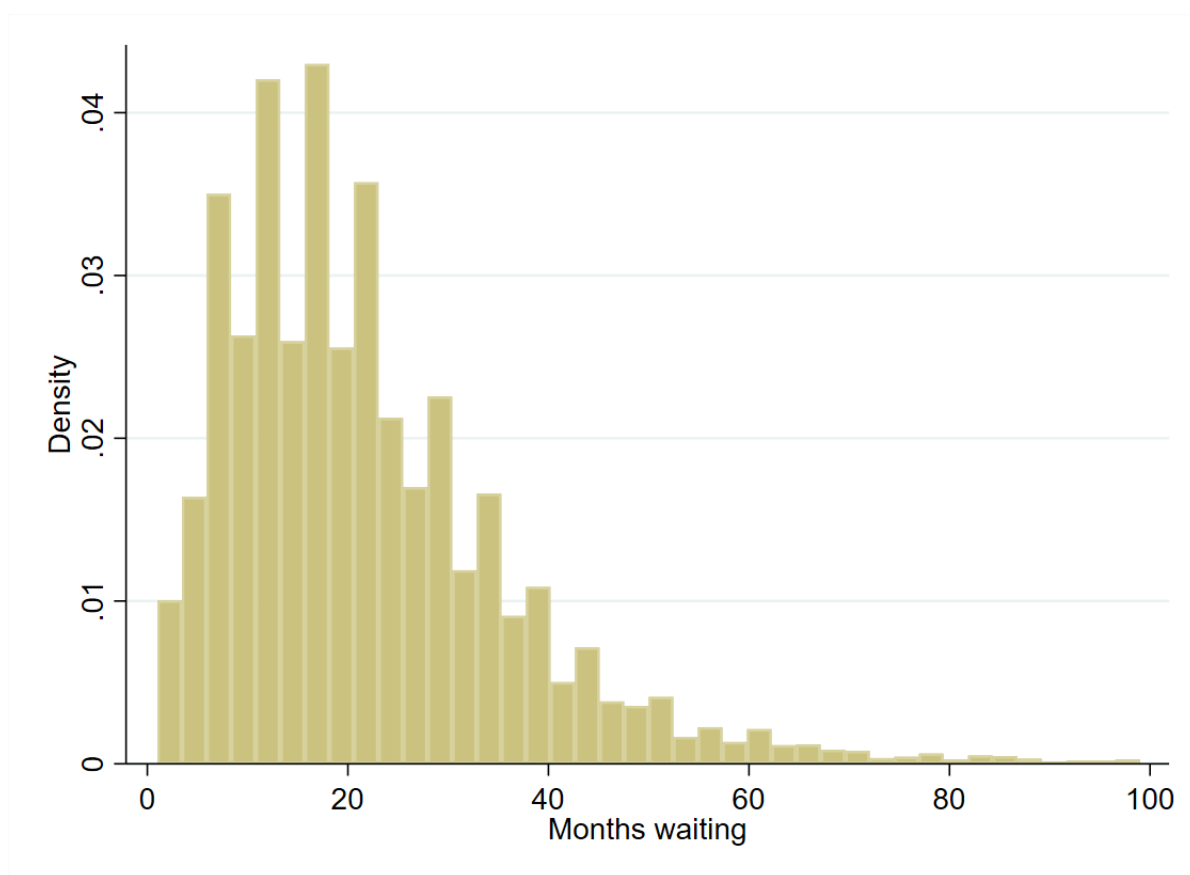
In the main text, I have already shown that both existing literature and SIPP data calculation finds that households do not move when they receive vouchers. However, one may still argue that even though households may not move under the current program, they may incentivize to move under some of my counterfactual experiments. To check whether this is the case, we first need to dig into why households are reluctant to move under the current program. Bergman et al. (2019) and Schwartz et al. (2017) have found that the reluctance of low-income households 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 social ties, acceptance, and familiarity with neighborhoods.³⁵ These social and institutional barriers are unlikely to be affected by the policy experiments that I considered in this paper. Therefore, if households do not move in the baseline due to such barriers, it will probably be the same in the policy experiments as well.

³⁵See also Dr. Kathryn Edin's work on urban poor using Chicago's Gautreaux Mobility Program. <https://pitt.hosted.panopto.com/Panopto/Pages/Viewer.aspx?id=024a1047-d72e-48e4-96b7-2fa1c9d53d55>

Robustness with respect to Waiting Periods

The waiting period data for each MSA each year is drawn from HUD Picture of Subsidized Households (2004-2018). The data records the average months households are on waiting lists before moving into their current subsidized housing. The distribution of the average months on waiting periods is reported in Figure B.1. The average time applicant households spend on waiting lists is 25 months (2.1 years), and there is large heterogeneity in the length of waiting periods across regions.

Figure B.1: Average Months of Households on Waiting Lists in Each MSA from 2004-2018



Notes: This figure displays the average months of households on waiting lists in each MSA from 2004-2018. Source: Department of Housing and Urban Development's (HUD's) Picture of Subsidized Households 2004-2018.

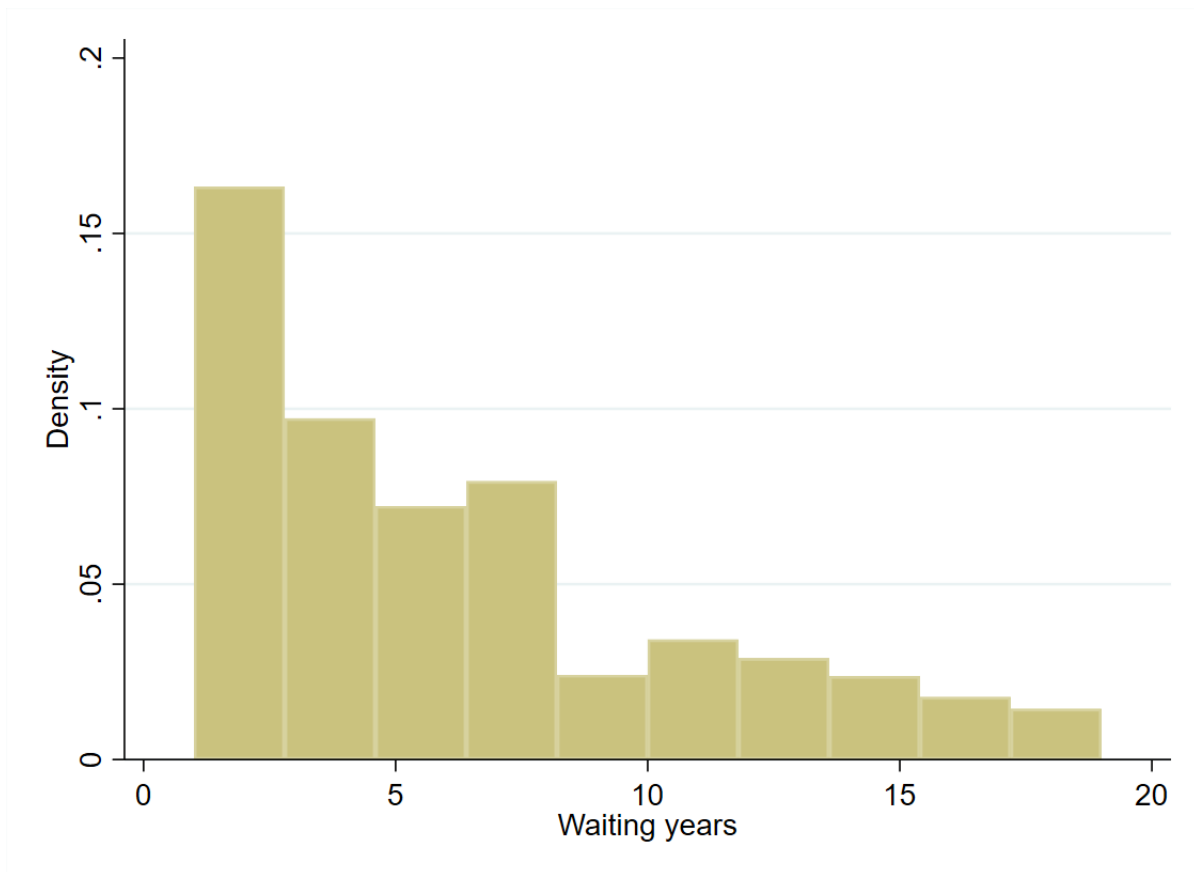
Without explicitly imposing waiting periods in the model, the rationing process will imply that a large fraction of households who apply for a voucher in a given period do not receive one in that period, thus generating a waiting year for an applicant household. The

waiting years implied by the rationing process in the model are defined as the total number of model periods (years) that a household applied for a voucher but did not receive one. Figure B.2 displays the waiting years from the baseline model-simulated data. The mean and standard deviation of the simulated waiting years are 6.09 and 4.71. Note that the mean of the waiting years is larger than that calculated from the Department of Housing and Urban Development’s (HUD’s) Picture of Subsidized Households 2004-2018, presented in Figure B.1. This is because the waiting periods calculated from HUD are based on the sample that eventually receives a voucher. Thus, it does not include the sample that is still on the waiting list but does not receive a voucher. In contrast, the model simulated waiting periods include the sample that finally receives a voucher and the sample that never receives a voucher. For this reason, the model simulated waiting years are, on average longer than the data calculated waiting periods. To make them comparable, I also calculated the mean and standard deviations of the model simulated sample that finally received a voucher. The mean and standard deviations are 2.3 and 4.02, comparable to the mean and standard deviations calculated based on the HUD data (2.1 and 3.78).

Robustness: voucher allocation when a family dissolves

In the baseline model, the voucher is allocated to the female when the family dissolves. Therefore, the program favors females indirectly. In this section, I test the robustness of the employment effect by allowing the voucher to be allocated to females and males with equal probability when the family dissolves. The results of this counterfactual and its comparison with the baseline model are shown in Table B2. Changing the allocation rule for dissolved families does not affect the main results very much, except that the female labor supply increases by 1pp. This is probably because most voucher recipients are single families; thus, changing the allocation rule when a family dissolves does not impact the majority of voucher recipients.

Figure B.2: Waiting Periods from Baseline Model Simulated Data



Notes: This figure displays the average years of households that apply for a voucher but do not receive one in the model simulated data.

Table B.2: Policy Experiments

Variables	Baseline (1)	Counterfactual (2)
<u>Panel A: Employment</u>		
Men	0.81	0.81
Women	0.56	0.57
<u>Panel B: Family formation</u>		
Proportion married	0.51	0.51
Proportion divorced	0.08	0.075
<u>Panel C: Participation</u>	0.29	0.29
<i><u>By productivity</u></i>		
Low productivity	0.45	0.44
Median productivity	0.27	0.28
High productivity	0.16	0.16
<i><u>By gender</u></i>		
Male	0.22	0.22
Female	0.34	0.34
<i><u>Ineligibles in baseline</u></i>	0	0
<u>Panel D: Prop. w/ vouchers</u>	0.12	0.12

Notes: This table reports the key statistics from the model simulated baseline and counterfactual experiment where the voucher is be allocated to female and male with equal probability when a family dissolves.

Robustness with respect to utility functional forms

One may worry that the main results are specific to the functional form chosen in the paper and are not robust to alternative functional forms. Before I show the robustness of the main results concerning alternative function forms, it is important to understand the underlying (model) assumptions and the driving mechanisms for each policy experiment. To begin with, I illustrate the critical model assumptions that drive the flat-assistance results more. The flat subsidy has a lower labor supply effect because, in the flat assistance experiment, the marginal tax imposed by the housing vouchers on labor supply is 0. In this experiment, working more and having a higher income does not reduce the amount of housing assistance. The critical assumption we need for the utility function to generate this result is that consumption and leisure are normal goods and substitutes for each other. In the second experiment, where we eliminate rationing and provide lower housing benefits, the negative treatment effect of housing assistance on labor supply is smaller than the current program's treatment effect due to a smaller income effect. The underlying assumption generating the income effect is the diminishing marginal utility of consumption. When an agent has a higher (lower) income, the incentives to work and increase income (consumption) are lower as the marginal utility from consumption decreases. For the third experiment, the treatment effect exhibits intertemporal differences: falling for the first few years and rebounding before running out of housing benefits. The underlying assumption that drives the pattern is that households are forward-looking and maximize expected lifetime utility. I then show that the paper's main results are robust to alternative functional forms and calibrated risk-averse coefficients. Specifically, the main results are robust if we adopt a utility function following [Voena \(2015\)](#) of linear separable consumption and leisure or using alternative risk-averse coefficient values of $\gamma = 1.2, 2, 3$.

Appendix C

In this appendix, I discuss more details of the issues that I left out of the main text for reasons of space. In particular, I provide further information on the variables and describe the numerical method as well as the parameters estimated outside the model in detail.

Variables and Data Selection

The main variable of interest is whether a household receives a housing voucher. This variable is drawn from the core waves of the SIPP. The 2001, 2004, and 2008 SIPP panels are constructed from the following two consecutive questions. If the answer to both questions is yes, the household is a voucher recipient.

“Receipt of government subsidized rent Is the rent here lower because the federal, state, or local government is paying part of the cost?” (Variable name: EGVTRNT)

“Is this through Section 8 or through some other government program?” (Variable name: EWRSECT8)

The questionnaire structure is different for the 2014 and 2018 SIPP panels. First, in the 2014 and 2018 panels, SIPP respondents are interviewed annually rather than three times per year; this means that the reference period covered in each interview is the previous 12 months rather than the previous 4 months. In both cases, SIPP provides person-month data for each respondent, so data users would still get monthly information on receiving a voucher. To be consistent with the data used for the 2001-2008 panels, I keep the 4th, 8th, and 12th-month observations for the 2014 and 2018 panels. Second, the variable of whether a household received a housing voucher in 2014 and 2018 is constructed using a new question.

“Does ... household have a housing voucher?” (Variable name: EVOUCHER)

The employment status variable is constructed such that the individual is employed if they usually work no less than 20 hours a week. The individual earnings are constructed from the variable "Total person's earned income for the reference month", wherein SIPP earned income is defined as "wages and salary, nonfarm self-employment income, and farm self-employment income". The marital status, age and gender is directly drawn from the demographic information recorded in SIPP. The data on household assets is drawn from the

topical modules from the SIPP data. The definition of an asset includes saving, checking, and bond. The definition of debt includes mortgages, car loans, and other types of debt.

Numerical Methods

My model has no analytical solution, so it is solved numerically. The model is solved by backward induction from the following terminal value function:

$$V^{Terminal} = u(M, a')$$

where the household consumes a' and the value depends on marriage M . Then I iterate backward, solving each model period for the value functions conditional on state variables. I solve the model separately for female head households and male head households.

The asset choice is discretized into 10 points exponentially spaced grids between 0 and the maximum asset. The number of the grid for rental housing is 3, where the value is calibrated from Zillow. The distribution of the match quality shock and permanent productivity shock is discretized into a 3-point stationary Markov chain using Tauchen method. Value functions and decisions are calculated based on the grids mentioned above.

The estimation method is the Method of Simulated Moments (MSM), as proposed by [McFadden \(1989\)](#). 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 I fit the model to $r = 1, 2, \dots, R$ statistics. I then construct moments of the form:

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

The vector of simulated moments is given by $g'(\Theta) = [m_1^s(s), \dots, m_R^s(s)]$. I 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). I minimize $G(\Theta)$ with respect to Θ using the *fminsearch* command from Matlab.

To calculate standard errors, I follow [Eckstein and Lifshitz \(2011\)](#) to construct the asymptotic standard errors. I must first compute the numerical derivative of the objective function with respect to each parameter, Θ_p , using 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, I compute the covariance matrix using the outer product approximation to the Hessian.

Welfare benefits estimates

Following [Eckstein et al. \(2019\)](#), the welfare benefits from Food stamps, TANF, and EITC are estimated outside the model. The welfare benefits from Food Stamps and TANF are extracted from the SIPP (2001-2018 panels). I adjust for inflation using the PCE (just as I did with wages). I regress the welfare benefits from Food stamps and TANF on children dummy, marital status, and wages for males and females separately. I then use the coefficients to estimate the amount of assistance each household will get in the model (depending on their characteristics). In particular, I am using SIPP data to estimate the following model:

$$Y_{it} = \beta_0 + \beta_1 child_{it} + \beta_2 married_{it} + \beta_3 logwage_{it} + \epsilon_{it}$$

where Y_{it} is the annual amount of welfare benefits from Food stamps or TANF. Since TANF is only targeted at female households with children, I predict the TANF for these households. The coefficients of this regression are reported in [Table C.1](#). I use these coefficients and the household characteristics to assign the welfare benefits for each household in the model. In addition, the EITC benefits are calculated for female households based on their income range, children dummy, and marital status using the EITC calculator provided by IRS.³⁶

³⁶<https://www.irs.gov/credits-deductions/individuals/earned-income-tax-credit/use-the-eitc-assistant>

Table C.1: Welfare benefits

VARIABLES	(1) Food stamp male	(2) Food stamp female	(3) TANF female
Children dummy	1,668 (88)	1,989 (74)	
Log wage	-315 (30)	-464 (30)	-313 (13)
Married	-177 (37)	-655 (64)	-366 (26)
Observations	6,757	9,530	7,868

Notes: This table reports the empirical estimates of welfare benefits. Data is drawn from SIPP (2001, 2004, 2008, 2014, and 2018 Panels). Welfare benefits are in real terms (take 2010 as the base year). Standard errors are reported in parentheses.

Rental price and housing size estimates

Rental price (rate) is defined as the unit price of housing. Thus, the total rental price for an (unsubsidized) renter is the rental rate P^R times the housing size h , i.e., $P^R h$. In the model, rental consumption is defined by rental housing size h , which is discretized as a three-value grid: $[0.7, 1, 1.5]$. The mean housing size is normalized to be 1. Since there is an FMR cap for voucher rented housing, the rental housing size is discretized for housing with a price below the national median rental price. Using information from Zillow about the median rental housing prices and the number of bedrooms for rental housing (Housing Data - Zillow Research, Rent Comparison Tool Rental Market Trends Data | Zillow Rental Manager), the rental housing less than the median rental price has on average 2.7 bedrooms.³⁷ Then regarding the rental housing with less than 2.7 bedrooms, I divide the distribution of housing size into three quantiles and take the mean of each, which are 1.2, 1.7, and 2.5. Next, I normalize the three values by making the middle value 1, so they are $[0.7, 1, 1.5]$. After normalization, the mean rental price is the same as the rental rate, that is $P^R h = P^R$. The unit rental rate in the model is not a unique number. To mimic the reality that different regions have different rental rates, I classify all MSAs by the program eligibility income cut-offs into five groups (quantiles) using the distribution of MSA income cut-offs across the nation (Data for the eligibility income cut-offs for each MSA and each year is drawn from

³⁷<https://www.zillow.com/research/data/>; <https://www.zillow.com/rental-manager/market-trends/>

<https://www.huduser.gov/portal/datasets/il.html>). Each group represents a larger regional unit (a group of MSAs with similar income cut-offs). Within each group, the rental price P^R for each household is drawn from a distribution with mean μ_{PR} and variance σ_{PR} , where the mean and variance are allowed to vary across the 5 groups. In particular, the mean and standard deviation of the rental price for each group of MSAs is estimated from the American Community Survey (2001-2017).