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Intergenerational Spillovers: The Impact of Labor Market Risk on the Housing Market

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Intergenerational Spillovers: The Impact of Labor Market Risk on the Housing Market*

Job Market Paper

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Abstract

Unemployment leads to large and persistent income losses for workers. Higher unemployment in the labor market therefore has spillover effects on the housing market. This paper studies such spillover effects from both empirical and theoretical perspectives. Using data from the Current Population Survey (CPS), I show that a 1 percentage point increase in the unemployment rate leads to a 1.55% decline in housing prices. Theoretically, I develop an overlapping generations model with a housing market. The calibrated model replicates the empirically observed spillover effect for the U.S. economy. Higher income uncertainty is the main driver of the spillover effect, rather than actual income losses. The spillover effect transmits one-third of the welfare losses of workers due to higher unemployment in the labor market to older, retired households by reducing their housing wealth. Younger workers benefit in part by buying houses at depressed prices. The magnitude of the spillover effect is shaped by the demographic structure of the population and the specific age groups affected by unemployment shocks. I find that increasing the generosity of unemployment insurance stabilizes the housing market, although it only partially mitigates the spillover effect.

Keywords: Unemployment, Housing demand, Portfolio choice, Overlapping generations

JEL: G11, R21, E21, E24

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1 Introduction

Recessions lead to significant welfare losses for workers, who suffer persistent earnings losses upon unemployment (Jacobson et al., 1993; Davis et al., 2011). Such labor market shocks can spill over into other markets and affect households that do not participate in the labor market. A prime candidate for such spillovers is the housing market, where younger, working-age households often drive housing demand and older, retired households seeking to sell represent the supply side. The housing market can form an "intergenerational hinge," linking the labor market situation of young, working-age households with older households. Despite the importance of such intergenerational spillovers, little is known about how unemployment risk affects housing markets. This paper aims to fill this gap.

In this paper, I provide a quantitative evaluation of the spillover effect of unemployment risk from younger, working-age households to older, retired households through the housing market from both empirical and theoretical perspectives. I empirically document that the spillover effect of unemployment on the housing market is quantitatively important. Motivated by these findings, I develop a theoretical framework to analyze the welfare consequences of the spillover effect of unemployment shocks on different age groups of households. In addition, I examine how the age structure of the unemployment increase and the demographic composition of the population shape the spillover effect and whether increasing the generosity of the unemployment insurance system during recessions can stabilize housing prices.

In the first part of this paper, I analyze the spillover effect of unemployment risk on the housing market using data from the Current Population Survey (CPS). Specifically, I document the existence of the spillover effect in the United States by showing that changes in the unemployment rate have a significant effect on housing prices. To this end, I use an instrumental variable approach with a shift-share instrument which helps to address potential endogeneity and omitted variable bias by identifying exogenous fluctuations in state-level unemployment rates. The CPS data provide information on the state-level unemployment rate and the industry composition of employment needed to construct the shift-share instrument. The results indicate that the effect is also economically significant: a one percentage point increase in the unemployment rate leads to a 1.55% decline in housing prices. An important driver of this spillover is changes in housing demand in response to fluctuations in the labor market. To show that housing demand tends to decline during periods of high unemployment, I use data from the Home Mortgage Disclosure Act

(HMDA), which provides data on mortgage applications by U.S. households. I analyze the relationship between mortgage applications and the unemployment rate at the state level using the number of mortgage applications as a proxy for housing demand. The results show a strong negative correlation between the number of mortgage applications submitted and the unemployment rate at the state level. Moreover, I document that financial institutions reject a higher proportion of mortgage applications when the unemployment rate is high, further reducing effective housing demand, in addition to fewer mortgage applications. These results provide evidence that housing demand tends to be substantially lower during periods of high unemployment.

Next, I construct a general equilibrium model with overlapping generations to study the mechanism and the welfare consequences of the spillover effect of unemployment shocks on the housing market. Workers choose their portfolio between housing and liquid assets, where housing prices are determined on the housing market. The life cycle of a household is divided into a working phase and a retirement phase. During the working phase, households face an exogenous income process with unemployment risk. Retired households are not subject to labor market risk because they receive retirement benefits. When buying a house, households take out a mortgage subject to constraints on payment-to-income and loan-to-value ratios. The model is calibrated to the U.S. economy using data from the Survey of Consumer Finances (SCF). The calibrated model fits the data well along many dimensions, including the life-cycle profiles of housing wealth, liquid wealth, and household leverage.

Using the model, I analyze the aggregate consequences of an unemployment shock on the housing market. The spillover effect of an unemployment shock on housing prices in the model is quantitatively similar to the empirically documented magnitude. Specifically, an increase in the average unemployment rate from 4% to 8% leads to a 5% drop in housing prices. Looking at the mechanism behind the price change, I find that more than 60% of this spillover effect is driven by the increase in income uncertainty when the unemployment shock occurs, which leads households to reduce their demand for housing. In contrast, the actual decline in household income due to higher unemployment accounts for 40% of the total spillover effect. When the unemployment shock occurs, households shift their portfolios away from illiquid housing assets to liquid financial assets. Although retired households are not directly affected by changes in unemployment risk, the spillover effect from the labor market on the housing market leads to a decline in housing prices, which reduces the housing wealth of retired households. Retired households lose out from a decline in wealth due to their bequest motive. In response to the decline in housing wealth, retired households reduce their non-durable consumption and increase their savings.

I explore the welfare consequences of unemployment shocks across different age groups of households. The spillover effect of the unemployment shock leads to significant welfare losses for older, retired households, transmitting approximately one-third of the welfare losses of working-age households to retired households measured in terms of remaining lifetime consumption. Young workers face large welfare losses because they are directly affected by the increased risk of unemployment. For a median worker at age 45, the welfare loss amounts to 2.5% of remaining lifetime consumption. At the same time, young workers can partially benefit from depressed housing prices. When housing prices fall, young workers can buy houses at lower prices and benefit from future price appreciation when the economy recovers from the recession. This finding indicates that neglecting the spillover effects of labor market risk on the housing market would ignore the welfare consequences for retired households and generate larger welfare losses for young workers.

Does the age structure of the unemployment shock matter for the magnitude of the spillover effect? While the above analysis assumes a uniform increase in the unemployment risk across all age groups, I study two alternative unemployment shocks to address this question: In the first case, only young workers under the age of 45 experience an unemployment shock, while in the second case, only older workers above the age of 45 are affected. I find that an unemployment shock that disproportionately affects young workers generates a spillover effect on housing prices that is more than three times larger than that caused by a shock to older workers. There are two main reasons for this difference. First, young workers play a significant role in housing demand because many young workers are first-time home buyers and want to move to larger houses over time. Therefore, their economic situation is an important driver of the spillover effect on housing prices. Second, young workers experience larger lifetime income losses when they become unemployed compared to older workers, leading to a larger decline in housing demand.

The overall demographic structure of the economy also plays a key role in the magnitude of the spillover effect of unemployment on housing prices. In light of the fact that the U.S. population is projected to age significantly in the next years, I analyze how an increase in the share of old population shapes the spillover effect. In a simple OLG model, it can be analytically shown that an increase in the share of the old, retired population mitigates the spillover effect if the relative change in the housing demand of working-age households is smaller than the relative change in the housing demand of old, retired households. In the quantitative model, I show that an increase in the old population from 25% to 35% mitigates the spillover effect by 4%. Overall, the demographic composition of an economy significantly affects how unemployment shocks propagate to the housing market.

An important question is whether policy can mitigate the spillover effects of unemployment shocks on housing prices in order stabilize the economy. In the final section of this paper, I show that an unemployment insurance (UI) system can serve as a stabilizer for housing prices during periods of high unemployment. Specifically, I find that raising the UI replacement rate from 60% to 80% in the first two years of a recession mitigates the spillover effect by 12%. However, the UI system is not able to fully counteract the spillover effect. The role of the UI system in mitigating the spillover effect is limited because workers face permanent income losses when they become unemployed and shift their portfolio toward more liquid assets during a recession. As a result, housing demand and prices fall and this effect remains little affected by higher UI generosity. While a higher UI replacement rate provides temporary income insurance and helps smooth consumption, it does not provide insurance against the risk of permanent income losses, so that the size of the spillover effect remains significant.

The remainder of this paper is structured as follows. The following subsection relates this paper to the existing literature. In Section 2, I analyze the empirical relationship between unemployment rates and housing prices. Section 3 presents the theoretical model which is followed by its calibration. Section 4 analyzes the aggregate dynamics and individual life-cycle consequences of an unemployment shock and explores the welfare consequences across different age groups. In Section 5, I examine age-dependent unemployment shocks and the importance of demographic structures for the spillover effect. Section 6 examines the role of unemployment insurance as a policy tool to mitigate the spillover effect from unemployment to housing prices. Section 7 concludes.

1.1 Related literature

This paper contributes to the extensive literature on the impact of income risk on household portfolio choices by integrating unemployment risk with housing market dynamics. In particular, the mechanism of this paper builds on the approach of Bayer et al. (2019) who show that higher uncertainty leads to higher precautionary savings of households through the accumulation of liquid assets while reducing illiquid investment and consumption, thereby affecting aggregate activity. My paper replicates this effect in a framework where housing is an illiquid asset and unemployment as a specific type of income risk, providing further support for the portfolio channel of income risk in Bayer et al. (2019).

The literature focusing on income risk and housing demand includes, among others, Attanasio et al. (2012) who use a life-cycle model to analyze how uncertainty about earnings and house prices affect the decision to buy a house. They find that households delay buying a house when they face larger uncertainty, while an increase in income leads to an earlier housing purchase. Paz-Pardo (2024) studies whether changes in homeownership rates across generations can be explained by changes in labor earnings risk. Around half of the decline in homeownership rate is due to the labor market becoming more unequal and volatile. Using age-dependent labor market uncertainty, Chang et al. (2018) show that unemployment risk and uncertainties regarding job turnover and career path shape the portfolio decision of workers. Changes in labor market risk also affected consumption fluctuations around the Great Recession according to Larkin (2019). The decline in labor market risk before the downturn shifted households' portfolio towards illiquid assets which amplified the consumption drop during the recession.

Regarding the model structure, this paper is closely related to the papers examining housing prices in an OLG economy with a housing market. Kaplan et al. (2020) analyze the house price fluctuations around the Great Recession in an OLG model with housing and aggregate risks. They find that shifts in beliefs, rather than credit conditions were the key driver of house price fluctuations. Landvoigt et al. (2015) explore the housing market in San Diego also in a quantitative framework with housing and a credit market. The availability of cheaper credit for poor households is the main reason for the observed changes in housing prices over time. Other papers using an OLG model with housing market are, among others, Corbae and Quintin (2015), Favilukis et al. (2017), as well as Chambers et al. (2009).

In terms of methodology, the paper is closely related to Glover et al. (2020) who analyze the welfare consequences of the asset price drop during the Great Recession on different age groups of households. They find that old households experience the largest welfare losses from asset price drops while the younger cohorts gain from buying the assets at a lower price. Whereas the idea of analyzing the differential welfare implications of asset price changes across age groups in this paper is similar to that of Glover et al. (2020), there are two crucial differences: Glover et al. (2020) consider an aggregate shock to all households in the economy and therefore, asset prices are determined by the behavior of all households. In this paper, the unemployment risk only has a direct effect on income of households in the labor market, generating a spillover effect on the housing market: The fluctuations in the house prices are then generated only through the labor market condition of younger households, while old, retired households who are homeowners have little influence on the housing market. Moreover, the model in this paper features financial constraints and heterogeneity within the same age group in contrast to Glover et al. (2020) in which there is no intragenerational heterogeneity. While some households may buy houses at a depressed price and gain from the house price appreciation in future time, most of the young households are subject to credit constraints and cannot afford the required down payment or meet the payment-to-income ratios.

This paper also speaks to the large literature on labor market policies, especially the literature on unemployment insurance systems. Beginning with Baily (1978) and Chetty (2008), many studies have focused on the trade-off between insurance against job loss and incentive for job search in the presence of moral hazard in the optimal unemployment insurance literature. More recent work analyzes how the unemployment insurance system affects the other parts of the labor market: Hagedorn et al. (2013) show that unemployment benefit extensions push up equilibrium wages such that vacancy posting of firms decreases and as a consequence, employment drops in the economy. Moreover, Landais et al. (2018) argue that the unemployment insurance changes the labor market tightness and therefore the optimal replacement rate. The results in this paper reveal that the unemployment insurance (UI) system also serves as a stabilizer of the housing market during a recession. In addition to providing insurance for workers, a more generous UI system indirectly benefits retired households by mitigating the spillover effects of unemployment shocks on housing prices. This leads to positive welfare effects for old, retired households, showing that the overall gain from an enhanced UI system during a recession are more significant than usually perceived in the macroeconomic literature.

2 Empirical analysis

In this section, I analyze the empirical relationship between unemployment rate and housing prices for the United States. To this end, I exploit the state-level variation in unemployment rate and housing prices from 1978 to 2019. The hypothesis is that fluctuations in unemployment rates influence house prices – specifically, that an increase in the unemployment rate results in a decline in housing prices. To test this hypothesis, I begin by describing the data sets used in the analysis. The empirical analysis then proceeds with an OLS regression. Following this, I apply an IV approach to account for potential endogeneity issues or omitted variable bias in investigating the relationship between unemployment rate and housing prices.

2.1 Data

The empirical analysis relies on data from the Current Population Surveys (CPS). The CPS provides official U.S. government statistics on labor market status and is available since 1962. The data set offers comprehensive information on employment and demographics of U.S. households, representing the civilian non-institutional population. The sample focuses on individuals aged 20 and older. From this data set, I extract data on age, labor force status, and the industry composition of employment for each state. Unemployment rates are calculated by using the basic monthly data and applying person-level weights for each month, which are then averaged over the months to obtain annual unemployment rates. As explained later, constructing the shift-share instrument requires data on industry employment shares by state. I use the Annual Social and Economic Supplement (ASEC) samples and apply the March supplement weights to derive the industry shares. Industry classifications follow the 2-digit North American Industry Classification System (NAICS).

Additionally, I use the Home Mortgage Disclosure Act (HMDA) data, published annually by the Consumer Financial Protection Bureau to analyze the relationship between mortgage applications and unemployment rates. The data set provides detailed information on the U.S. mortgage market, based on the reports of financial institutions. Using HMDA data from 2006 to 2020, I analyze the relationship between unemployment rate and the number of mortgage applications. As in the previous step, the data is aggregated at the state level and on an annual basis.

2.2 House price and unemployment

As a first step, I examine the relationship between the unemployment rate and housing prices using an OLS regression. Specifically, I regress the natural log of state-level housing price changes on the state-level unemployment rate, while controlling for state-level average household income, national macroeconomic conditions, and state- and year-fixed effects. The results, presented in Table 1, indicate a statistically significant relationship between unemployment rates and housing prices, where a 1 percentage point increase in the unemployment rate is associated with a 1.41% decline in housing prices (column 1). This

Table 1: OLS regression

Δlog(HPI)	All data			Excluding Great Recession		
	(1)	(2)	(3)	(4)	(5)	(6)
Unemp. rate	-1.41^{***}	-1.41^{***}	-1.00^{***}	-1.41^{***}	-1.41^{***}	-1.12^{***}
	(0.17)	(0.17)	(0.16)	(0.19)	(0.19)	(0.17)
Observations	2091	2091	2091	1938	1938	1938
R^2	0.57	0.57	0.63	0.54	0.54	0.60
State- and year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
House supply controls	No	Yes	Yes	No	Yes	Yes
Demographic controls	No	No	Yes	No	No	Yes

Notes: This table summarizes the results from state-panel regressions of log changes in housing prices on the unemployment rates, state and year fixed effects, and the listed controls. Columns (1)-(3) present the results when the regression analysis considers all data from 1978 to 2019. Columns (4)-(6) exclude the period of Great Recession from the considered data. Standard errors are adjusted for clustering at the state level and reported in parentheses.

relationship persists even after controlling for additional factors such as housing supply and demographic controls (columns 2 and 3). To ensure the results are not solely driven by the Great Recession, I exclude the period of Great Recession from the data set and repeat the regression analysis. As shown in columns 4-6, the results remain largely unchanged.

A potential concern with the OLS regression analysis is that there might be a problem with endogeneity and omitted variable bias when analyzing the relationship between unemployment rates and housing prices. For example, while unemployment rates influence housing prices, it is also possible that changes in housing prices affect the demand for non-durable consumption and lead to changes in employment in the local labor market. To address this issue, I employ a shift-share instrument, also known as the Bartik instrument, following the methodology developed in Bartik (1991). This instrument helps to identify exogenous movements in the state-level unemployment rates that are not affected by fluctuations in housing prices.

$$Bartik_{s,t} = \sum_{j=1}^{J} e_{sjt-1} \left(\log E_{jt} - \log E_{jt-1}\right) \tag{1}$$

Equation (1) shows how the instrument is constructed. The idea of the instrument is to measure local labor demand that is not affected by local labor supply. The Bartik instrument

Table 2: First-stage regression

Unemployment rate	All data	Excluding Great Recession
	(1)	(2)
Bartik	-0.38^{***}	-0.37^{***}
	(0.06)	(0.06)
Observations	2091	1938
R^2	0.80	0.79

Notes: This table shows the first-stage regression for the IV analysis. The state-level unemployment rates are regressed on the Bartik shocks including state and year fixed effects, state-level characteristics (average household income, population growth, and ratio of young to old households), and national characteristics (GDP growth, national unemployment rate, stock price index, consumer price index, Federal funds rate, new housing permits, and the supply of new housing). The state-level and national characteristics contain the lags of these variables up to four years. Columns (1) presents the results when the regression analysis considers all data from 1978 to 2019. Columns (2) excludes the period of Great Recession from the considered data. Standard errors are adjusted for clustering at the state level and reported in parentheses.

is constructed by multiplying the employment share e of industry j in state s, measured one year ahead, by the national growth rate of industry j, excluding state s. This approach uses the variation in industry composition across states to isolate exogenous changes in unemployment rates. To avoid potential bias, the industries classified under "construction" and "real estate and rental and leasing" sectors are excluded from the set of industries J, as these industry categories could affect housing prices through a different channel than through the labor market situation of a state.

$$\Delta \log(HPI_{s,t}) = \beta \hat{u}_{s,t} + \delta X_{s,t-\tau} + \gamma Z_{t-\tau} + \lambda_s + \zeta_t + \alpha_1 + \eta_{s,t} \quad (2)$$

The IV regression is shown in Equation 2. The dependent variable is the percent change in housing prices in state s between year t and $t-1$. The vector X includes state-level characteristics with up to τ lags, where τ is set to four years. The state-level characteristics consist of the average household income, population growth, and the ratio of young to old households. The vector Z captures national-level characteristics, such as GDP, national unemployment rate, stock price index, consumer price index, Federal funds rate, new housing permits, and the supply of new housing, along with the lags of these variables, also up to four years. State and year fixed effects are denoted by λ and ζ, respectively.

Table 2 presents the results of the first-stage regression. There is a significantly negative

Table 3: IV regression

Δlog(HPI)	All data			Excluding Great Recession		
	(1)	(2)	(3)	(4)	(5)	(6)
Unemp. rate	-1.98^{***}	-1.98^{***}	-1.50^{***}	-1.93^{***}	-1.93^{***}	-1.55^{***}
	(0.47)	(0.47)	(0.55)	(0.47)	(0.47)	(0.57)
Observations	2091	2091	2091	1938	1938	1938
R^2	0.43	0.43	0.52	0.38	0.38	0.46
State and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
House supply controls	No	Yes	Yes	No	Yes	Yes
Demographic controls	No	No	Yes	No	No	Yes

Notes: This table summarizes the state-panel IV regressions of log changes in housing prices on the instrumented unemployment rates. The controls include state and year fixed effects, state-level characteristics (average household income, population growth, and ratio of young to old households), and national characteristics (GDP growth, national unemployment rate, stock price index, consumer price index, Federal funds rate, new housing permits, and the supply of new housing). The state-level and national characteristics contain the lags of these variables up to four years. Columns (1)-(3) presents the results when the regression analysis considers all data from 1978 to 2019. Columns (4)-(6) exclude the period of Great Recession from the considered data. Standard errors are adjusted for clustering at the state level and reported in parentheses.

relationship between the state-level unemployment rate and the Bartik instrument. This indicates that an exogenous decline in labor supply due to shifts in the national industry composition in a local labor market is correlated with an increase in the state-level unemployment rate.

Table 3 reports the main IV estimates of the effect of unemployment rate on housing prices. Similar to the OLS regression, the first three columns show the results using the full data set, while the last three columns exclude the Great Recession period from the analysis.[1] Overall, the IV estimates show a significantly negative relationship between unemployment rate and housing prices. In the final column, which includes all control variables, the IV estimate suggests that a one percentage point increase in the unemployment rate leads to a 1.55% decline in housing prices. Notably, the absolute magnitude of the IV estimates is larger than those from the OLS regression. This indicates that in the OLS regression, the effects of unemployment rate on housing prices are biased downwards.

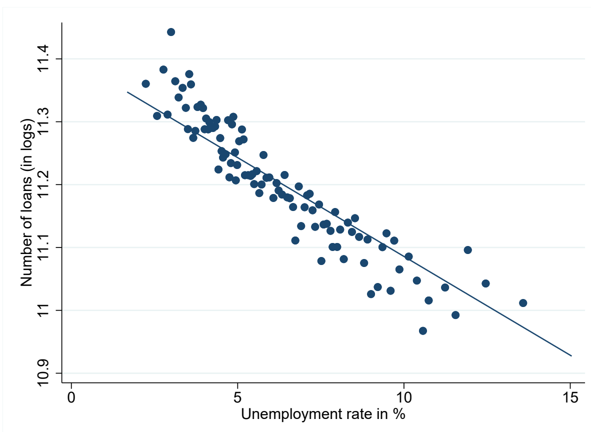
[1]The underidentification and weak identification statistics are reported following Kleibergen and Paap (2006). The strength of the instrument is not a concern as the p values for the underidentification are less than 0.01 and the Kleibergen-Paap weak identification statistics are larger than the critical value of 16.38 for 10% maximal IV size.

2.3 Mortgage applications

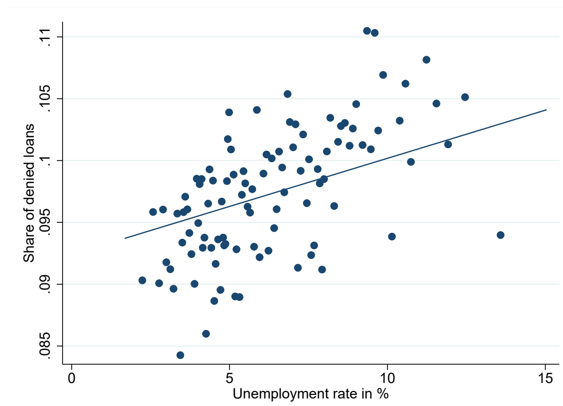
The results of the IV regression reveal a significantly negative relationship between the unemployment rate and housing prices. One possible explanation for this finding is that higher unemployment rate may reduce housing demand, leading to a decline in housing prices. To further explore this, I analyze the link between housing demand and unemployment rate using data from the Home Mortgage Disclosure Act (HMDA). The HMDA data set, which contains mortgage applications submitted by households to financial institutions, serves as a proxy for housing demand of households.

Figure 1: Mortgage applications and unemployment rate

(a) Number of loans



(b) Share of denied applications



Notes: Panel (a) shows the number of mortgage applications against unemployment rate by each state. Panel (b) shows the share of mortgage applications that have been rejected. The results are after controlling for GDP, nationwide unemployment rate, and state- and year-fixed effects.

Figure 1 presents a summary of the results. In Figure 1a, there is a strong negative correlation between the number of mortgage applications and the unemployment rate at the state level. Additionally, Figure 1b displays the relationship between the share of denied mortgage applications and the unemployment rate at the state level, showing a positive correlation. This suggests that financial institutions are more likely to deny mortgage applications during times of high unemployment. These findings point to two key observations during times of high unemployment: first, fewer households apply for mortgage loans, and second, a larger share of those applications is denied by the financial institutions. Together, both observations indicate that housing demand declines when the economy is experiencing a rise in the unemployment rate.

In summary, this section analyzes the empirical relationship between unemployment rates and housing prices in the United States from 1978 to 2019. The IV regression analysis reveals that higher unemployment rates result in a significant decline in housing prices. An investigation of the HMDA data indicates that high unemployment reduces housing demand, as indicated by fewer mortgage applications and a higher share of denied loans.

3 Model

This section begins by outlining the household problem, followed by the equilibrium condition and the calibration of the model to the U.S. data. Finally, I present the properties of aggregate shocks in the model.

3.1 Households

The economy is populated by overlapping generations with finitely lived households. Time is discrete and the life cycle of a household is divided into a working $(1 - J^{ret})$ and a retirement phase $(J^{ret} - J)$. During the working phase, households provide an inelastic labor supply of one efficiency unit, while facing uninsurable idiosyncratic labor income risk. Households are risk averse and maximize expected lifetime utility by allocating resources to non-durable consumption, housing services, and savings in liquid financial assets. The age of households is denoted by j. The functional form of the utility function is given by

$$u(c, s) = \left([(1-\phi)c^{1-\gamma} + \phi s^{1-\gamma}]^{(1-\vartheta)/(1-\gamma)} - 1\right)/(1-\vartheta)$$

as in Kaplan et al. (2020), where c denotes non-durable consumption, s denotes housing services, and b is the amount of liquid assets. Households leave bequests which yield a utility of

$$\upsilon(b) = v\frac{(b + \underline{b})^{1-\vartheta} - 1}{1-\vartheta}.$$

The utility function for the bequest motive follows De Nardi (2004). During the working phase, households are either employed or unemployed. Employed households earn labor income y_j^e given by

$$\log y_j^e = \log \Theta + \chi_j + \varepsilon_j,$$

where Θ represents the aggregate productivity of labor, and χ_j captures the deterministic, age-dependent income profile. The idiosyncratic income component, ε_j, evolves according to a first-order Markov process. Households can experience unemployment for a fraction d^u of a period. While unemployed, they receive a transfer $b^u \cdot y_j^e$, where b^u is the replacement rate of the unemployment insurance system. For the remaining fraction $1 - d^u$ of the period, households earn their labor income y_j^e. Consequently, the total income of an unemployed household is given by

$$y_j^u = y_j^e \left[(1 - d^u) + b^u d^u\right].$$

Upon becoming unemployed, workers face the risk of persistence earnings losses with probability $q_{j,t}^u$. Specifically, workers experience a decline in their idiosyncratic component ε_j of their labor income process. In this case, there is a persistent reduction in future earnings, leading to long-term effects of unemployment on labor income of workers. The recursive formulation of the household problem, presented below, provides a more detailed account of how these earnings losses are incorporated during unemployment.

3.2 Recursive formulation of the decision problem

Households who own a house face the decision between staying in their current house and repaying the mortgage or selling their house and buying a new house. Thus, the value function at the beginning of a period is given by

$$V_{j,t}(b, y, l, m, h) = \max\left\{V_{j,t}^h(b, y, l, m, h),\ V_{j,t}^s(b, y, l, m, h)\right\}. \tag{3}$$

$V_{j,t}^h$ denotes the value function of a homeowner repaying the mortgage, and $V_{j,t}^s$ is the value function of a new house buyer. The state variable l denotes the labor market status of the household, with $l = e$ if a household is employed and $l = u$ if unemployed. Households that decide to remain in their current house and repaying the mortgage maximize their utility by choosing consumption c and liquid savings b', given the expectation about future employment and income state and subject to a zero borrowing constraint. The household's optimization problem is given by

$$V^h_{j,t}(b,y,l,m,h) = \max_{c,b'} u(c,s) + \beta \mathbb{E}_{y',l'}\left[V_{j+1,t+1}(b',y',l',m',h')\right] \tag{4}$$
$$s.t. \quad c + (\tau_h{+}\delta)p_t h + b'/(1+r_f) + \omega_j(m) \leq b + y - \tau(y,h)$$
$$b' \geq 0, \quad s = h, \quad h' = h, \quad m' = (1+r_m)m - \omega_j(m)$$

where β is the time discount factor, τ_h is the property tax rate, d_h is the maintenance cost, p_t is the housing price, and $\omega_j(m)$ is the mortgage repayment as a function of the remaining mortgage balance m. The next period's mortgage balance m' is the difference between today's mortgage plus mortgage interest rates r_m and today's mortgage repayment. The mortgage repayment $\omega_j(m)$ follows a constant amortization formula:

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

The term $\mathbb{E}_{y',l'}\left[V_{j+1}(b',y',l',m',h')\right]$ contains the expectation about the employment and income states in the next period where

$$\begin{aligned}\mathbb{E}_{y',l'}\left[V_{j+1,t+1}(b',y',l',m',h')\right] &= (1-\lambda_{j+1,t+1}) \cdot \mathbb{E}_{y'}\left[V_{j+1,t+1}(b',y',e,m',h')\right] \\ &\quad + \lambda_{j+1,t+1}\left\{(1-q^u_{j+1,t+1}) \cdot \mathbb{E}_{y'}\left[V_{j+1,t+1}(b',y',u,m',h')\right]\right. \\ &\quad \left. + \; q^u_{j+1,t+1} \cdot \mathbb{E}_{y'}\left[V_{j+1,t+1}(b',y^-,u,m',h')\right]\right\}\end{aligned}$$

Here, $\lambda_{j,t}$ represents the age-dependent unemployment probability, while $q^u_{j,t}$ is the probability of experiencing persistent earnings losses. When households become unemployed, they may suffer a persistent income loss with a reduction in the income state to y^- with probability $q^u_{j,t}$. For households who decide to sell their house and buy a new one, the budget constraint reflects the sale of the house:

$$b^s = b + (1-\delta-\tau_h-\kappa)p_t h - (1+r_m)m \tag{5}$$

where κ denotes the transaction cost. Households who purchase a new house obtain a new mortgage m' per housing unit, which is subject to the loan-to-value (LTV) limit ρ_m and payment-to-income ratio ρ_y. The value function of a new house buyer is:

$$V^s_{j,t}(b,y,l,m,h) \;=\; \max_{c,h',b'} \; u(c,s) \;+\; \beta \cdot \mathbb{E}_{y',l'}\left[V_{j+1,t+1}(b',y',l',m',h')\right] \tag{6}$$
$$s.t. \quad c + p_t \cdot h' + b'/(1+r_f) \;\leq\; b^s + y - \tau(y,h) + m'$$
$$b' \geq 0, \quad s = h', \quad m' \leq \rho_m \cdot p_t \cdot h', \quad \omega(m') \leq \rho_y \cdot y$$

In retirement, workers have the same decision problem as in the working phase, but face an age-dependent death probability of d_j and leave a bequest of b^j upon death. The problem of households staying in the same house is then

$$V^h_{j,t}(b,y,m,h) = \max_{c,b'} u(c,s) + \beta\left[(1-d_{j+1})V_{j+1,t+1}(b',y',m',h') + d_{j+1} \cdot v(b^{j+1})\right] \tag{7}$$
$$s.t. \quad c + b'/(1+r_f) + (1+r_m)m \leq b + y - \tau(y,0)$$
$$b' \geq 0, \quad s = h, \quad b^J = b' + (1-\delta-\tau_h-\kappa)\cdot p_t h$$

The combination of a death probability and a bequest motive is similar to the model of Kopczuk and Lupton (2007).

3.3 Equilibrium

The individual state variables consist of liquid assets b, income state y, employment l, mortgage balance m, and housing stock h. The individual state vector is denoted by $x \coloneqq (b,y,l,m,h) \in \mathbb{X}$. A competitive equilibrium is a collection of value functions $\left\{V_{j,t}(x), V^h_{j,t}(x), V^s_{j,t}(x)\right\}$, household decision rules $\{g_{j,t}(x), b_{j+1,t}(x), c_{j,t}(x), h_{j+1,t}(x)\}$, equilibrium housing prices p_t as functions of time t such that:

1. Given the housing prices p_t, the decision rules $\{g_{j,t}(x), b_{j+1,t}(x), c_{j,t}(x), h_{j+1,t}(x)\}$ solve the households' decision problem by solving problems (3)-(7), with the value functions $\left\{V_{j,t}(x), V^h_{j,t}(x), V^s_{j,t}(x)\right\}$.

2. The housing market clears at the equilibrium price p_t and the housing stock in the economy satisfies

$$\sum_{j=1}^{J} \int_{\mathbb{X}} h_{j,t}(x) d\mu_{j,t} = \overline{H} \quad \forall t$$

where $\mu_{j,t}$ is the cumulative distribution of individual states in the population and the total housing stock $\overline{H}$ is fixed.

A steady state of the economy is a competitive equilibrium where the distribution of agents is stationary.

3.4 Calibration

This section explains the calibration of the model and discusses its empirical fit. The steady-state equilibrium is calibrated to the U.S. economy using data from the Survey of Consumer Finances (SCF) in year 2019.

Table 4: Model parameters

Parameter	Value	Description
J^w	42	Working life
J^r	24	Retirement
β	0.98	Discount factor
$1/\gamma$	1.25	Elasticity of substitution
ϑ	2.0	Risk aversion
υ	100	Bequest motive
$\underline{b}$	5	Bequest as luxury
$\mathcal{H}$	$\{.01, 1.5, 1.92, 2.46, 3.15, 4.03, 5.15\}$	House sizes
κ	.07	Transaction cost
δ	.015	Housing depreciation rate
τ	.75, .151	Income taxation function
χ_j	Kaplan and Violante 2014	Deterministic age profile
ρ_ϵ	.97	Autocorrelation of earnings shocks
σ_ϵ	.20	Standard deviation of earnings shocks
r_f	.03	Risk-free interest rate
r_m	.055	Mortgage interest rate

Notes: This table shows the parameter values in the model. One model period corresponds to one year.

A period in the model corresponds to one year. Households enter the model and are in the labor force at age 25 and retire at age 67. All households are assumed to die at age 91. The parameter values used in the calibration are summarized in Table 4. The estimated annual discount factor β is 0.98, which aligns with values commonly used in the macroeconomic literature. The elasticity of substitution between housing and non-durable consumption is set at 1.25 following Piazzesi et al. (2007). To match an elasticity of intertemporal substitution of 0.5, ϑ is calibrated to 2. The parameters governing the bequest motive are $\upsilon = 100$ and $\underline{b} = 5$, which are consistent with the estimates provided by Kaplan et al. (2020).

The income process is calibrated using the deterministic age profile from Kaplan and Violante (2014). The idiosyncratic earnings shock ε_j follows an AR(1) process with a persistence of 0.97 and standard deviation of innovations of 0.2. Consistent with Heathcote et al. (2010), this calibration of earnings shocks produces an increase in the variance of log labor earnings of 2.5. The risk-free interest rate r_f is set at 0.03 and the mortgage interest rate r_m at 0.055.

In order to calibrate the pension system in the model to match the U.S. Social Security system, I follow the 2019 U.S. Social Security legislation. The Social Security cap is set at \$132,900, with the first and second bendpoints at \$926 and \$5,583, respectively. The retirement benefits formula is given by

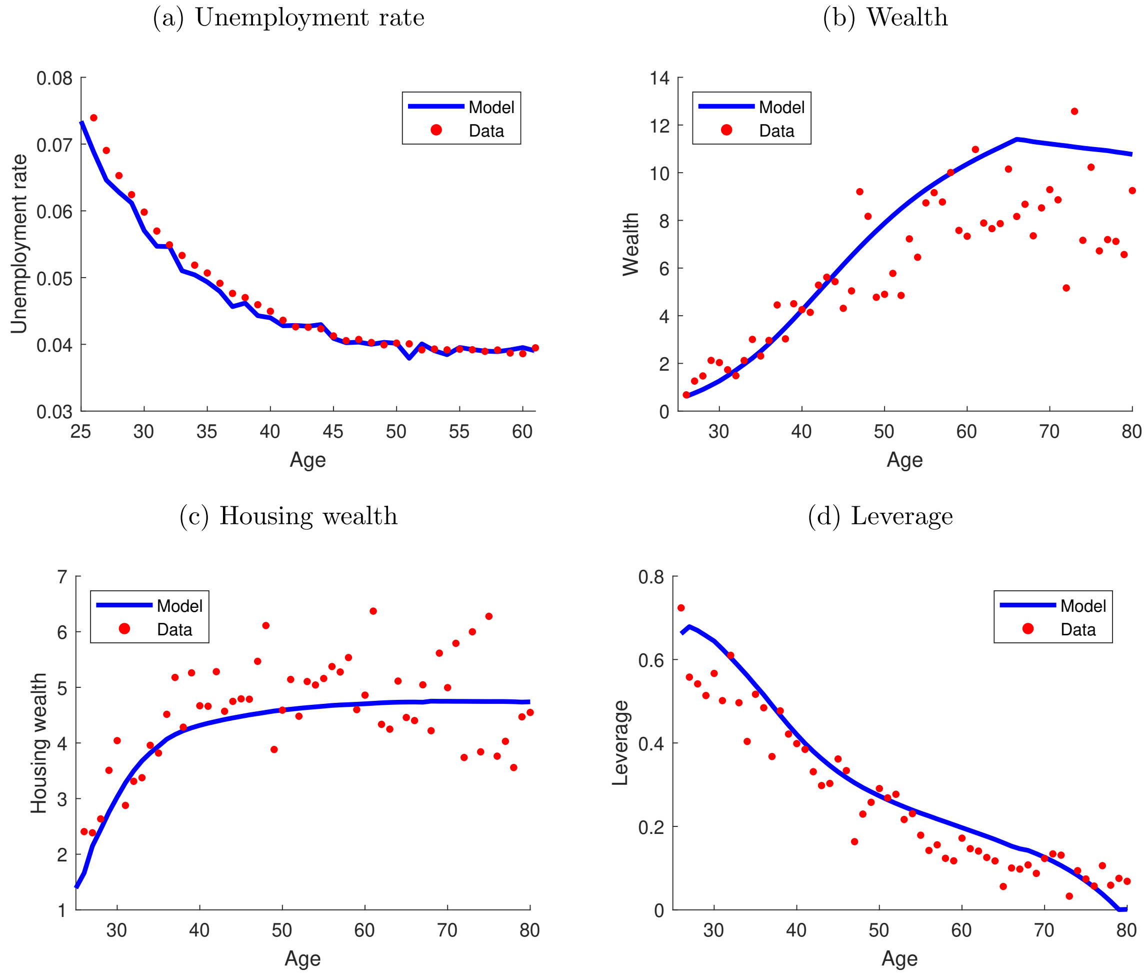
$$\Omega(\bar{y}) = \begin{cases} 0.9\bar{y} & \text{if } \bar{y} < bp_1, \\ 0.9bp_1 + 0.32(\bar{y} - bp_1) & \text{if } bp_1 \leq \bar{y} < bp_2, \\ 0.9bp_1 + 0.32(bp_2 - bp_1) + 0.15(\bar{y} - bp_2) & \text{if } bp_2 \leq \bar{y} < cap, \\ 0.9bp_1 + 0.32(bp_2 - bp_1) + 0.15(cap - bp_2) & \text{if } \bar{y} > cap \end{cases} \tag{8}$$

where $\bar{y}$ denotes the average lifetime earnings, $\Omega(\bar{y})$ denotes the assigned benefit level, and bp_1 and bp_2 denote the two bendpoints.[2]

Figure 2 presents the life-cycle profiles for the unemployment rate, wealth, housing wealth, and leverage, comparing the model outcomes to their empirical counterparts. Looking at the unemployment rate by age in Figure 2a, the model closely matches the empirical profile. Both in the model and the data, there is a strong decline in the unemployment rate until age 35, after which it stabilizes at approximately 4%. Figure 2b demonstrates that the model effectively captures the steep increase in wealth throughout the life cycle as observed in the data. The bequest motive in the model is crucial for matching the empirical wealth profile. In the absence of bequest motive, households would decumulate their wealth as they approach the end of the life cycle, resulting in a steep fall in wealth. The model also matches

[2]The retirement benefit formula is taken from http://www.ssa.gov/OACT/COLA/piaformula.html.

Figure 2: Life-cycle profiles



Notes: This figure shows the life-cycle profiles of unemployment rate, wealth, housing wealth, and leverage. The dots show the empirical profiles, while the solid lines show the corresponding model profiles. The empirical unemployment rate profile is computed using data from the Current Population Survey. Other empirical profiles are computed using data from the Survey of Consumer Finances.

the profiles of housing wealth and leverage very well. The profile of housing wealth, shown in Figure 2c, implies a strong increase in housing wealth during the early stages of the life cycle, peaking around age 40. Afterwards, the profiles remain almost constant. Concerning household leverage, Figure 2d shows a gradual decline in leverage over the life cycle both in the model and in the data. Young workers exhibit high leverage as they climb the housing ladder and take on mortgage loans. As they get older, households repay their mortgages, which drives down the leverage level.

3.5 Unemployment shock

Table 5: Properties of the unemployment shock

Description	Value	
	Steady state	Recession
Average unemployment rate	4%	8%
Unemployment duration	0.25	0.5
Probability of earnings loss	0.2	0.8

Notes: This table compares the model parameters and properties when the economy is in steady state and when an unemployment shock occurs.

The economy is initially in a steady state. The unemployment shock is introduced as a one-time, unanticipated shock at $t = 0$. Households have perfect foresight and know that the economy will revert to the initial steady state after T periods. When the unemployment shock occurs, the age-dependent separation probability and the unemployment duration increase. Moreover, the risk of persistent income losses also increases. Table 5 outlines the properties of the unemployment shock for the baseline economy. When the unemployment shock occurs, the average unemployment rate increases from 4% to 8%, while the average unemployment duration increases from a quarter to 6 months.

Table 6: Income losses upon unemployment

State of economy	Model	Davis and von Wachter (2011)
Steady state	−25%	−25%
Recession	−44%	−39%

Notes: This table compares the earnings losses at the time of displacement for workers at age 40 in the model (column 2) and the results in Davis and von Wachter (2011) (column 3).

Table 6 compares the average income loss following unemployment relative to pre-displacement income in the model to the findings of Davis and von Wachter (2011). In the steady state, the model produces a 25% decline in earnings in the period of displacement, while during a recession, the income loss is much larger and amounts to 45%. Compared to Davis and von Wachter (2011), the income loss in a recession is slightly larger in the model at hand, but the overall calibration aligns well with the empirical income losses.

4 Spillover effect of unemployment on the housing market

This section explores the spillover effect of an unemployment shock on the housing market using the calibrated model. In particular, I show that the impact of the spillover effect is large, both on the aggregate level and for individual households. The calibrated model matches the housing price drop observed in the empirical data documented in Section 2. For the aggregate effects, I analyze the dynamics of housing price and average income over time following an unemployment shock to the economy. At the individual level, I show how the unemployment shock affects housing demand and the differential welfare consequences of the spillover effect on households of different age groups.

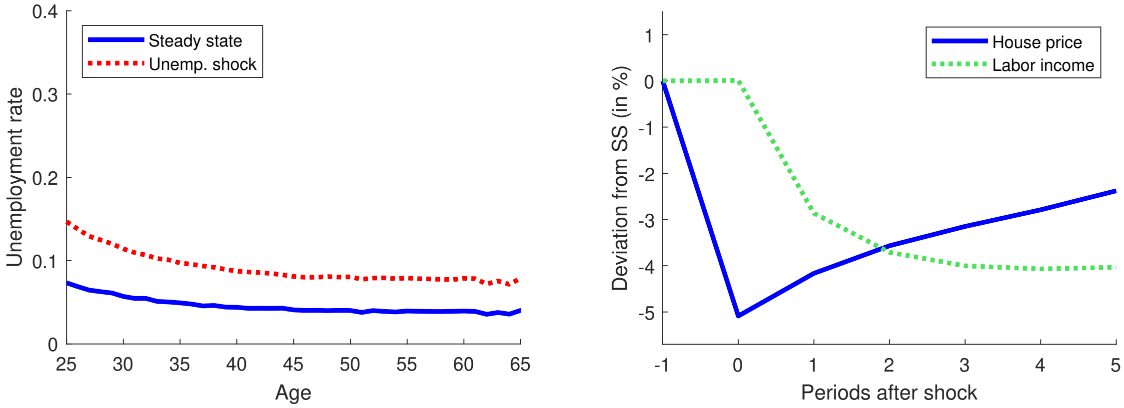
4.1 Aggregate dynamics

Figure 3a shows the average unemployment rate by age for the steady state of the economy and in the first period of a recession. In the baseline economy, the unemployment shock leads to a doubling of the unemployment rate across all age groups, implying a uniform increase in unemployment for workers of all ages. As the unemployment rate is on average higher for younger workers, the absolute increase in the unemployment rate during a recession is more pronounced for young workers. To analyze the impact of the unemployment shock on the aggregate economy, I start from the steady state of the model. At time zero, the unemployment shock hits the economy. In the following periods, the economy slowly returns to its steady state, with the unemployment rate and all other parameters reverting to their steady-state levels. The results are displayed in Figure 3b. In response to the aggregate shock, both housing prices and average income drop significantly. Specifically, the housing price drops by 5%, while the average income falls by 2.9% in the first period of the shock. The recovery of the average income is slow due to large and persistent income losses of workers who were affected by the shock.

In the first period after the unemployment shock, there is a strong initial recovery of the housing price which can be explained by two reasons. First, the income uncertainty declines over time such that households increase their housing demand. Second, households shift their portfolio during the recession. When the unemployment shock hits the economy, workers reduce their housing demand and shift their savings into liquid assets to insure themselves against the heightened income risk (see Appendix A.6). Once the economy is recovering from

Figure 3: Unemployment shock and housing price

(a) Unemployment rate (b) Housing price



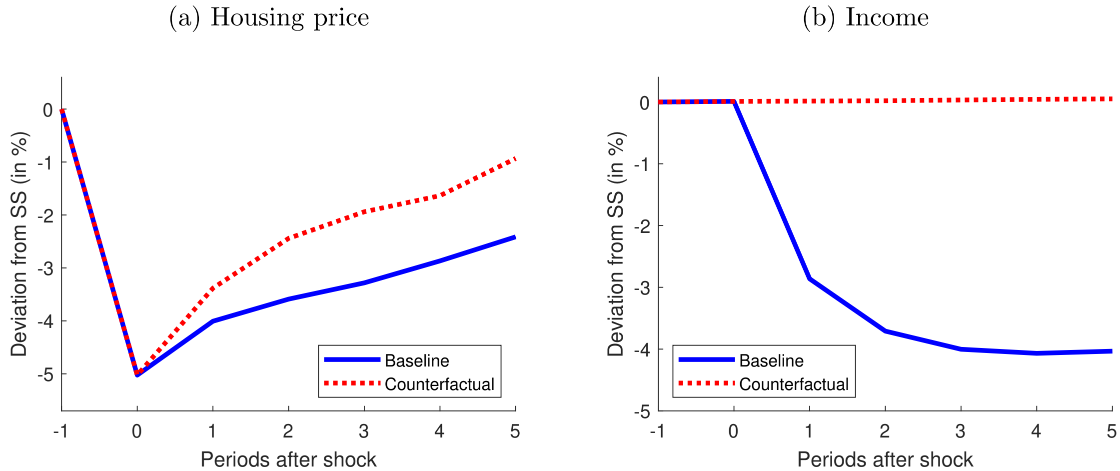
Notes: This figure shows the unemployment shock and the house price dynamics after the unemployment shock hits the economy. Panel 3a compares the average unemployment rate by age when the economy is in a normal state (solid line) with the average unemployment rate in a recession (dotted line). Panel 3b shows the dynamics of housing price (solid line) and and average labor income (dotted line) when the unemployment shock hits the economy at time zero.

the unemployment shock, workers hold more liquid assets for precautionary savings motive than usual, resulting in an overshooting in housing demand. As a consequence, the housing price quickly recovers one period after the shock.

The above results show that the calibrated model matches the observed drop in housing price following unemployment shocks, consistent with empirical data. Two key factors account for the drop in the housing price: first, the average income level declines due to higher unemployment rate and large persistent income losses of workers. As a consequence, workers reduce their demand for housing, and in turn, the general equilibrium effect pushes down the price on the housing market. Second, the persistence of the unemployment shock also plays an important role. Due to the persistence of the shock, workers face a heightened risk of unemployment and income losses in future periods. The increased income risk further suppresses housing demand, leading to an additional decline in housing prices.

One key question is how much the decline in income level and the increase in income uncertainty each contribute to the observed drop in housing prices following an unemployment shock. In the following, I conduct a counterfactual experiment where the economy experiences the same unemployment shock as before, but with the average income level held constant at the steady-state level. In this case, workers are still subject to a

Figure 4: Counterfactual case with fixed income



Notes: This figure shows a counterfactual experiment where the economy is hit by the same unemployment shock as in the baseline economy, but the average income level is held constant at the steady-state level. By keeping the spillover effect stemming from the income channel to zero, the counterfactual experiment isolates the risk effect of higher probability of unemployment and permanent income losses when the unemployment shock hits the economy. Panel 4a shows the dynamics of housing price and Panel 4b the dynamics of income after the unemployment shock occurs at time zero. In both panels, the solid lines refer to the baseline economy and the dotted lines to the counterfactual model.

higher risk of unemployment and higher probability of persistent income losses, but the actual realized unemployment rate and the average income remain unchanged from the steady state.

The results from the counterfactual experiment are displayed in Figure 4. By comparing the housing price drop in the baseline model with the results from the counterfactual economy after the unemployment shock in Figure 4a, it becomes evident that the main cause of the housing price drop in the initial period of the shock is the increase in income uncertainty. In the counterfactual experiment, the unemployment shock leads to the same housing price drop of 5% on impact as in the baseline economy, but in the later periods the housing price recovers more quickly. After 5 periods, the housing price in the counterfactual economy is 1% below the steady state compared to 2.4% in the baseline economy. This is because the average income level remains unchanged from its steady state, and as a consequence, the housing price quickly returns to its steady state. Quantitatively, higher income risk explains approximately 60% of the total housing price deviation from the steady state, while actual income losses account for the remaining 40%.[3] The main reason for a lower housing demand

[3]The total house price deviation is defined as the cumulative house price deviation from the steady state

is therefore the heightened risk of unemployment. This finding complements the study by Bayer et al. (2019) who show that higher uncertainty leads to a drop in illiquid investment of households, while increasing precautionary savings.

4.2 Housing demand and the consequences of the spillover effect

The above results show that unemployment shocks generate large spillover effects on the housing market. Next, I demonstrate that unemployment shocks have a significant impact on housing demand of younger workers compared to older workers.[4] To explore this, I construct a set of counterfactual experiments. In the first experiment, workers never experience unemployment over their life cycle. In the second case, workers become unemployed either at age 26 or 45 during a period without an unemployment shock. The final counterfactual experiment assumes that workers become unemployed during a recession. In the last two counterfactuals, workers become unemployed only at age 26 or age 45 and experience no further unemployment spells thereafter.

Figure 5 shows the life-cycle profiles of house size of workers who become unemployed at age 26 and at age 45, respectively. For younger workers who experience unemployment at age 26, the average house size drops by 20% two years after the unemployment shock. In contrast, older workers who become unemployed at age 45 see a drop in house size by only 5%. Even though the gap between young workers unemployed at age 26 and the control group who do not experience unemployment decreases with time, they are not able to fully catch up. Even after 15 years when the unemployment shock occurs, the average house size of workers who become unemployed at age 26 is still almost 15% lower than those who do not experience unemployment. For older workers, the gap in house size does not decrease over time and remains persistent, resulting in a 10% smaller housing size compared to the control group who never become unemployed.

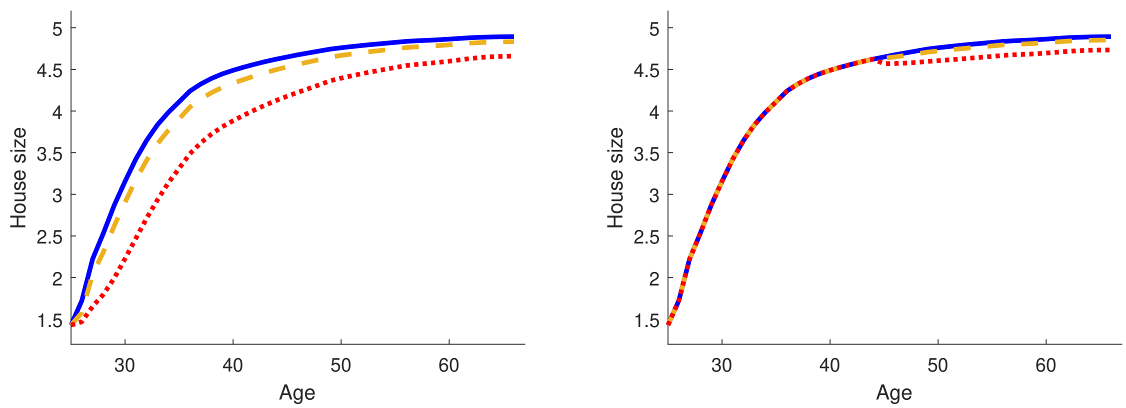
The unemployment shock has more severe consequences for younger households due to several reasons. First, due to losses in permanent income upon unemployment, younger workers who have a longer remaining life span experience larger drops in lifetime earnings compared to the older workers. Another reason is that among young workers, the share of marginal buyers is higher. Younger workers on average have smaller houses and climb the

across time in both the baseline and the counterfactual scenario.

[4] In Appendix A.7, I show that an unemployment shock at the beginning of the life-cycle has substantial and long-lasting consequences on income, housing wealth, and asset accumulation.

Figure 5: Housing demand and unemployment shocks at different ages

(a) Unemployment at age 26 (b) Unemployment at age 45



Notes: This figure shows the life cycle profiles of house size in a counterfactual experiment. Panel 5a displays the case where workers become unemployed at age 26. Panel 5b shows the counterfactual experiment where workers become unemployed at age 45. The solid lines display the life-cycle profiles of workers who never experience unemployment. The dashed and dotted lines show the life-cycle profiles of workers who become unemployed at age 26 or age 45 when the economy is at its steady state and in a recession, respectively.

housing ladder as their incomes grow over time. Hence, young workers have a higher demand for larger houses compared to older workers, who typically own larger houses. Moreover, the demand for housing of older workers is less affected by the unemployment shock because they have on average higher incomes, making it easier to meet mortgage requirements such as the payment-to-income and loan-to-value ratios when buying a new house. In contrast, younger workers subject to unemployment and income drops may struggle to meet credit conditions, so that it is more difficult for younger workers to obtain mortgage loans. Finally, younger workers have little liquid wealth to smooth consumption when they are hit by the unemployment shock. Older workers, on the contrary, have accumulated more liquid wealth for precautionary savings motive and as life-cycle savings, and thus have a better ability to smooth consumption without adjusting their optimal housing size. Overall, the findings imply that unemployment shocks to young workers entail larger spillover effects on the housing market as the labor market condition of young workers is key for housing demand in the economy.

Although housing demand declines when workers face increased income uncertainty, the resulting spillover effect partly stabilizes housing demand. As house prices fall, some workers increase their housing demand because they can buy housing at depressed prices and benefit

Table 7: Change in housing size relative to a counterfactual without spillover effect

Model	Deviation from steady-state housing size (in %)	
	Unemployment at age 26	Unemployment at age 45
Baseline	−14.79	−1.71
No spillover effect	−16.69	−3.22

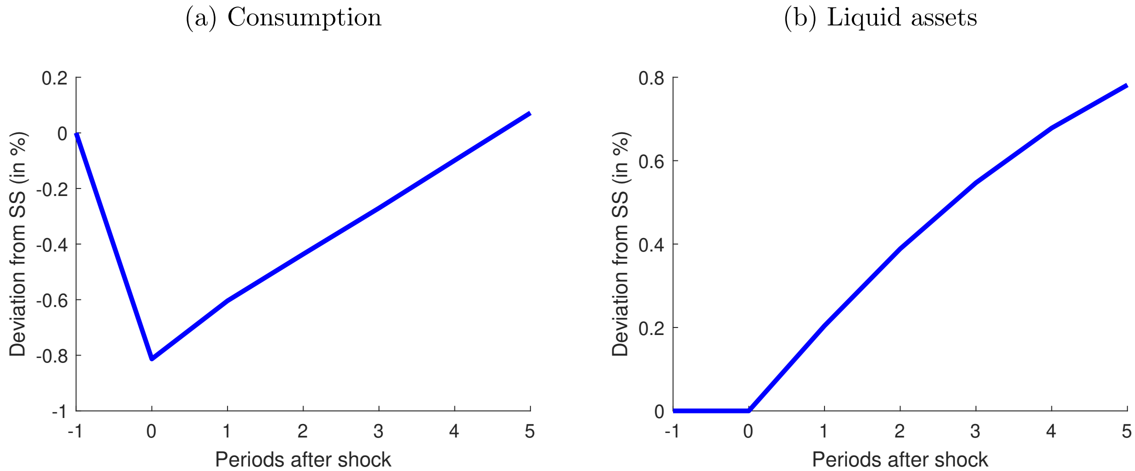
Notes: This table compares the steady-state deviation in housing size in the period when an unemployment shock occurs in the baseline economy and in a counterfactual economy where the spillover effect on the housing market is shut down. Column 1 specifies the model. Column 2 shows the results for workers at age 26 who become unemployed. Column 3 considers the case where workers at age 45 become unemployed.

from the housing price gain in future periods. In the following, I explore the consequences of the spillover effect on working-age households. To quantify the impact of the spillover effect on housing demand of young workers, I construct a counterfactual economy where I shut down the spillover effect. That is, the housing prices are fixed at the steady-state levels and do not move when the economy experiences an unemployment shock. The results are presented in Table 7.

In the baseline economy with the spillover effect, the average house size of unemployed workers is 14.79% lower relative to employed workers when the unemployment shock occurs. In the counterfactual economy without the spillover effect, where housing prices remain fixed at steady-state levels, housing becomes more expensive. As a result, housing demand declines further compared to the baseline economy with the spillover effect, with the average house size of unemployed workers at age 26 being 2 percentage points lower than in the baseline model. For workers who are unemployed at age 45, their average house size decreases by 1.71% in the baseline and by 3.22% in the counterfactual economy. These findings suggest that the spillover effect of unemployment shocks on the housing price has strong effects on housing demand of working-age households. The general equilibrium feedback effect mitigates the decline in housing prices, partly stabilizing housing demand during periods of high unemployment.

What are the consequences of the spillover effect of unemployment shocks on housing prices for old, retired households? In the final part of this section, I analyze how the spillover effect of unemployment shocks on the housing market affects old households who are already in retirement and are not directly impacted by the unemployment shock. In particular, I ask how consumption and savings behavior of retired households changes when the unemployment shock hits the economy.

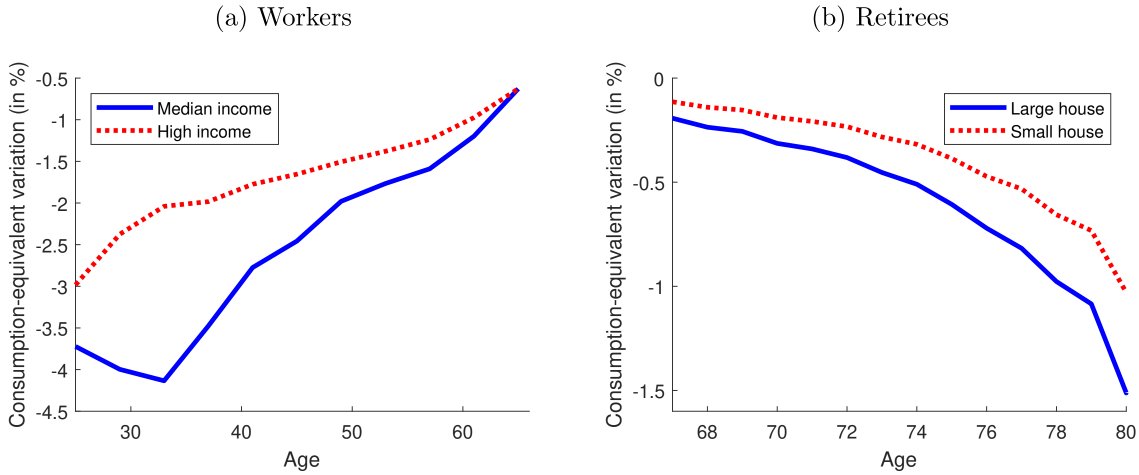
Figure 6: Spillover effect of unemployment shocks on retired households



Notes: This figure shows the changes in non-durable consumption (Panel 6a) and liquid assets (Panel 6b) of retired households (age ≥ 67) in response to the unemployment shock which occurs at time zero.

Figure 6 shows the impact of the unemployment shock on non-durable consumption and liquid assets for older, retired households. In Figure 6a, there is a sharp drop in non-durable consumption at time zero when the unemployment shock occurs. This decline is driven by the drop in housing wealth, which induces retired households to adjust their consumption-saving behavior. As shown in Figure 6b, retired households save more into liquid assets to compensate for the loss in housing wealth in response to the unemployment shock. In the later periods, as the unemployment shock diminishes, the consumption level of retired households gradually recovers over time and eventually overshoots the initial steady-state level. This overshooting occurs because retired households accumulate more liquid assets than in the steady state during the recession. As the economy reverts back to its steady state, retired households increase their consumption beyond the steady-state level and drive down their liquid savings. These findings show that even though old, retired households are not directly exposed to unemployment risk, they still experience negative welfare effects when the unemployment shock hits the economy. To further investigate the consequences of the spillover effect on retired households, I analyze the welfare consequences in the next subsection.

Figure 7: Welfare consequences of unemployment shocks



Notes: This figure shows the welfare consequences of a recession for each age in consumption-equivalent variation. Panel 7a displays the welfare results for workers who have median income (solid line) and workers with higher income (dotted line). Panel 7b shows the welfare results for retirees who own relatively small houses (solid line) and retirees owning a larger house (dotted line).

4.3 Welfare analysis

The previous sections have shown that unemployment shocks generate large spillover effects on housing prices. In response to the shock, housing demand and consumption-saving behavior of households change through its direct effect on household income and also through the spillover effect on the housing market. In this section, I explore the welfare consequences of unemployment shocks across different age groups of households. I also analyze the heterogeneous welfare effects within households of the same age group, asking how employment status and house sizes lead to varying welfare outcomes.

The welfare results are summarized in Figure 7. For households in the labor market, Figure 7a shows the welfare consequences of a recession, measured in terms of consumption-equivalent variation (CEV), across different ages for workers with median and high income.[5] The welfare losses are large for workers at the beginning of the life cycle. At age 25, workers are subject to welfare losses equivalent to 3.7% of remaining lifetime consumption. For older workers, these welfare effects are smaller, declining to 2.5% for workers at age 45 and declining further as workers get close to the retirement age.

[5]The consumption-equivalent variation (CEV) is defined as the percentage of consumption a household would be willing to give up in the baseline economy in order to have the same level of lifetime utility as in the economy where the unemployment shock occurs.

Households at the beginning of the life cycle bear the largest welfare costs due to following reasons. First, younger workers see larger losses in their lifetime income compared to older workers as younger workers have more years to remain in the labor market and hence, face a larger impact from persistent losses in labor earnings. Second, workers at the beginning of the life cycle gradually increase their housing size in order to save into illiquid asset, and at the same time, draw utility from housing consumption. In a recession, mortgage loans become less accessible to unemployed workers, and as a consequence, this restricts their ability to move up the housing ladder. Workers with high incomes also experience significant welfare losses from the unemployment shock, though the impact is smaller compared to median workers. This is because high-income workers are less constrained in their housing consumption decisions. The difference in welfare effects between high- and median-income workers is particularly large early in life, with a gap of more than 1.5 percentage point at age 30. This disparity gradually decreases in age.

The spillover effect of unemployment shock on housing prices generates large welfare consequences for retired households, as depicted in Figure 7b. Households with larger houses at age 70 are subject to welfare losses equivalent to 0.31% of their remaining lifetime consumption. Closer to the end of the life cycle, the welfare losses increase significantly, reaching 1.51% by age 80. Households who own smaller houses experience dampened welfare effects because they see smaller declines in housing wealth. Moreover, retirees in the early stages of retirement face relatively modest welfare losses, as they expect that the economy will recover and the housing prices return to steady-state levels. Overall, the spillover effect of unemployment shocks through the housing market transmits approximately one-third of the welfare losses of workers to retired households, measured in terms of consumption-equivalent variation. It is important to note that retired households are affected by the unemployment shocks only through the spillover effects on housing prices. Retired households are not directly exposed to unemployment risk as they are not taking part in the labor market and their main source of income consists of retirement benefits. As a large share of household wealth consists of housing wealth, the decline in housing prices caused by the spillover effect of unemployment shocks implies that housing wealth declines during a recession. This affects the amount of wealth left as a bequest motive, leading to negative welfare effects on retirees.

How important is the spillover effect of unemployment shocks on housing prices for the welfare consequences reported in Figure 7? The above findings suggest that young workers experience significant welfare losses because they lose the opportunity to climb the housing ladder and the decline in income, while old retired households are subject to negative welfare

Table 8: Welfare decomposition

Age	Welfare effects (in %)	
	Baseline	No spillover effect
25	−3.72	−5.26
30	−3.99	−4.55
35	−3.65	−3.63
40	−2.91	−2.90
45	−2.46	−2.46
50	−1.95	−1.95
55	−1.66	−1.66
60	−1.31	−1.29
65	−0.63	−0.54
70	−0.19	0.00
75	−0.39	0.00
80	−1.03	0.00
85	−1.06	0.00
90	−7.66	0.00

Notes: The welfare effects are measured in consumption-equivalent variation on remaining lifetime consumption. In all models, the welfare effects are computed for a median household in the economy in terms of assets, employment status, income, housing size, and remaining mortgage balance. The baseline model refers to the results in Figure 7. The model with fixed housing price is a counterfactual case where the housing prices are always at the steady-state price of the baseline model.

effects due to the spillover effect on housing prices and drops in housing wealth. In the following, I construct a counterfactual model to quantify the importance of the spillover effect for the welfare results.

The counterfactual experiment is a ”fixed housing price” scenario, in which the housing price remains constant at its steady-state level. Households have rational expectations, and they know that the housing price is constant and does not change over time. The results are summarized in column 3 of Table 8. In this counterfactual model, retired households experience no welfare losses because they are not subject to the heightened earnings risk during a recession. This finding indicates that the welfare losses of retired households in the baseline economy, summarized in column 2, are entirely due to the depressed housing prices during a recession.

In the absence of the general equilibrium effect of housing prices, young households experience even larger welfare losses during a recession. The reason is that when housing prices decline, young households can buy houses at lower prices and gain from the price appreciation in future periods once the economy recovers from the recession. However, when housing prices are fixed, young households are subject to larger welfare losses compared to the baseline economy because they cannot benefit from buying houses at lower prices. This mechanism is in line with the findings of Glover et al. (2020) who show that young households can buy assets at depressed prices, and therefore the welfare losses are smaller than older households.

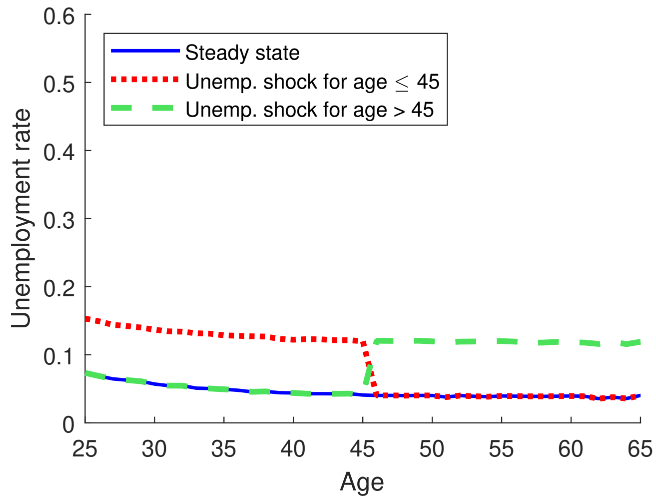
5 Demographic structure and unemployment shocks

The analysis so far has assumed a uniform age distribution of the population and that the unemployment shock leads to a uniform increase in the unemployment rate and income risk for all workers in the economy. In this section, I explore the role of age for the spillover effects of unemployment on housing prices, focusing on the consequences of both age-dependent unemployment shocks and demographic shifts. Unemployment shocks disproportionately affecting younger workers might have larger consequences on the housing market as the housing demand of younger workers are more sensitive to income shocks (see Section 4). Moreover, long-term changes in the demographic structure, such as the growing share of older households, change the housing demand patterns and the consequences of recessions. By analyzing both the impact of age-dependent unemployment shocks and the consequences of demographic shifts, this section provides a comprehensive study of the impact of population age structure on the spillover effects of unemployment on the housing market.

5.1 Age-dependent unemployment shocks

The structure of the unemployment shock, more specifically, whether the shock disproportionately affects workers in certain age groups, might play a key role for the magnitude of the spillover effect on housing prices. Previous research has found that different recession periods disproportionately affected workers of different age groups. For example, young people suffered most during the Great Recession (Bell and Blanchflower, 2011; Hoynes et al., 2012). Moreover, studies covering the post-war period in the United States have shown that the macroeconomic volatility is U-shaped in age, the young experiencing

Figure 8: Different age-group specific unemployment shocks



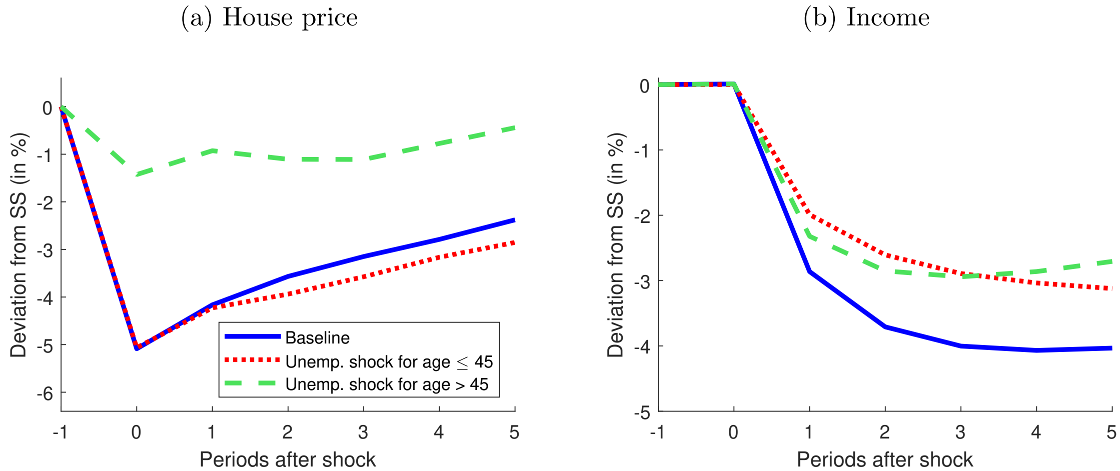
Notes: This figure shows the average unemployment rate in the steady state of the economy and under different structures of the unemployment shock. The solid line displays the average unemployment rate in the steady state. The dotted line shows the average unemployment rate when workers below age 45 are subject to the unemployment shock. The dashed line shows the average unemployment rate when workers above age 45 are subject to the unemployment shock.

larger labor market volatility than older workers (Clark and Summers, 1981; Ríos-Rull, 1996; Gomme et al., 2004). Also, Jaimovich and Siu (2009) highlight the importance of demographic structures for business cycle volatility.

To investigate whether and how the structure of the unemployment shock shapes the spillover effect, I now examine two distinct scenarios where the unemployment shock is age-dependent: in the first case, only young workers up to age 45 are impacted, with their unemployment rate and their risk of permanent income losses increasing. In the second case, only old workers above age 45 are subject to the increase in unemployment rate and income risk. In both cases, the model assumes an increase of the unemployment rate by 8 percentage points to match the average increase in the baseline model and the risk of persistent income losses increases to 0.8. Other assumptions and parameters remain unchanged from the baseline model. Figure 8 shows the changes in unemployment rates under these alternative unemployment shocks.

The results of the counterfactual experiment, summarized in Figure 9, reveal important differences in the spillover effects of unemployment shocks on the housing market. The unemployment shock affecting young workers (up to age 45) leads to a large drop in the housing price by more than 5% as in the baseline economy. Additionally, the recovery of

Figure 9: House price and income after different unemployment shocks



Notes: This figure shows the consequences of different unemployment shocks where either only young workers (below age 45) or only old workers (above age 45) are subject to higher unemployment risk compared to the steady state. Panel 9a shows the dynamics of housing price and Panel 9b the dynamics of income after the unemployment shock hits the economy. In both panels, the solid lines refer to the baseline economy. The dotted and dashed lines refer to the experiments where only young workers and only old workers are affected by the unemployment shock, respectively.

the housing price is slower than in the baseline economy, remaining around 0.5 percentage points below the price path of the baseline economy in the following periods. When only older workers (above age 45) are subject to the unemployment shock, the spillover effect on the housing market is smaller and the housing price decreases only by 1.5% when the shock occurs. The impact on the housing price is also less persistent. After the unemployment shock, the housing price quickly recovers to its steady-state level, which indicates that the housing demand of older households remains relatively stable. Hence, the same size of the unemployment shock generates a much larger spillover effect on the housing market when many young workers are subject to the unemployment shock.

One reason why the unemployment shock to young workers generates larger spillover effects on the housing market is because of their significant role in driving housing demand. The economic condition of young workers is an important determinant of housing prices, as many young workers are either first-time house buyers or want to climb the housing ladder by selling the current house and purchasing a larger one. Another reason why the unemployment shock to young workers generates larger spillover effects is that they suffer larger lifetime income losses upon unemployment compared to older workers whose remaining years in the labor market are expected to be much shorter. Figure 9b shows that an unemployment shock affecting workers under age 45 leads to a more persistent gap in income that remains at -3% even 5 years after the unemployment shock. In contrast, when only old workers are affected by the unemployment shock, the income level recovers more quickly.

5.2 Population age structure

In this section, I analyze how shifts in the demographic structure affect the spillover effects of unemployment on housing prices. The demographic composition of the U.S. population is projected to change considerably over the next decades. According to Vespa et al. (2018), the population aged 65 and older is projected to double by 2060. These demographic changes will have important implications for the housing market in the economy: first, the demanded housing size is different across age groups and second, households at different stages of life react differently to changes in housing prices and other economic conditions which also affect the demand for housing.

The relationship between demographic structures and the housing and asset markets has been widely studied in the literature. Poterba (2001) finds no significant relationship between the share of population in the prime saving years and the real returns on financial assets, while Leombroni et al. (2020) show that the asset market participation of baby boomers led to a drop in wealth relative to GDP. Focusing on the housing market, Levin et al. (2009) show that aging and shrinking population leads to decreasing housing prices. Similarly, Gong and Yao (2022) show that changes in demographics can explain the housing price growth from 1970 to 2010.

At first glance, the impact of the age structure of the population on the spillover effect is ambiguous. On the one hand, a decline in the working-age population could dampen the spillover effect, because a lower share of households would face the direct consequence of higher unemployment risk, leading to a smaller decline in housing demand and prices. On the other hand, housing demand of younger households may be more sensitive to changes in price. As a consequence, the decline in housing prices could be amplified as fewer young households buy housing to profit from lower prices during a recession.

To gain intuition, consider a simple OLG economy where we have two generations: the young and the old. Let $h_o(p)$ and $h_y(p)$ denote the total housing demand of old and young households, respectively, as a function of the housing price p. Define Δh_o and Δh_y as the housing demand deviation in recession from the steady state of old and young households, respectively. It can be shown that

$$\frac{\Delta h_y}{\hat{h}_y(\hat{p})} \Big/ \frac{\Delta p}{\hat{p}} \quad < \quad \frac{\Delta h_o}{\hat{h}_o(\hat{p})} \Big/ \frac{\Delta p}{\hat{p}} \tag{9}$$

is a sufficient condition for the housing price to decline less strongly during a recession when the share of old households increases. Δp denotes the housing price difference in a recession and in the steady state. The inequality (9) compares the elasticity of housing demand with respect to prices in a recession and in the steady state. Hence, if the housing demand elasticity of the young households is smaller than the elasticity of the old households, the inequality in (9) is satisfied, implying that the spillover effect of unemployment shock on the housing price is mitigated. Appendix A.9 provides the detailed derivation of the above expression.

Now, two conditions are sufficient to satisfy the inequality in (9). First, the elasticity of the young households is negative if their housing demand during a recession is lower than in the steady state at the equilibrium housing prices. Second, the elasticity of the older households is positive as they are not directly impacted by the recession and they would increase their housing demand if prices fall during a recession. The first assumption that the total housing demand of young households declines during a recession is plausible given the empirical evidence in Section 2. The second assumption regarding the change in housing demand of retired households is more ambiguous. This condition is satisfied in the current model as the credit conditions remain unchanged in a recession and retired households, if anything, increase their housing demand if prices decline. However, if credit conditions become tighter during times of high unemployment, the demand for housing from retired households could also change significantly, and the inequality in 9 might not be necessarily satisfied.

In the following analysis, I conduct a steady-state comparison of two economies which are otherwise identical but differ in terms of the demographic structures. More specifically, the new steady state assumes that 65% of the population consists of working-age households, while the remaining 35% of the population are retired households. In contrast, in the baseline model, approximately 75% and 25% of the population consist of working-age and retired households, respectively.

The results in Table 9 show that the demographic structure is key to the magnitude of the spillover effect of unemployment shocks on housing prices. In the new steady state with

Table 9: Housing price deviation

Time	Model	
	Baseline	Aged economy
0	−5.09	−4.89
1	−4.16	−3.87
2	−3.57	−3.39
3	−3.15	−3.00
4	−2.79	−2.72
5	−2.38	−2.37

Notes: This table shows the percentage deviation of the housing price from its steady-state level following an unemployment shock (uniform across all ages) at time zero.

a larger share of retired households, the drop in housing price following the unemployment shock is 4% smaller compared to the baseline economy. Hence, in the model at hand, an increase in the share of retired population mitigates the spillover effect. The reason is that the reduction in housing demand by working-age households, who are directly affected by unemployment shocks, becomes smaller compared to the additional housing demand of retired households. The income of retired households remains unaffected by the unemployment shock, and as a result, their housing demand slightly increases when housing prices decline. These findings suggest that the demographic composition of an economy can significantly affect the magnitude of the spillover effect from unemployment to the housing market. Under plausible assumptions, a larger share of retired population mitigates the impact of unemployment shocks on housing prices.

6 Unemployment insurance and housing prices

The previous sections have shown that unemployment shocks have large spillover effects on the housing prices, resulting in negative welfare consequences for old, retired households. An interesting question is which policy tools may mitigate this effect and stabilize housing prices. One natural candidate is to increase the generosity of the unemployment insurance system during times of high unemployment. Unemployment insurance systems provide benefits to workers who become unemployed, offering insurance against temporary income losses and helping them to smooth consumption. This insurance effect could potentially reduce the drop in housing demand and, in turn, mitigate the spillover effect on housing prices and stabilize the housing market.

This section examines whether, and to what extent, the UI system can reduce the spillover effects of unemployment shocks on the housing market. It is important to note that the theoretical framework applied in this paper is not designed to evaluate the optimal design of UI systems. In particular, the model is calibrated on an annual basis, whereas it is necessary to have a model calibrated to higher-frequency data to accurately capture worker flows in and out of unemployment. Moreover, the income process in this model is exogenous, and there is no job search and endogenous unemployment duration of workers. These components play a key role in analyzing the trade-offs when designing optimal UI systems. Therefore, while this section evaluates whether the UI system dampens the spillover effects of unemployment shocks on the housing market, it does not discuss the optimal design of the policy.

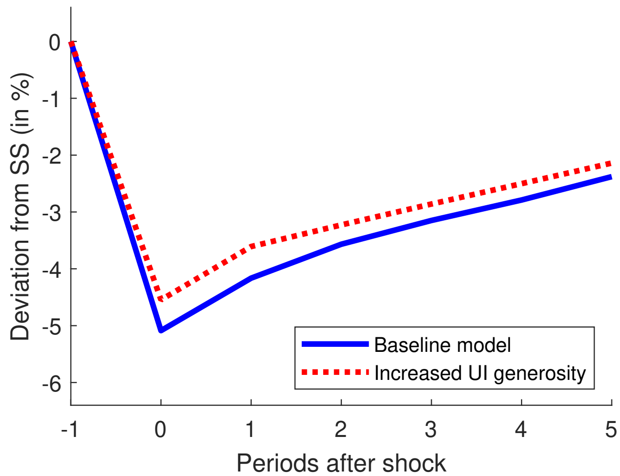
In the United States, the generosity of the UI system tends to increase during recessions. A notable example is the Great Recession: although benefits are typically available for a maximum of 26 weeks, programs such as the Emergency Unemployment Compensation (EUC) and Extended Benefits (EB) have provided additional weeks of support during the Great Recession (Mueller et al., 2016; Hsu et al., 2018). During the Covid-19 pandemic, the Federal Pandemic Unemployment Compensation (FPUC) supplement increased the weekly UI benefits by $600, leading to a substantial increase in the replacement rate for eligible workers (Ganong et al., 2020). In the following analysis, two scenarios are considered to examine the effects of the UI system for the spillover effect of unemployment shocks to housing prices. The baseline economy assumes a replacement rate of 60%, while the alternative system provides a higher replacement rate of 80%.

6.1 Baseline economy

Figure 10 shows the effect of increasing the UI replacement rate on the spillover effect of unemployment shocks on housing prices. The solid line represents the baseline model discussed in Section 4 with a UI replacement rate of 60%, while the dotted line displays the results in an economy where the UI replacement rate is increased to 80% in the first two years of the recession. The increase in the UI replacement rate partly stabilizes the housing market by reducing the spillover effect of unemployment shocks on housing prices by 12%.[6]

[6]The effect on the spillover effect is computed by integrating the housing price drop in the baseline economy and in the economy with higher UI replacement rate and comparing these total spillover effects in

Figure 10: Higher replacement rate of the unemployment insurance system



Notes: This figure shows the spillover effects of unemployment shocks on housing prices for the baseline UI replacement rate of 60% (solid lines) and for a UI system with a replacement rate increased to 80% (dotted lines). The results refer to the dynamics of housing prices after an unemployment shock that affects workers at all ages.

Hence, increasing UI generosity during recessions partly mitigates the spillover effect, but is not able to fully counteract it. In Appendix A.10, I show that higher UI generosity reduces the welfare losses of retired households from a recession.

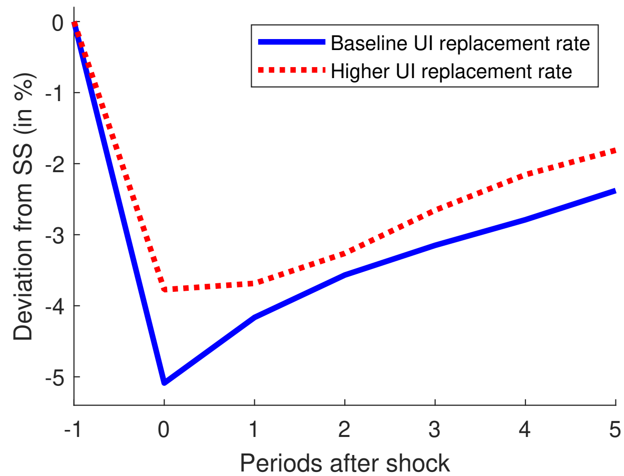
However, the impact of UI generosity does not fully mitigate the spillover effect. The reason is that workers experience losses in their permanent income upon unemployment and households shift their portfolios away from housing wealth, which is illiquid, towards more liquid assets. The main driver of the spillover effect is the increased unemployment risk rather than the actual drop in household income, as shown by Figure 4 of Section 4. While providing insurance against temporary income losses, UI systems do not protect workers from permanent income losses upon unemployment. Hence, the insurance against the temporary income loss provided by higher UI replacement rate does not have a large effect on housing demand, and consequently, the spillover effect on housing prices remains significant.

6.2 Model without permanent income losses

In the model at hand, an increase in UI benefit generosity does not significantly change the spillover effect of unemployment shocks on housing prices. The main reason is that higher UI

the two economies.

Figure 11: Counterfactual without permanent income losses



Notes: This figure shows the results of a counterfactual experiment in which unemployed workers are not subject to permanent income losses. Upon unemployment, workers only lose their income in the unemployed period. The figure considers the dynamics of housing prices after an unemployment shock for the baseline UI replacement rate of 60% (solid line) and for a UI system with a replacement rate increased to 80% (dotted line).

benefits do not provide insurance against permanent income losses. When unemployment results in permanent income losses, households shift their portfolios away from housing toward other more liquid assets.

To confirm that permanent income losses upon unemployment are the main reason why the generosity of UI benefits does not greatly impact the spillover effect, I consider an alternative model that assumes that workers do not experience permanent income losses when they become unemployed. In this alternative framework, workers only lose their incomes during the period of unemployment, after which their incomes fully recover to their pre-unemployment income paths. All other model assumptions remain unchanged from the baseline model, and I calibrate the size of the transitory income drop during unemployment to match the empirically observed drop in housing prices following an unemployment shock. This calibration ensures that the alternative model generates the same spillover effect from an unemployment shock to housing prices as in the baseline model. Next, I repeat the analysis from the previous section by increasing the UI benefit replacement rate from 60% to 80% in the first two periods of the recession, using the unemployment shock that increases unemployment risk for all workers in the economy.

Figure 11 displays the dynamics of the housing prices under different UI replacement rates. In the model without permanent income losses, increasing the UI replacement rate from the baseline of 60% to 80% leads to a remarkably smaller decline in housing prices: higher UI replacement rate reduces the decline in housing price by almost one-fifth compared to the baseline economy.

In summary, this section explores the potential of the UI system as a stabilizer of the housing market, reducing the spillover effect of unemployment shocks on housing prices. The analysis shows that increasing the UI replacement rate from 60% to 80% in the beginning of the recession periods reduces the spillover effect by 12% in the baseline model. The spillover effect is not fully mitigated because workers face permanent income losses when unemployed so that they shift their portfolio toward more liquid assets during times of high unemployment risk, which in turn leads to a drop in housing demand and housing prices. While a higher UI replacement rate provides temporary income insurance and helps smooth consumption, it does not provide insurance against the risk of permanent income losses. These findings suggest that labor market policies that stabilize the economy by preventing layoffs during recessions rather than temporary income support, such as short-time work programs, could be more effective in mitigating spillover effects from unemployment on housing prices.

7 Conclusion

In this paper, I analyze the spillover effect of unemployment risk for young, working-age households on the old, retired households through the housing market. The paper offers an empirical and a theoretical contribution. First, I empirically show that the size of the spillover effect is large. To this end, I employ the Current Population Survey (CPS) which provides data on state-level unemployment rates and the industry composition of employment in the United States. Using a shift-share instrument to address potential endogeneity and omitted variable bias, I find that an increase in the unemployment rate by one percentage point leads to a decline in the housing price by 1.55%. An analysis in the Home Mortgage Disclosure Act (HMDA) data reveals that there is a strong negative correlation between mortgage applications and unemployment rates, implying that housing demand decreases during times of high unemployment in the economy.

In a next step, I develop an overlapping generations model with a housing market and unemployment risk. In the model, workers choose a portfolio of housing and liquid assets where the housing price is determined in the housing market. The model is calibrated using the data from the Survey of Consumer Finances (SCF). The calibrated model produces spillover effects of unemployment shocks on the housing prices that are similar in magnitude as in the data. Using the model, I study the aggregate consequences of an unemployment shock. More than 60% of the spillover effect of unemployment risk on housing prices is driven by an increase in income uncertainty when the unemployment shock occurs so that households reduce their housing demand. In contrast, the actual drop in income due to higher unemployment rate only accounts for 40% of the spillover effect.

Old, retired households bear significant welfare losses even though they are not directly affected by the increase in unemployment risk: the spillover effect of unemployment risk on housing prices transmits approximately one-third of the welfare losses of working-age households to retired households measured in terms of consumption equivalent variation. Due to the spillover effect, retired households see a drop in housing wealth which constitutes an important share in wealth of old households. Young workers experience significant welfare losses, but they partly benefit from buying houses at depressed prices.

Moreover, I show that unemployment shocks disproportionately affecting younger workers generate a spillover effect that is more than 3 times larger than those affecting older workers. As young workers are typically on the demand side on the housing market, their economic condition is an important driver of the spillover effect on housing prices. The demographic structure of the economy is also key for the magnitude of the spillover effect. I find that a demographic shift towards a larger population share of retired households mitigates the spillover effect.

Finally, I show that increasing the generosity of the unemployment insurance during recession partly stabilizes housing prices. However, the unemployment insurance system is not able to completely counteract the spillover effect as it does not provide insurance against persistent income losses upon unemployment. The channel through persistent income losses limits the ability of unemployment insurance systems to stabilize housing prices.

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A Appendix

A.1 Data sources

- House prices: House Price Index in U.S. states (Source: Federal Housing Finance Agency)
- Stock Market Index: Wilshire 5000 Price Index (Source: Wilshire Associates, Wilshire Indexes)
- Consumer Price Index: U.S. Bureau of Labor Statistics Consumer Price Index
- Housing supply: New housing permits (U.S. Census Bureau, U.S. Department of Housing and Urban Development, New Residential Construction)
- Population growth: U.S. Census Bureau, Annual Estimates of the Population for the U.S. and States
- Federal Funds Effective Rate: Board of Governors of the Federal Reserve System (U.S.), H.15 Selected interest rates
- Real GDP growth: U.S. Bureau of Economic Analysis, Gross Domestic Product

A.2 IV regression

The IV approach in Eq. 2 uses the Bartik instrument to identify exogenous movements in the state-level unemployment rate. As a robustness check, the IV regression in this section considers the relative changes in state-level unemployment rate over time. While the construction of the Bartik instrument remains unchanged as in Eq. 1, the second-stage regression is given by

$$\Delta \log(HPI_{s,t}) = \beta \Delta \hat{u}_{s,t} + \delta X_{s,t-\tau} + \gamma Z_{t-\tau} + \lambda_s + \zeta_t + \alpha_1 + \eta_{s,t} \tag{10}$$

where $\Delta u_{s,t} = \log u_{s,t} - \log u_{s,t-1}$. Table A.1 shows the first-stage regression results. The second-stage results are summarized in Table A.2.

Table A.1: First-stage regression

Changes in unemployment rate	All data	Excluding Great Recession
	(1)	(2)
Bartik	-2.61^{***}	-2.67^{***}
	(0.64)	(0.66)
Observations	2091	1938
R^2	0.74	0.72

Notes: This table shows the first-stage regression for the IV analysis. The relative changes in state-level unemployment rates are regressed on the Bartik shocks including state and year fixed effects, state-level characteristics (average household income, population growth, and ratio of young to old households), and national characteristics (GDP growth, national unemployment rate, stock price index, consumer price index, Federal funds rate, new housing permits, and the supply of new housing). The state-level and national characteristics contain the lags of these variables up to four years. Columns (1) presents the results when the regression analysis considers all data from 1978 to 2019. Columns (2) excludes the period of Great Recession from the considered data. Standard errors are adjusted for clustering at the state level and reported in parentheses.

Table A.2: IV regression

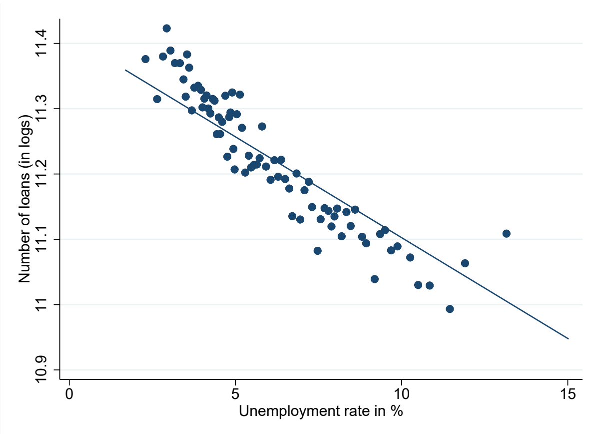
Δlog(HPI)	All data			Excluding Great Recession		
	(1)	(2)	(3)	(4)	(5)	(6)
Unemp. rate	-0.32^{***}	-0.32^{***}	-0.21^{***}	-0.29^{***}	-0.29^{***}	-0.21^{***}
	(0.08)	(0.08)	(0.07)	(0.08)	(0.08)	(0.08)
Observations	2091	2091	2091	1938	1938	1938
R^2	0.34	0.34	0.49	0.29	0.29	0.43
State and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
House supply controls	No	Yes	Yes	No	Yes	Yes
Demographic controls	No	No	Yes	No	No	Yes

Notes: This table summarizes the state-panel IV regressions of log changes in housing prices on the instrumented changes in unemployment rates. The controls include state and year fixed effects, state-level characteristics (average household income, population growth, and ratio of young to old households), and national characteristics (GDP growth, national unemployment rate, stock price index, consumer price index, Federal funds rate, new housing permits, and the supply of new housing). The state-level and national characteristics contain the lags of these variables up to four years. Columns (1)-(3) presents the results when the regression analysis considers all data from 1978 to 2019. Columns (4)-(6) exclude the period of Great Recession from the considered data. Standard errors are adjusted for clustering at the state level and reported in parentheses.

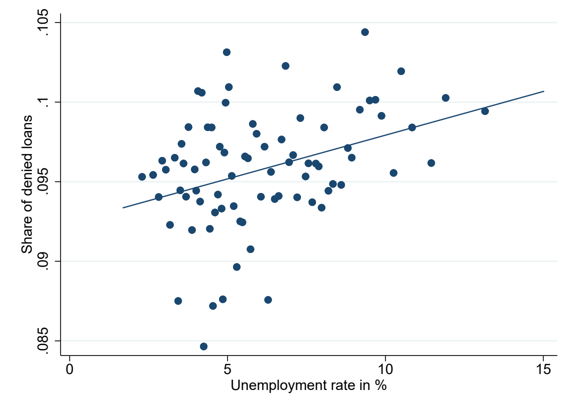
A.3 Home Mortgage Disclosure Act data

Figure A.1: Mortgage applications and unemployment rate excluding the Great Recession

(a) Number of loans



(b) Share of denied applications



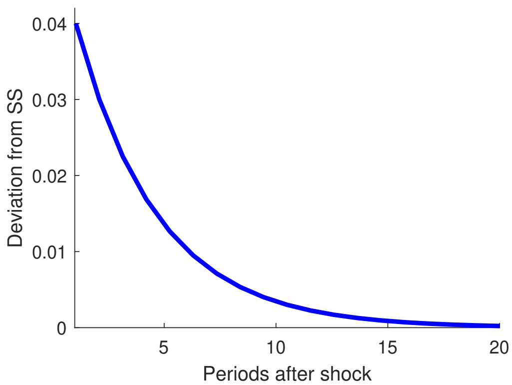
Notes: Panel (a) shows the number of mortgage applications against unemployment rate by each state. Panel (b) shows the share of mortgage applications that have been rejected. The results are after controlling for GDP, nationwide unemployment rate, and state- and year-fixed effects.

The empirical analysis on the relationship between unemployment rates and mortgage applications using the Home Mortgage data in Section 2 reveals a strong negative relationship. In order to check that this relationship is not solely driven by the Great Recession, I repeat the analysis excluding the data in the years from 2008 until 2010. Figure A.1 summarizes the results. In Figure A.1a, there is a strong negative correlation between the number of mortgage applications and the unemployment rate at the state level. Regarding the share of denied mortgage applications, Figure A.1b shows a positive correlation between unemployment rate and the share of mortgage applications rejected by the financial institutions. These results indicate that the negative correlation between housing demand and unemployment rate remains strong even when the Great Recession is excluded.

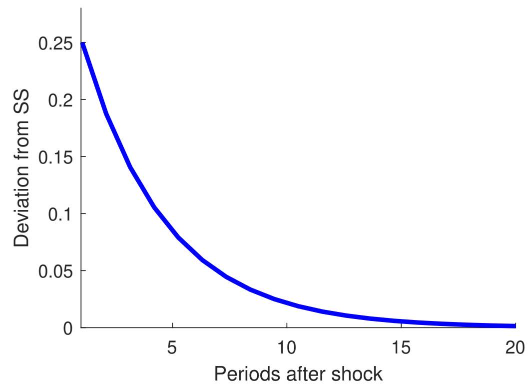
A.4 Calibration

Figure A.2: Properties of unemployment shock

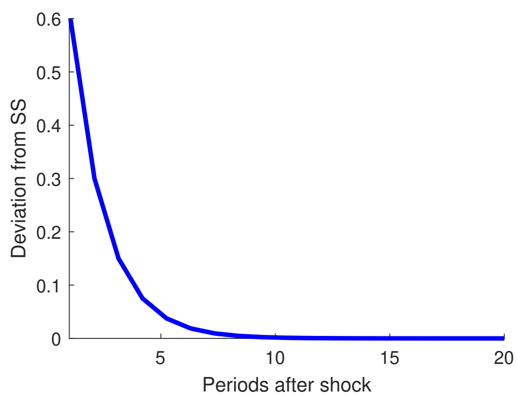
(a) Unemployment rate



(b) Unemployment duration



(c) Probability of permanent income loss



Notes: This figure shows the the evolution of the unemployment shock over time. Panel A.2a and A.2b show the percentage deviation of unemployment rate and unemployment duration from the steady state. Panel A.2c displays the percentage deviation of permanent income loss probability from the steady state.

Figure A.2 shows the evolution of the unemployment shock over time. The unemployment shock affects the unemployment rate (Figure A.2a), the unemployment duration (Figure A.2b), and the probability of permanent income loss (Figure A.2c). When the unemployment shock occurs, the average unemployment rate in the economy increases by 4 percentage points. The unemployment duration increases from one quarter to 6 months. The probability of permanent income losses jumps from 0.2 to 0.8. For the unemployment rate and the unemployment duration, the shock decays at a rate of 0.5, while the probability of persistent income loss is assumed to decay at a rate of 0.75.

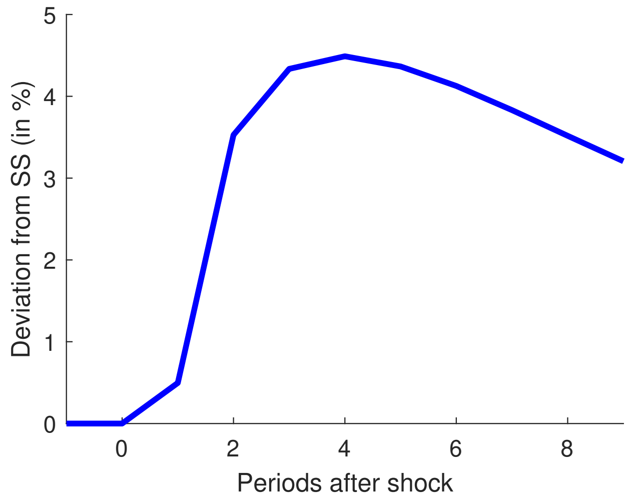
A.5 Transitional equilibrium

The aggregate shock is introduced as a one-time, unanticipated shock at $t = 0$. The shock increases the probability of unemployment, the unemployment duration, and the probability of earnings loss as described in Section 3.5. Households are initially in the steady state of the economy. When the shock occurs, households have perfect foresight and know that the economy will return to the initial steady state after the shock decays. The solution algorithm is as follows.

1. Choose a period T in which the economy is assumed to have returned to the initial steady state.
2. Guess a path for the house prices $(\{\hat{p}_t\}_{t=0}^{T})^0$.
3. Solve the value functions and policy functions backwards from $t = T - 1, ..., 0$ where households in T have the value and policy functions in the initial steady state.
4. Starting from the steady-state distribution of households, the economy is simulated forward from $t = 0, ..., T$ using the value and policy functions and the exogenous states of the economy.
5. At each t, the equilibrium house prices p_t is computed using the distribution of households.
6. Compute the maximum difference between the guess and the equilibrium house price $\xi = \max |p_t - \hat{p}_t|$ in all periods.
7. If $\xi < 10^{-5}$, the solution has been found.
8. If $\xi \geq 10^{-5}$, update the guess $(\{\hat{p}_t\}_{t=0}^{T})^1 = \alpha(\{\hat{p}_t\}_{t=0}^{T})^0 + (1 - \alpha)\{p_t\}_{t=0}^{T}$ and repeat the steps from 3.

A.6 Aggregate dynamics

Figure A.3: Ratio of liquid assets to income



Notes: This figure shows the percentage deviation of the ratio of liquid assets to income from its steady-state level after the unemployment shock (uniform across all ages) hits the economy at time zero.

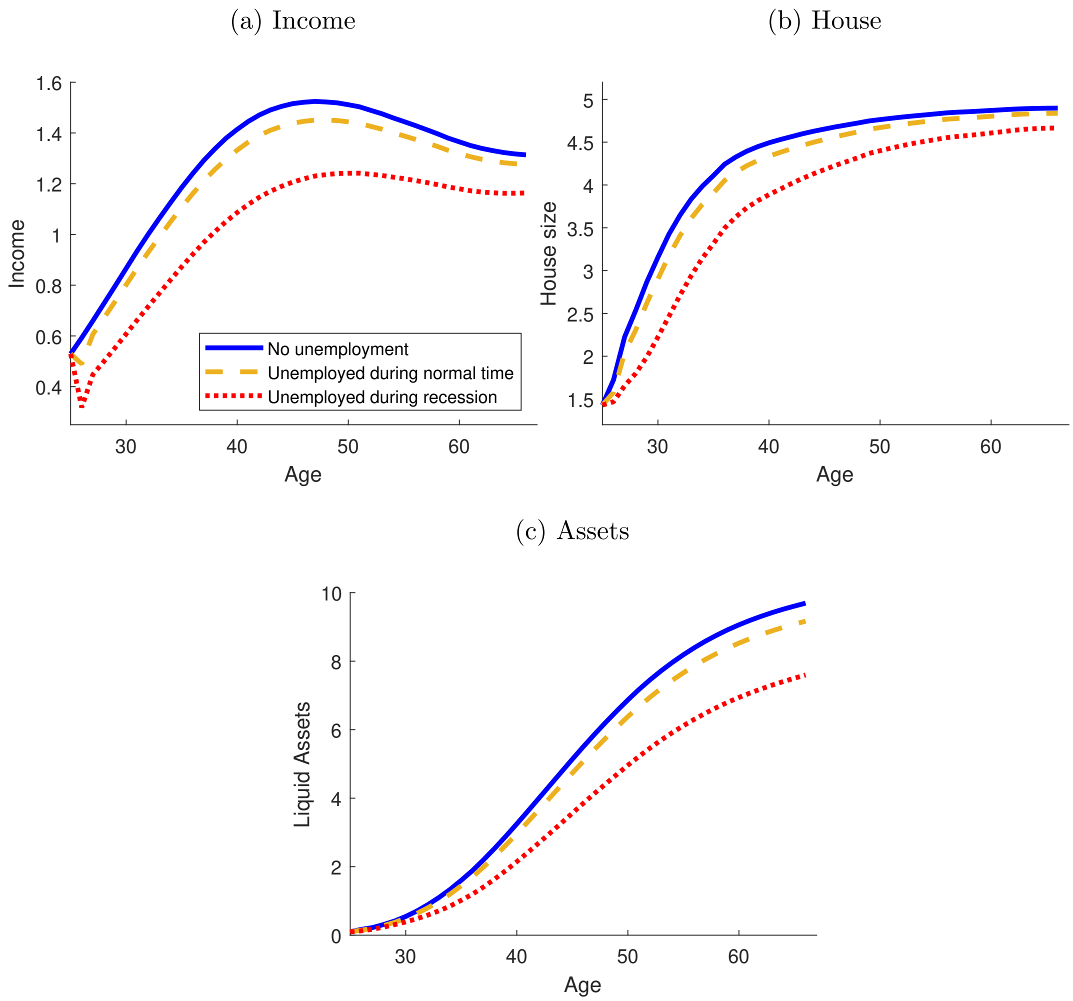
Figure A.3 displays the steady-state deviation of the ratio of average liquid assets to average household income in the economy. When the unemployment shock occurs, households accumulate additional liquid savings as buffer stocks in response to the increase in income uncertainty. When the unemployment shock abates, the ratio of liquid assets to income decreases as the average income recovers and households face lower uncertainty and households reshuffle their portfolio.

A.7 Life-cycle consequences of unemployment shock

What are the individual consequences of unemployment on income, housing, and wealth accumulation? To address this question, I conduct a counterfactual experiment. The first counterfactual case assumes that workers never experience unemployment over the whole life cycle. In the second counterfactual, workers become unemployed at age 26 when the economy is in a normal state. The last counterfactual assumes that workers become unemployed at age 26 during a recession. In the last two scenarios, workers become unemployed only at the beginning of the life cycle and experience no further unemployment spells thereafter.

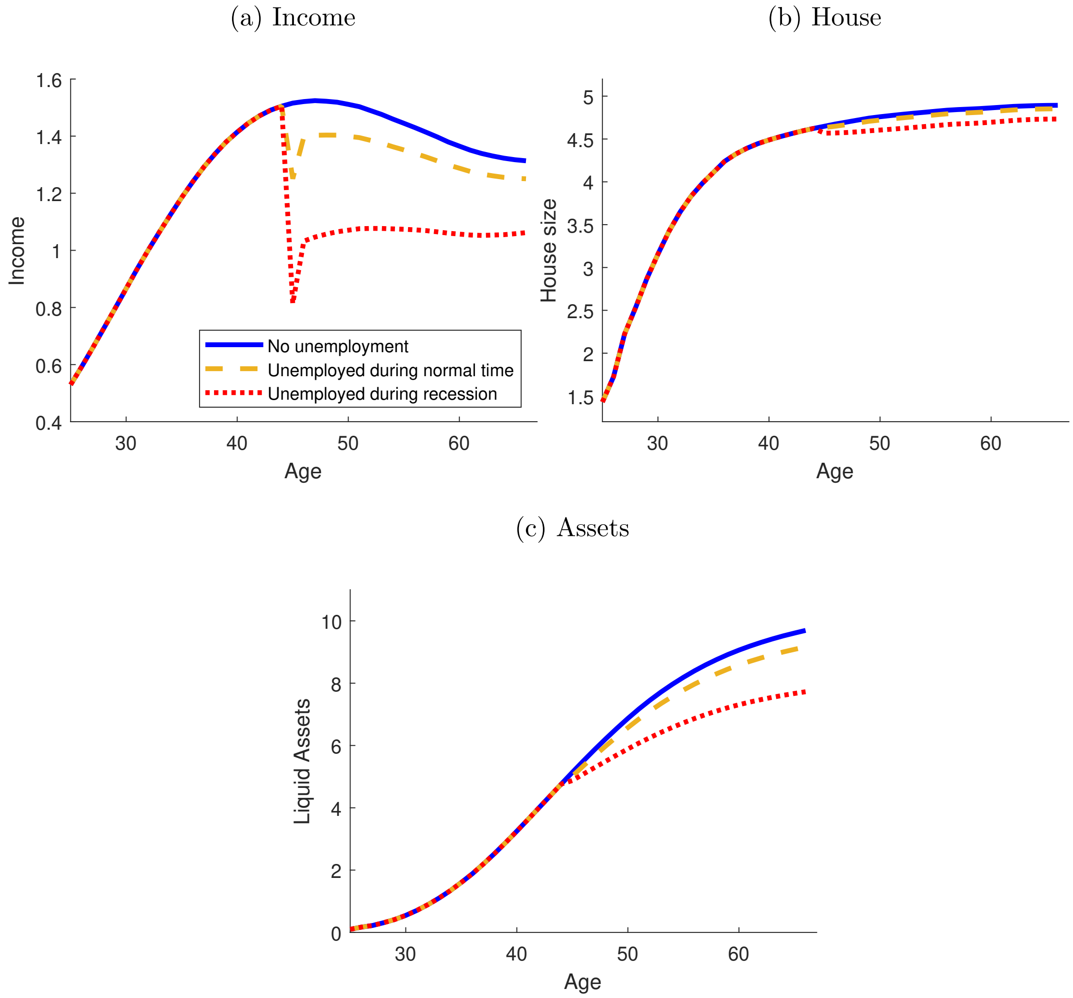
Figure A.4 presents the life-cycle profiles of income, house size, and assets under the three counterfactual cases. Figure A.4a shows that unemployment when the economy is in a normal state leads to 13% drop in average income, whereas unemployment during a recession leads to a almost 40% drop in average income. In both cases, unemployment results in permanent income losses, the average income level being 6% lower 15 years after being unemployed during a good state of the economy and 22% lower 15 years after an unemployment spell during a recession. The permanent income losses after unemployment depresses housing demand over the life cycle as shown in Figure A.4b. Compared to the baseline case without unemployment, workers have on average 15% smaller houses when they become unemployed in a recession. On the contrary, being unemployed during a good state has only has a small effect on housing demand of around 8%. Finally, Figure A.4c shows the life-cycle profiles of assets. The permanent loss of income reduces both the housing demand and the life-cycle saving motive of workers. At the end of the working phase, workers who become unemployed in a recession have on average 21% lower assets.

Figure A.4: Life-cycle profiles after unemployment shock at age 26



Notes: This figure shows the life cycle profiles of labor income, house size, and liquid asset. The solid lines display the life-cycle profiles of workers who never experience unemployment. The dashed and dotted lines show the life-cycle profiles of workers who become unemployed at age 26 when the economy is in a normal state and in a recession, respectively.

Figure A.5: Life-cycle profiles after unemployment shock at age 45

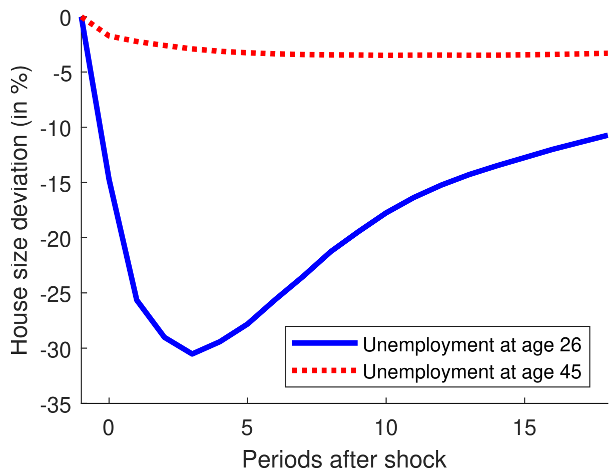


Notes: This figure shows the life cycle profiles of labor income, house size, and liquid asset. The solid lines display the life-cycle profiles of workers who never experience unemployment. The dashed and dotted lines show the life-cycle profiles of workers who become unemployed at age 45 when the economy is in a normal state and in a recession, respectively.

Figure A.5 shows the life-cycle profiles of income, house size, and liquid assets when households become unemployed at age 45. Similar to the results in Figure A.4, households at age 45 experience the largest decline in their income when unemployed during a recession. The average house size and liquid assets also decline following an unemployment shock. The decline in house size is, however, less pronounced than in the counterfactual case where households experience unemployment at age 26.

Figure A.6 compares the change in the average house size between the two counterfactuals

Figure A.6: House size after unemployment shock at age 26 and 45



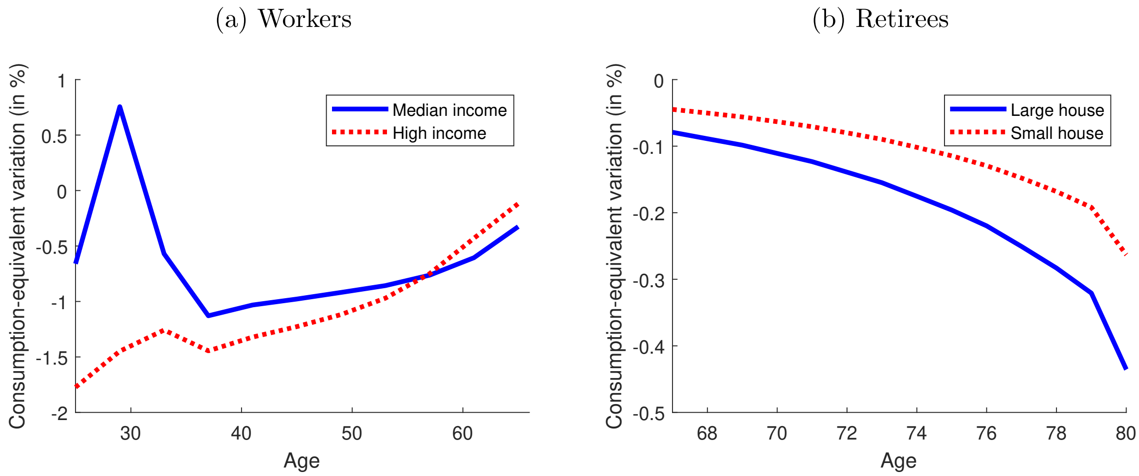
Notes: This figure shows the relative change in house size of workers who experience unemployment at age 26 (solid line) and at age 45 (dotted line) compared to a control group who does not experience unemployment.

where households become unemployed at age 26 and 45, respectively. When becoming unemployed at age 26, the average house size declines by 30% compared to a control group who do not experience unemployment and recovers slowly over time. In contrast, the average house size of households becoming unemployed at age 45 only declines by less than 5%.

The change in the house size is stronger when young households become unemployed due to the following two reasons. First, older households already own large houses, have higher income, and have accumulated more liquid wealth over the life cycle compared to young households. When they become unemployed, many households stay in their house and there is no need to adjust the house size. Younger household who become unemployed own on average smaller houses, and cannot move to larger houses when they are affected by the unemployment shock. The second reason is that the decline in lifetime earnings due to unemployment is larger for young workers than for the older workers. The persistent income losses following an unemployment spell reduces future labor earnings as well, which is more important for the younger workers.

A.8 Welfare consequences

Figure A.7: Welfare consequences of unemployment shocks



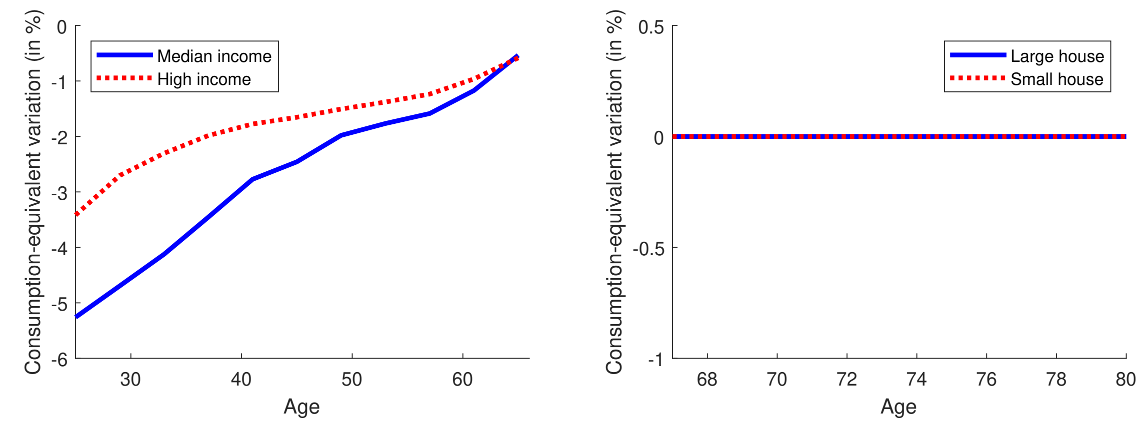
Notes: This figure shows the welfare consequences of a recession for each age in consumption-equivalent variation for households who are rich in liquid assets. Panel A.7a displays the welfare results for workers who have median income (solid line) and workers with higher income (dotted line). Panel A.7b shows the welfare results for retirees who own relatively small houses (solid line) and retirees owning a larger house (dotted line).

This section presents additional welfare results to Section 4.3. In Figure A.7, I consider the case where households at all ages are rich in liquid asset. Figure A.7a shows that young workers around age 30 experience a welfare gain from the unemployment shock. As households are not liquidity constraint, they can buy a house at depressed prices and benefit from future house price appreciations, leading to a welfare gain. For households with high income, the risk of permanent income losses is more important such that they still experience a welfare loss from the recession.

Compared to the welfare results in Section 4.3, Figure A.7b indicates smaller welfare losses for retired households from the recession. As households are rich in liquid asset, the share of housing wealth in their total wealth is smaller such that the relative decline in housing wealth is muted. As a consequence, a high amount of liquid wealth decreases the welfare losses from a recession for the retired households.

Figure A.8: Welfare consequences of unemployment shocks

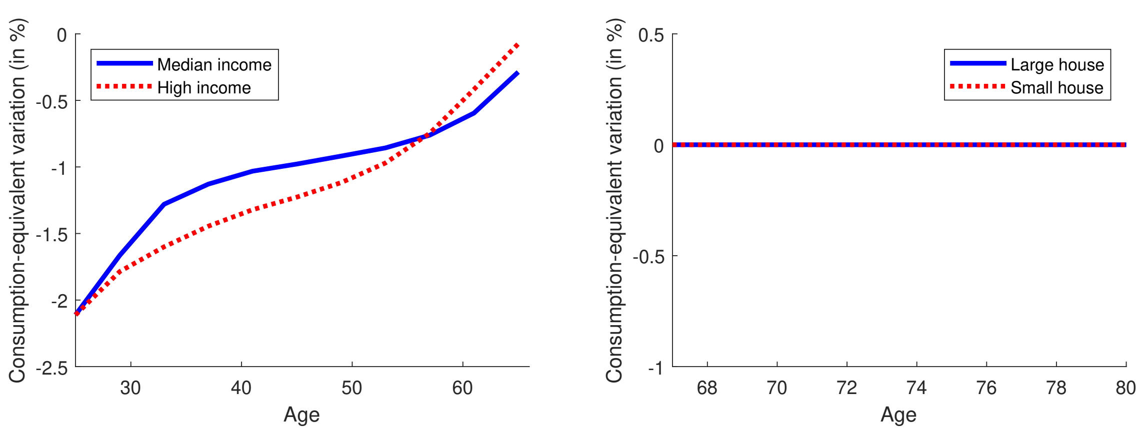
(a) Workers (b) Retirees



Notes: This figure shows the welfare consequences of a recession for each age in consumption-equivalent variation when house prices are fixed at the steady-state prices. Panel A.8a displays the welfare results for workers who have median income (solid line) and workers with higher income (dotted line). Panel A.8b shows the welfare results for retirees who own relatively small houses (solid line) and retirees owning a larger house (dotted line).

Figure A.9: Welfare consequences of unemployment shocks

(a) Workers (b) Retirees



Notes: This figure shows the welfare consequences of a recession for each age in consumption-equivalent variation for households who are rich in liquid assets when house prices are fixed at the steady-state prices. Panel A.9a displays the welfare results for workers who have median income (solid line) and workers with higher income (dotted line). Panel A.9b shows the welfare results for retirees who own relatively small houses (solid line) and retirees owning a larger house (dotted line).

Figure A.8 shows the welfare consequences in the counterfactual where house prices are fixed at the steady-state levels. Young workers bear larger welfare losses compared to the baseline economy as they cannot benefit from the decline in house prices. Old households do not experience any welfare losses as their housing wealth remains unaffected by the recession. As a consequence, the profiles in Figure A.8b remain flat at all ages.

Figure A.9 shows the welfare results for households who are rich in liquid wealth in the counterfactual economy where house prices are fixed at the steady-state levels. Looking at the working-age population in Figure A.9a, the welfare losses are much smaller for households with large liquid wealth: at age 25, the welfare losses are approximately 2% in terms of consumption-equivalent variation. The welfare losses from the recession are smaller for workers with median income as these households can afford a house when house prices decline during the recession. In contrast, for high-income workers, the change in house prices is less important than for the median-income workers and the persistent income losses upon unemployment leads to larger declines in income for them. Hence, high-income workers face larger welfare losses from a recession. The welfare results for retired households are displayed in Figure A.9b. Similar to the previous results in Figure A.8, retired households do not bear any welfare costs because the house prices do not move over time and their housing wealth remains unaffected from the unemployment shock.

A.9 Population age structure and housing demand

Let $h_o(p)$ and $h_y(p)$ denote the total housing demand of old and young households, respectively, as a function of the housing price p. Housing demand always decreases in price p, i.e. $h'_o(p) < 0$ and $h'_y(p) < 0$. Let λ denote the population share of old households. Then, the total housing demand in the steady state of the economy is given by

$$\hat{H}(\hat{p}) = \lambda \hat{h}_o(\hat{p}) + (1-\lambda)\hat{h}_y(\hat{p}). \tag{11}$$

where the hats denote the steady-state values. The relative change in total housing demand when a recession occurs is

$$\eta = \frac{H^r(p^r) - \hat{H}(\hat{p})}{\hat{H}(\hat{p})} \tag{12}$$

where $H^r(p^r)$ denotes the total housing demand in the recession at price p^r. In a recession, housing demand at a given price p is assumed to be lower than in the steady state so that $H^r(p) < \hat{H}(p)$. Plugging in the expression from Equation (11) yields

$$\begin{aligned}
\eta &= \frac{H^r(p^r) - \hat{H}(\hat{p})}{\hat{H}(\hat{p})} \\
&= \frac{\lambda h_o^r(p^r) + (1-\lambda) h_y^r(p^r) - \lambda \hat{h}_o(\hat{p}) - (1-\lambda)\hat{h}_y(\hat{p})}{\lambda \hat{h}_o(\hat{p}) + (1-\lambda)\hat{h}_y(\hat{p})} \\
&= \frac{\lambda \left[h_o^r(p^r) - \hat{h}_o(\hat{p})\right] + (1-\lambda)\left[h_y^r(p^r) - \hat{h}_y(\hat{p})\right]}{\lambda \hat{h}_o(\hat{p}) + (1-\lambda)\hat{h}_y(\hat{p})}
\end{aligned}$$

Define $\Delta h_o \coloneqq h_o^r(p^r) - \hat{h}_o(\hat{p})$ and $\Delta h_y \coloneqq h_y^r(p^r) - \hat{h}_y(\hat{p})$. Then, we obtain

$$\begin{aligned}
\eta &= \frac{\lambda \Delta h_o + (1-\lambda)\Delta h_y}{\lambda \hat{h}_o(\hat{p}) + (1-\lambda)\hat{h}_y(\hat{p})} \\
&= \frac{\Delta h_y + \lambda(\Delta h_o - \Delta h_y)}{\hat{h}_y(\hat{p}) + \lambda\left(\hat{h}_o(\hat{p}) - \hat{h}_y(\hat{p})\right)}.
\end{aligned}$$

The partial derivative of η with respect to λ yields

$$\frac{\partial \eta}{\partial \lambda} = \frac{(\Delta h_o - \Delta h_y) \cdot \left[\hat{h}_y(\hat{p}) + \lambda \left(\hat{h}_o(\hat{p}) - \hat{h}_y(\hat{p})\right)\right]}{\left[\hat{h}_y(\hat{p}) + \lambda \left(\hat{h}_o(\hat{p}) - \hat{h}_y(\hat{p})\right)\right]^2} - \frac{\left[\Delta h_y + \lambda \left(\Delta h_o - \Delta h_y\right)\right] \left(\hat{h}_o(\hat{p}) - \hat{h}_y(\hat{p})\right)}{\left[\hat{h}_y(\hat{p}) + \lambda \left(\hat{h}_o(\hat{p}) - \hat{h}_y(\hat{p})\right)\right]^2}$$

It holds that η is equal to zero at market clearing prices $p^r = \hat{p}^r$ because the total housing supply is assumed to be fixed. Now, consider a new steady state with a higher share of old households compared to the initial steady state. The equilibrium housing price in the initial economy is denoted by p_1^r in recession, while p_2^r denotes the equilibrium housing price in the new economy during a recession. Assume that the housing supply and steady-state housing price remains at the same level in the new steady state. If $\frac{\partial \eta}{\partial \lambda} > 0$, then in the new steady state with a higher share of old population, the housing price p_2^r has to increase in equilibrium. In this case, the change in housing price is $\hat{p} - p_2^r < \hat{p} - p_1^r$, implying that the drop in housing price during a recession becomes smaller in absolute value. We want to assess in which cases we obtain $\frac{\partial \eta}{\partial \lambda} > 0$. Simplifying the above expression yields

$$\begin{aligned} & (\Delta h_o - \Delta h_y) \cdot \hat{h}_y(\hat{p}) + \lambda \left(\Delta h_o - \Delta h_y\right) \cdot \left[\hat{h}_o(\hat{p}) - \hat{h}_y(\hat{p})\right] \\ & - \Delta h_y \cdot \left[\hat{h}_o(\hat{p}) - \hat{h}_y(\hat{p})\right] - \lambda \left(\Delta h_o - \Delta h_y\right) \cdot \left[\hat{h}_o(\hat{p}) - \hat{h}_y(\hat{p})\right] > 0 \\ \Leftrightarrow \quad & (\Delta h_o - \Delta h_y) \cdot \left[\lambda \hat{h}_o(\hat{p}) + (1-\lambda) \hat{h}_y(\hat{p})\right] > (\lambda \Delta h_o + (1-\lambda) \Delta h_y) \cdot \left[\hat{h}_o(\hat{p}) - \hat{h}_y(\hat{p})\right] \end{aligned}$$

Rearranging yields

$$\begin{aligned} \Delta h_o \cdot \hat{h}_y(\hat{p}) &> \Delta h_y \cdot \hat{h}_o(\hat{p}) \\ \Leftrightarrow \quad \frac{\Delta h_y}{\hat{h}_y(\hat{p})} &< \frac{\Delta h_o}{\hat{h}_o(\hat{p})} \\ \Rightarrow \quad \frac{\Delta h_y}{\hat{h}_y(\hat{p})} \Big/ \frac{p^r - \hat{p}}{\hat{p}} &< \frac{\Delta h_o}{\hat{h}_o(\hat{p})} \Big/ \frac{p^r - \hat{p}}{\hat{p}} \\ \Leftrightarrow \quad \frac{\Delta h_y}{\hat{h}_y(\hat{p})} \Big/ \frac{\Delta p}{\hat{p}} &< \frac{\Delta h_o}{\hat{h}_o(\hat{p})} \Big/ \frac{\Delta p}{\hat{p}}. \end{aligned} \tag{13}$$

If the inequality is satisfied, a higher share of old population leads to, all else equal, a smaller spillover effect on housing prices.

A.10 Welfare implications of higher generosity of unemployment insurance

The findings in Section 6 indicate that the unemployment insurance system partly stabilizes housing prices during a recession. In the following, I analyze the changes in welfare consequences of an unemployment shock induced by higher generosity of the UI system. In particular, the goal is to assess whether increasing UI benefits mitigates the welfare consequences on old, retired households who suffer from the spillover effect of unemployment risk on the housing prices.

Table A.3 summarizes the results. Comparing the welfare results in the economy with higher UI generosity during a recession (column 3) to the baseline economy (column 2), it becomes evident that retired households also gain from the increase in the UI generosity. As a more generous UI system stabilizes the housing prices, the housing wealth of retired workers is stabilized as well during a recession, and as a consequence, the welfare losses of retired households are mitigated. Interestingly, the welfare losses of the young households (age 25) is slightly larger in the economy with higher UI generosity, as a stabilization of housing prices reduces the asset price gain of young households.

Table A.3: Welfare decomposition

Age	Welfare effects (in %)	
	Baseline	Higher UI generosity
25	−3.72	−3.83
30	−3.99	−3.97
35	−3.65	−3.60
40	−2.91	−2.87
45	−2.46	−2.43
50	−1.95	−1.92
55	−1.66	−1.63
60	−1.31	−1.28
65	−0.63	−0.59
70	−0.19	−0.17
75	−0.39	−0.34
80	−1.03	−0.81
85	−1.06	−0.96

Notes: The welfare effects are measured in consumption-equivalent variation on remaining lifetime consumption. In all models, the welfare effects are computed for a median household in the economy in terms of assets, employment status, income, housing size, and remaining mortgage balance. The baseline model refers to the results in Figure 7. The model with a more generous unemployment insurance system refers to the results in Figure 10.