Job Risk, Separation Shocks and Household Asset Allocation

Kieran P. Larkin*

Job Market Paper

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Abstract

This paper studies the interaction of household asset and labor market choices. In particular, I study the amplification due to this channel of the severity of the Great Recession as a result of the low risk environment prior to the downturn. A recent literature has established that the distribution of assets is crucial for the aggregate response of the economy to shocks. The income risk a household faces in the labor market is a key determinant of their asset allocation decision, but a household's asset position may also affect the jobs they choose. Therefore, causation can run in both directions. I build a model that incorporates a jobs ladder, heterogeneity in job risk and saving in liquid and illiquid assets. The model replicates the positive correlation between job risk and the liquidity of household portfolios and captures the housing choices following a job separation both measured in the PSID. The joint determination of asset and labor market outcomes provides a novel mechanism by which the state of the economy affects the magnitude of the aggregate response of consumption and housing choices to labor market shocks. The fact the Great Recession occurred following a decline in the job separation rate increased the negative response of consumption by 40 percent.

Keywords: Heterogeneous Agents, Consumption, Housing, Job Risk

*University College London, contact: kieran.larkin.11@ucl.ac.uk. I thank my supervisor Morten Ravn for continued direction and support. I thank Vincent Sterk, Wei Cui and Ralph Luetticke for helpful comments and input.

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1 Introduction

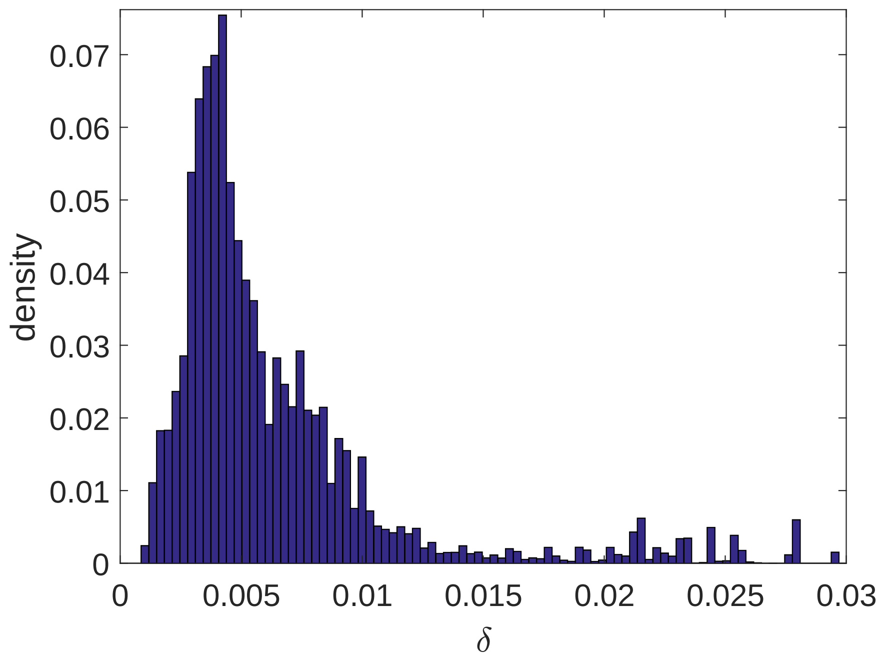
What determines the response of consumption, output and prices to shocks and do the conditions in the economy prior to the shocks matter? Modern macroeconomics has increasingly recognized that the distribution of assets is of first order importance to the aggregate response of the economy to shocks (Kaplan and Violante (2018)). Krusell et al. (1998) argue that under certain conditions heterogeneity in the wealth distribution delivers similar results to a representative agent economy. However, recently the savings decisions of households and the resulting wealth distribution has received renewed focus in a growing literature that has linked features of the asset distribution, in particular the illiquidity of some forms of saving, to the distribution of the marginal propensity to consume (MPC).[1] Targeting the rich heterogeneity in the wealth distribution has allowed progress to be made on matching the large empirical responses of household consumption to transitory income shocks observed in the data, a response which is otherwise small in permanent income type models. This finding has important implications for the response of the economy to fiscal policy changes and for the transmission of monetary policy.

Household's exposure to risk in the labor market is a key determinant of their asset allocation decision.[2] Yet it is clear that a household's asset position may also impact the jobs they choose and risk households face. For example, *a priori* one might assume that a worker with little savings may be unwise to accept risky employment. Theoretically, it is not obvious how these effects interact and which dominates.

The prevailing approach to modeling income risk has been to treat uncertainty as a fixed parameter with all households facing the same level of risk. Yet in reality there is significant variation in the income risk faced by households. Figure 1 shows the cross sectional distribution of the monthly job separation rate in the US as estimated from data sampled

[1] See for example Kaplan and Violante (2014), Kaplan et al. (2016), Lütticke (2017)

[2] The role that income uncertainty plays in shaping the consumption-savings decisions of households has been one of the primary areas of study in macroeconomics during the past 30 years. Prominent examples include: Zeldes (1989), Deaton (1991), Aiyagari (1994), Carroll and Kimball (2001), Castañeda et al. (2003)



Data: CPS (1987-2016). For details of estimation see section 3.1

Figure 1: Distribution of US job risk

from the Current Population Survey (CPS). [3] This measure is referred to as job risk. There is significant heterogeneity in the level of job risk faced with some individuals facing very low risk of unemployment while other facing a much larger expected separation rate. This distribution also exhibits variation over time. Perhaps most notably is the long term secular decline in the job separation rate (Figure 2).

This paper studies the joint determination of household's asset allocation decisions and labor market outcomes. Its main contribution is to introduce novel labor market features into a state of the art general equilibrium incomplete markets model to understand the role that job risk heterogeneity plays in household asset allocation and how labor market and consumption savings decisions interact. I then investigate how changes in the labor market environment alter a household's portfolio choice and the impact that these distributional changes have on the response of the economy to aggregate shocks.

To do this I build a model that incorporates a jobs ladder, heterogeneity in job risk and

[3]Full details of the construction of this measure are provided in section 3.2.

saving in liquid and illiquid assets. In the labor market, I propose a model where households receive job offers that vary across two dimensions - wage and separation rate (job risk), see Jarosch (2015). A household that receives a new job offer is able to accept or reject the new wage-job risk combination and this decision depends on its current asset position. As a result job risk in the economy is endogenous. To capture the rich heterogeneity in the wealth distribution the model feature three assets: liquid assets, housing and mortgages. On the asset side I focus on housing as it is the largest illiquid assets for many households, with housing equity accounting for 52 percent of the median household's illiquid asset portfolio.[4] Housing is also important because it is financed by long term debt obligations, which leverage a household's illiquid asset position and can make them sensitive to changes in house prices.

I show that the model delivers empirically realistic asset and labor market interactions. Firstly, the model replicates the positive correlation between job risk and the liquidity of a household's portfolio as observed in the Panel Study of Income Dynamics (PSID). Job risk is important for how households choose to allocate their assets, as households facing less risk and requiring lower precautionary savings are able to allocate a greater share of their assets to more illiquid forms of wealth. Secondly, I show the model captures the housing choice of households that suffer a job separation shock. The new consensus in the labor literature is that unemployment shocks can result in significant and persistent income losses. As in other work, the jobs ladder feature of our model reconciles the model with this empirical fact, meaning that for many households unemployment shocks are far from transitory. In contrast to the labor literature I also study the asset choices of households and show the model replicates the magnitude of downsizing in the housing market in response to job separation shock as measured in the PSID.

A contribution of the paper is to allow for a feedback mechanism from the asset allocation decision to the labor market via households' choices over which jobs to accept or reject. Counter intuitively, I find that poorly insured households with low liquid asset holdings are

[4]In the 2016 Survey of Consumer Finance (SCF) the median net housing holdings was $25,000. The median net worth holdings was $48,360

more willing to forgo increased job security for an increased wage than households with high liquid asset holdings. The reason for this is the slope of the illiquid household consumption function, favoring wage gains today over security tomorrow. As a results if all households were to make decisions over jobs following the choices of wealthy households, the economy would feature a lower unemployment rate.

Introducing job risk heterogeneity is found to raise the aggregate MPC. This provides an alternative explanation to the previous literature which has introduced lifecycle motives, a large spread between the return on illiquid and liquid assets or heterogeneous preferences (see Kaplan and Violante (2014) and Carroll et al. (2017)). However, I find that job risk only raises MPCs by a small amount (around 15 percent on a quarterly basis). A key reason for this is that households' precautionary savings motive is highly non-linear in uncertainty with only very low risk households reducing liquid savings sufficiently to become hand to mouth. In the data there is relatively few of these households. Further, the negative correlation between job risk and earnings means that households with low job risk tend to have high earnings - strengthening their precautionary savings motive - and have had long employment durations - allowing time to build up liquid savings. These mechanism weaken the relationship between job risk and wealthy hand to mouth status in the model.

In the main result, I show the importance of the joint determination of asset and labor market outcomes by investigating the response of the economy to labor market shocks seen in the Great Recession. I shock the economy with labor market shocks from the Great Recession, estimated in the CPS, allowing for heterogeneity in the shocks across job types. I compare the response of the aggregates when the shocks occur following a period of relative calm in the labor market to the case with higher job risk. The fact the Great Recession occurred following a period of moderation and low risk in the labor market, notably a steady decline in the job separation rate, increased the negative response of consumption by around 40 percent. Households' equity holdings also suffer a larger fall, incorporating both price and quantity effects. The amplification of the response is due to households adopting more illiquid portfolios, increasing their housing stocks and sorting into higher wage jobs. Labor market heterogeneity is important for this result, the amplification is reduced if all households face the same job risk, particularly in the housing market. I also evaluate the model's ability to replicate the cross sectional consumption and asset choice dynamics. The model is able to replicate key features of the asset market decisions during this period, including the cross sectional ordering of the housing response across job types.

The rest of the paper is set out as follows. Section two sets out the related literature, section three provides empirical evidence on job risk and asset allocation; section four presents the model; section five analyses households choices in the steady state equilibrium, section six presents the response of the economy to the Great Recession shocks; while section seven concludes.

2 Related literature

This paper brings together to two broad literatures: firstly, research studies heterogeneous agent economies with incomplete markets and multiple assets, and secondly, research into the effect of variation in income risk or job uncertainty on household choices. In the former strand, Kaplan and Violante (2014) is arguably the foremost contribution. That paper introduced the concept of wealth-hand-to-mouth agents that hold little liquid assets but substantial illiquid assets and have high a marginal propensity to consume. Introducing wealth hand-to-mouth household's into a heterogeneous agents model enabled the authors to replicate the expenditure out tax rebates empirically observed in the literature e.g. Souleles et al. (2006) and Parker et al. (2013). Kaplan et al. (2016) embedded this framework in a New Keynesian sticky price model, finding the response to monetary policy shocks to be of the same magnitude to that of a representative agent model.

The role of housing in the heterogeneous agent environment has been studied by a wide number of authors. Notable recent contributions include Berger and Vavra (2015); Hedlund

(2016); Favilukis et al. (2017); and Kaplan et al. (2017). On particular relevance to this paper is Berger et al. (2015) which relates the consumption response to house price shocks to the marginal propensity to consume and shows that the response is sensitive to the level of household debt in the economy. A related finding is Aaron Hedlund and Ozkan (2017) who develop a frictional housing market in a heterogeneous New Keynesian model, and highlight the housing channel in the transmission of monetary policy. On the interest rate channel, Wong (2017) documents and replicates a lifecycle pattern in the consumption response to interest rate shocks, where the heterogeneity is due to the desire to remortgage a households mortgage in response to a interest rate cut. A related result is Cloyne et al. (2016), who find in the US and UK data that mortgage holders respond strongly to interest rate changes, whereas homeowners do not.

The link to the labor market in this class of models has been made by Ravn and Sterk (2017) where countercyclical income risk is driven by endogenous changes in the job finding rate. Challe (2017) studies optimal policy when unemployment risk is endogenous, finding that the setting calls for accommodative monetary policy responses to cost-push shocks, the opposite of the optimal policy in representative model, due to the additional precautionary savings motive. More closely related to this paper is Bayer et al. (2015), where the precautionary savings motive responds to a time varying changes in income uncertainty. Output contracts in response to an increase in income risk with the liquidity of a household portfolio increasing. Here I mainly focus on the implications of cross sectional variation in income uncertainty rather than time variation, although the response to the Great Recession shocks are similar.

A second important literature is the study of labor market risk and its effect on household choices. Recent contributions include Lise (2013) who studies on the job search with precautionary savings, highlighting the interactions between choices in the labor and asset market. Hubmer (2018) extends this model with human capital and lifecycle dynamics to show a jobs ladder model is capable of replicating the higher order incomes moments estimated in administrative data sources, documented by Guvenen et al. (2015). In that model the wealth of households effects their income process by determining search effort, rather than a wage-job risk trade-off studied here. Low et al. (2010) make progress on disentangling the exogenous and endogenous sources of risk in a lifecycle set up with job mobility, focusing on the welfare value of different forms of partial insurance. Also relevant is Krusell et al. (2010) who introduce a Diamond-Mortensen-Pissarides style labor market in an otherwise standard incomplete markets model and find important implications for optimal unemployment insurance. Eeckhout and Sepahsalari (2015) study the relationship between asset holdings and unemployment, but focus on the precautionary job search motive rather than job risk heterogeneity. Their model is directed search but features only one asset. Jung and Kuhn (2017) introduce heterogeneity in job stability to explain the size of income losses, stressing the importance of the loss of good jobs at the top of the jobs ladder.

The study most related to this paper is Jarosch (2015). In a similar spirit to the model studied here, that paper proposed a random search model where jobs vary over two dimensions, productivity and job security. This generates 'slippery' lower rungs of the job ladder, characterized by movement in and out of unemployment. The model is able to capture the persistent negative employment and wage effects following job loss in Germany. In comparison to that paper here a simpler labor market is studied, but the model is enriched with a consumption savings choice. The allows the implications for the wealth distribution to be analyzed. In contemporaneous work, Krivenko (2018) also builds a model combining unemployment scarring and the housing market during the Great Recession, emphasizing the importance of exogenous moving shocks in generating the large house price decline of the Great Recession. Compared to that paper the labor market specification here is richer featuring household choice over jobs risk, rather than an exogenous process.

There is also a literature that has sought to find evidence of a precautionary savings motive in the data, without full agreement. [5] Our approach is most similar to Carroll et al.

[5] Carroll and Samwick (1998) find evidence in the PSID of higher wealth for individuals with greater income uncertainty consistent with a buffer-stock model. While Mishra et al. (2012) find evidence of pre-

(2003) who find evidence for precautionary effect for moderate and higher income households but not for low income households in the Survey of Consumer Finance, although surprisingly this effect is only found to be present when illiquid housing equity is included in the definition of wealth. In contrast in the PSID there is a correlation between risk and the liquidity of the household portfolio. Basten et al. (2016) present Norwegian evidence consistent with an increase in financial wealth and reallocation towards safe assets prior to a unemployment spell.

In the broader empirical literature, once controlling for sorting Cubas and Silos (2017) find evidence of labor earnings compensation for higher permanent risk. Chetty et al. (2017) consider the effect of housing on a household's portfolio choice, with higher property value reducing stock holdings while greater equity wealth having the opposite effect. Chetty et al. (2017), shows that job-stayers face less dispersion in earnings growth, with positive rather than negative skew and experience greater kurtosis in income shocks than job switchers.

3 Data

This section motivates the model presented subsequently. Firstly, it discusses the aggregate job separation rate and shows the separation rate changed for different groups during the Great Recession. Secondly, it presents the measure of job risk used in this paper and considers how it varies over time. Finally, it presents analysis linking job risk to household asset allocation, providing evidence that supports the hypothesis that households facing lower job risk keep more of their wealth in illiquid assets.

cautionary savings for farm households. Guiso et al. (1992) present evidence of precautionary savings in the Italian data, but the size of the effect is fairly small. Conversely, Fulford (2015) finds little evidence of precautionary savings based on households stated preferences. Jappelli et al. (2008) reject the buffer stock behavior in Italian data.

3.1 Job separation rate

Figure 2 illustrates the job separation rate (or employment exit probability) using aggregate data from the CPS and the methodology of Shimer (2012). The series is constructed from the level for employment, unemployment and short term unemployed (less than four weeks) published by the Bureau of Labor Statistics for the period 1976-2018.[6]. It account for time aggregation that causes short spells of unemployment to be missed.

The estimated job separation rate exhibits a strong downward trend. While the decline is partly explained by demographic and education changes, it is also symptomatic of declining turnover in the US labor market (see Molloy et al. (2016), Kaplan and Schulhofer-Wohl (2017), Fujita (2018)). While there were a number of trends in the risks facing households during the period known as the Great Moderation, on the job separation dimension households experienced rising economic security as argued by Davis (2008).

The key finding of Shimer (2012) is the lack of cyclicality in the job separation rate, with business cycle movements in the unemployment rate instead being largely determined by changes in the job finding rate. Despite this conclusion a notable feature of the Great Recession was the significant rise in the job finding rate, which increased from 2.6 percent in December 2007 to 3.8 percent in January 2009.[7]

The rise in the job separation rate during the Great Recession was not uniform across job types. Figure 3 presents the change in the job separation rate at an annual frequency for different groups of workers. Job types are broken up into high and low wage types and into jobs with a higher or lower ex ante risk of job separation (high and low risk types to be discussed in Section 3.2). Between 2007 and 2009, the job separation rate rose by more in percentage terms for high risk types (76 percent versus 50 percent) and high wage types

[6]For the period after January 1994, CPS micro data is needed to construct the short term unemployment measure. See Shimer (2012) for details

[7] A recent literature has also reevaluated the importance of job separation shocks. Ahn and Hamilton (2016) emphasis that Shimer understates the importance of job separation shocks to unemployment variations as these shocks alter the composition of the unemployed driving changes the job finding rate. From a theory perspective, Coles and Kelishomi (2015) relax the free entry condition in the standard DMP model and argue the model no longer implies a small role for job separation shocks.

(84 percent versus 56 percent).[8] After 2009, the heterogeneity in separation rate increases dissipates for both groups. As shown in Appendix C Figure C.1 the effect on weekly earnings also differed by group type. The fall in wages by risk type was fairly similar, with high risk types seeing a slightly larger fall. In comparison low wage types saw much larger declines in weekly earnings.

3.2 Job risk distribution

As shown in Figure 1 the US labor market is characterized by significant heterogeneity in the degree of job risk workers face. Job risk is a key measure used in this paper, in this section I explain how this measure is constructed. The data used is from the Current Population Survey (CPS) micro data for the years 1987-2018. Let the outcome variable u be a dummy with the value of 1 if an individual i is employed next month and 0 otherwise. I estimate the Probit model for job separation:

$$Pr(u_{i,j,o,s,t} = 1) = \alpha_0 + \gamma_j + \mu_o + \eta_s + \phi_t + \theta y_{i,t} + \beta \mathbf{X}_{i,t} + \epsilon_{i,j,o,r,t} \tag{1}$$

I include fixed effect for industry j, γ_j; occupation o, μ_o; state s, η_s; and ϕ_t time.[9] Industries and occupations are designated at the broad industry and occupation classification level generating 13 industry and 25 occupation types in the data set. The additional controls are a measure of income, $y_{i,t}$, and a set of observables including a quartic in age, education dummies, and other demographic controls, $\mathbf{X_{i,t}}$.

The value of job risk used is the predicted probability of job separation for an industry-occupation-state cell, excluding idiosyncratic factors:

$$\hat{Pr}(u_{j,o,r} = 1) = \hat{\alpha}_0 + \hat{\gamma}_j + \hat{\mu}_o + \hat{\eta}_r + \phi_{2007} + \hat{\theta}\bar{y} + \bar{\mathbf{X}}\hat{\beta} \tag{2}$$

[8]The aggregate rise in the job separation rate is larger here as these figures are not adjusted for temporary unemployment spells

[9]For industry the 1990 Census Bureau industry classification scheme is used. For occupation the 2010 Census Bureau occupation classification scheme is used.

The year is set to 2007. The distribution of these jobs can then be plotted using the distribution of jobs in the dataset.

In the baseline specification shown in Figure 1 the log. of average weekly earnings is used.[10] Figure C.2 in the Appendix present the distribution using alternative income controls. The distribution produced is fairly consistent, with the income controls accounting for part of the heterogeneity and reducing the mean separation rate.

This method can also be used to investigate how job risk has changed over time. To do this I run the same regression (1) for five year intervals, $\{j-4,...,j\}$ and then use the distribution of jobs in the last year, j, as a measure of the job risk faced. This approach captures changes in both the job risk of a given job and changes in the composition of jobs in the economy.[11]

The distribution of job risk has changed substantially over time as shown in Figure 4. Prior to 2005, both the mean and the median job risk underwent a secular decline as previously seen in Figure 3. There has also been a change in the higher cross sectional moments on the the distribution. There has been a large reduction in the cross sectional standard deviation of job risk, falling by almost 50 percent between 1985 and 2000, before rising after the Great Recession see Panel b. Similarly the cross sectional skewness of the distribution reached a minimum in 2005, before increasing during the recession.[12] Kurtosis (not shown) follows a similar pattern to skewness. Finally, Panel d provides a cross sectional example of the extent to which the job risk distribution has changed, comparing the distribution in 2007 when the standard deviation was low with 1984 when the standard deviation was high. Figure C.3 in Appendix C provides a further selection of years evidencing how the distribution of job risk has evolved over time.

[10]For each individual weekly earnings is recorded twice, the observations are one year apart at the end of individuals' four month rotations. The average over these two values is taken to reduce measurement error.

[11]No income control is used for this exercise, to extend the years available in the analysis and to maximize the sample size for each year.

[12]Pearson's moment coefficient of skewness is used

3.3 Asset allocation and job risk

3.3.1 Portfolio liquidity

Having constructed a measure of job risk in the data, I now consider how the liquidity of a household's asset allocation is correlated with job risk it faces. Later, I will compare these results to the model to validate the ability of the model to match the joint determination of assets and labor market outcomes. For this analysis I use data from the PSID which due to its panel structure can be used to construct a measure of job risk and since 1984 also contains information on household wealth. Household wealth information is available in 1984, 1989, 1994 and then every year in the biannual PSID from 1999 onwards.

The idea is to regress a measure of liquidity, $L_{i,t}$, on estimated job risk, $\hat{\delta}_{i,t}$, a function of the industry, occupation and state of the individual. Household wealth is divided into liquid and illiquid assets. Liquid wealth includes checking accounts and stocks net of credit card debt, student loans, medical debt, legal and family debt, while illiquid wealth includes housing equity, other real estate, other assets and IRA accounts, following Kaplan et al. (2014).

To address the non-linearities in household liquidity, with the possibility of the denominator becoming very small or negative, two alternative measures of liquidity are used: 1. the liquid asset to illiquid asset ratio; 2. liquid asset to total asset ratio. An inverse hyperbolic sine transformation is applied to this ratio following Carroll et al. (2003).[13] For both dependent variable specifications regressing the non-transformed liquidity measure on job risk does not generate significant results.

In the baseline specification job risk is estimated in the PSID. This follows the same methodology as in 3.2, with the log of permanent family income used for the income control.[14]

[13]Like a log transformation the inverse hyperbolic sine transformation $g(Y,\theta) = \log\left(\theta Y + \sqrt{(\theta Y)^2 + 1}\right)/\theta$, down weights large values of Y, however, in contrast to log it admits zero and negative values of Y, as suggested by Burbidge, Magee and Robb (1988). In Carroll et al. (2003) the parameter θ is estimated, here following Basten et al. (2016) θ is set to one.

[14]Permanent family income is the average income over all household observations. As there is a long panel for each household this measure should not be too affected by a future unemployment spell.

In the second stage the equation:

$$L_{i,t} = \alpha_0 + \lambda\hat{\delta}(j, o, s)_{i,t} + \phi_t + \theta y_{i,t} + \beta\mathbf{X}_{i,t} + \epsilon_{i,t} \qquad (3)$$

is estimated where controls for permanent income $y_{i,t}$, year fixed effects, ϕ_t and a quartic in age, education dummies, demographic variables, $\mathbf{X_{i,t}}$, are included.[15] The parameter of interest is λ.

The results for the ratio of liquid assets to illiquid assets are presented in Table 1. In the baseline specification, column (1), it can be seen increased job risk is associated with a more liquid asset allocation. The relationship is highly significant. At the 10^{th} percentile of the liquid asset to illiquid asset ratio, a one standard deviation increase in job risk implies a 5.5 percent reduction in the liquid asset to illiquid asset ratio, the 10^{th} percentile liquidity holding is negative so this is an increase in the liquidity of the portfolio. At the median liquidity holdings a one standard deviation increase in job risk implies 74 percent increase in the liquidity ratio.

As will be seen below, the model predicts the relationship between liquidity and job risk will be particularly strong at the very low job risk levels. Evidence for this in the data is provided by using dummy indicators for the lower percentiles of job risk, column (2). The effect on asset allocation is particularly strong for household in the 1^{st} job risk percentile, after that the effect decreases although is still significant for the 5^{th} and 10^{th} percentile.

The rest of the table provides a series of alternative specifications to serve as robustness checks. Column (3) restricts the sample used in the PSID to the Core sample, the results are significant but the coefficient is slightly reduced.[16] Thus far, the evidence presented does not prove a causal link, as it could equally be the case that households with illiquid asset allocations choose low risk jobs or in the confounding case households with greater risk aversion

[15] Our identification shares similarities with Carroll et al. (2003). They estimate a logit model of the probability of unemployment and use the predicted values, instrumented by state.

[16] The justification for not restricting the sample to the core sample in the PSID in the baseline analysis is that the unemployment rate is higher for the additional samples: Core: 0.039; SEO: 0.095; immigrant: 0.075; latin: 0.087. Including these observations provides greater variation in the job risk variable.

chose safer jobs and a more liquid portfolio. While for the purpose of model validation it is sufficient to consider correlations in the data, evidence is also presented that shows a causal relationship from risk to assets appears to exist. In column (4) I include a series of controls for the household's risk preferences, including the share of liquid assets invested in stocks, expenditures on home, automotive and health insurance relative to household income, and total assets. The results remain with only a small decline in the coefficient. In column (6) I control for individual risk preferences by using a household fixed effect. Again the coefficient is a little lower but remains significant. In columns (7) and (8) I address reverse causality by instrumenting job risk by value at two and six years lags. The results remain statistically significant, with some reduction in the coefficient in the latter case. The only robustness test which returns contrary results is reported in column (5). Here additional controls for industry and occupation in the second stage are used, essentially using only the variation across region to identify job risk. This is a similar approach to Carroll et al. (2003). Here the coefficient is negative, but the effect is statistically insignificant.

I repeat the analysis with an alternative definition of liquidity: the ratio of liquid assets to total assets. The results presented in Table 2 are broadly similar. In contrast to the ratio of liquid assets to illiquid assets, I do find evidence of a liquidity effect when controlling for industry and occupation, column (6). However, the results when including individual fixed effects are not significant. As a further robustness check I repeat the results using job risk estimated from the CPS. These are presented in Appendix B, Tables B.1 and B.2. For the liquid asset to illiquid asset ratio the results are largely supportive, although no longer significant when using individual fixed effects. For liquid assets to total assets the results are less clear with the sign changing for some of the specifications.

3.3.2 Hand to Mouth status

To relate the analysis directly to the hand to mouth literature, a dummy variable for hand to mouth status, differentiating between Poor Hand to Mouth (PHTM) and Wealthy Hand to Mouth (WHTM) is regressed on the job risk measure. Hand to mouth is defined as those with positive liquid wealth, but less than one week of household income in liquid assets, or negative liquid wealth and less than one week of household income from their budget constraint.[17] Poor hand to mouth are hand to mouth households with weakly negative illiquid assets.

The results in Table 3 show higher job risk is associated with a higher probability of being PHTM and a lower probability of being WHTM. I also present results when controlling for industry and occupation and lagged job risk.[18] One explanation that fits with this pattern is that households with high job risk end up being PHTM following a period of unemployment when they consume their liquid assets. Low job risk households in contrast end up choosing to allocate their assets toward more illiquid forms, such as housing, as they require less insurance given their lower job risk. In Appendix B Table B.3 replicates the analysis for the core PSID sample, while B.4 uses job risk estimated from the CPS. The results show the same pattern.

4 Model

This section sets out the model that I will use to study the joint determination of labor and asset market outcomes. I study an infinite horizon model in which households make asset allocation decisions and sort across job types. There is a unit mass of households. In the labor market, workers' time is converted into output with a linear production function. The government collects taxes, which it spends on benefits and government expenditure.

[17]The budget constraint is defined as one month of household income

[18]The other specifications presented in the portfolio analysis yield similar results so are not presented here. One exception is the inclusion of individual fixed effect for which the results were not significant.

4.1 Model environment

Households are infinitely lived and value consumption over non-durables, c_t and housing services, $\tilde{h}_{t+1}$. Households make choices to maximize the expected value of lifetime utility:

$$\mathbf{E_t} \sum_{t=0}^{\infty} \beta^t u(c_t, \tilde{h}_{t+1})$$

Households can be employed or unemployed. Employed households hold jobs that vary in two dimensions: by the wage, ω_t, and separation probability, δ_t. Job offers arrive stochastically for both the employed and unemployed. Households that receive a new offer can reject the new job and remain in their current job. If the unemployed household rejects a job offer they remain unemployed. In addition, unemployed households vary by the quality of their job draw, ϵ_t.

There is a fixed stock of owner occupied housing, $\bar{H}$, in the economy with aggregate house price p_t. A rental market converts the consumption good into rental units with price r^p. Each employed worker, i, is employed by a firm, j. Firm-worker pairings generate match quality, μ_t. Workers are paid their marginal product, such that $\omega_t = \mu_t$. Aggregate output is the integral over firms, j. $Y_t = \int y_t^j dj$. Finally, the government provides unemployment insurance, collects taxes, issues bonds and undertakes government spending.

4.2 Household asset choice

At the beginning of each period households make a consumption savings decision. Households can choose to allocate their wealth between liquid assets, b_t, and housing, h_{t+1}. Households holding a positive housing stock may also borrow in the form of a mortgage, m_{t+1}. The three assets differ in their return and liquidity.

4.2.1 Liquid assets

Liquid assets are freely adjustable and earn the period return r. Households are able to borrow in liquid assets up to a borrowing constraint $\underline{b}$. Borrowing is more costly than saving with the spread being r^b. The interest rate schedule on liquid assets can be represented by the function $R(b)$, which features a kink at zero savings.

$$R(b_t) = \begin{cases} r \; if \; b_t \geq 0 \\ r + r^b \; if \; b_t < 0 \end{cases}$$

4.2.2 Housing

Housing choice is discrete with the choice from the set $h_{t+1} \in \mathcal{H} \subseteq [\underline{h}, \bar{h}]$. The discrete choice of housing is chosen for tractability and to capture the lumpy nature of the housing choice. The housing stock does not depreciate. In addition, housing is an illiquid store of wealth. Housing does not generate a financial return but provides a period utility flow, with the housing service flow proportional to the size of the stock $\tilde{h_t} = h_t$. Adjusting the housing stock requires the household to pay the non-convex adjustment cost $\Psi(h_t, h_{t+1})$, which enters into the budget constraint.

$$\Psi(h_t, h_{t+1}) = \begin{cases} \Psi h_t \; if \; h_t > 0 \; \& \; h_{t+1} \neq h_t \\ \Psi h_{t+1} \; if \; h_t = 0 \; \& \; h_{t+1} > 0 \\ 0 \; if \; h_{t+1} = h_t \end{cases} \tag{4}$$

For existing homeowners the cost is proportional to the current stock, for households with zero housing holdings the cost is proportional to the end of period choice. The cost can be thought of as a combination of realtor fees and a time cost of finding a new property. The adjustment cost is spent resources and does not flow to a financial institution.

Households can also choose to rent. I impose that renters may only rent the smallest housing stock size, $h^r_t = \underline{h}$. Renters receive a housing service flow proportional to the size they rent $\tilde{h}_{t+1} = h^r_{t+1}$ and must pay the rental price $r^h p h^r$ each period. As in Aaron Hedlund and Ozkan (2017), renters do not rent housing from other households. Instead, a rental technology exist to convert the consumption good into rental services.

4.2.3 Mortgages

Housing can be purchased with a mortgage, m_t, which is subject to a higher interest rate $r + r^m$. There is no default and renters cannot access mortgages. Households able to remortgage or make a mortgage repayment.[19] Households that remortgage take out a new mortgage worth $\Theta p_t h_{t+1}$ where Θ is the maximum loan to value ratio. They must also pay a fixed refinancing cost, Ψ^m.

Households that make the mortgage repayment must pay the interest on the mortgage today $r + r^m$ and make the minimum repayment $(1 - \gamma)m_t$. The value of the mortgage tomorrow is $m_{t+1} = \gamma m_t$. Households are restricted from paying off their mortgage early. If making a mortgage payment (rather than refinancing) and moving to a smaller property a household's mortgage must not exceed the maximum loan to value ratio of the new property. In this case they must also pay the difference $\Theta p_t h_{t+1} - \gamma m_t$.[20]

Mortgage refinancing is only available to employed households with wage exceeding $\tilde{\omega}$, consistent with the requirement to provide income proof for non-self certified mortgages. This simple set up captures a variety of the features of the mortgage market - mortgage debt is a long term commitment to payments, there are restrictions on access to credit and mortgages lever a household's asset position in the face of house prices changes. Mortgages also provide a way for households to access the wealth in their illiquid asset housing and one that is cheaper than unsecured borrowing.

[19] Restricting the mortgage choice set ensures the problem is computationally feasible

[20] Prepayment of mortgages is a feature of the US mortgage market, however in this model with a fixed mortgage rate there is relatively weak incentives for a household to pay back a mortgage early. Households are in fact able to pre-pay a mortgage in two periods, by becoming a renter and then repurchasing the same housing stock next period, although this would incur adjustment costs.

4.3 Job choice

The labor market is characterized by the stochastic arrival of job opportunities that households can choose to accept or reject. Households can either be employed or unemployed. All employed workers inelastically supply one unit of labor, with no utility cost. Unemployed households receive unemployment insurance, κ. The replacement rate does not depend on the household's previous employment.

Jobs vary across two dimensions: the wage, ω_t, and job separation probability, δ_t, which I will refer to as 'job risk'. Given this set up each job can be summarized by the state (ω_t, δ_t). The labor market transitions take place after the asset choice for the period has been made.

Each period the unemployed receive a new job offer with probability λ_0. The unemployed vary in the quality of job offers they receive, this is summarized by the state ϵ_t. Conditional on receiving a job offer they draw a job from the distribution $G_\epsilon(\omega_{t+1}, \delta_{t+1})$ and may choose to accept or reject this offer. If they reject the offer the household remains unemployed and updates their job offer quality state ϵ_t with distribution $Z_\epsilon(\epsilon_{t+1})$. The quality of job offers is declining with the duration of unemployment.

After making choices in the asset market the employed first discover whether they will suffer a job separation, which occurs with the job specific probability δ_t. Households that do not lose their job then receive a job offer with probability λ_1, the job offer arrival rates satisfy $\lambda_0 > \lambda_1$ such that jobs offers arrive more quickly for the unemployed, reflecting the cost of on the job search. The new job is drawn from the distribution $F_{\omega,\delta}(\omega_{t+1}, \delta_{t+1})$ capturing that the employed may receive different job offers to the unemployed, which is conditional on the current job state (ω_t, δ_t). With probability ρ^y households can choose to accept or reject the offer. If they reject the offer they continue to the next period with their current job (ω_t, δ_t). As jobs differ across two dimensions, wage level and job risk, the choice of whether to accept or reject a new job is not trivial and may depend on the household's other state variables. With probability $1 - \rho^y$ the household must accept the job drawn. This is interpreted as an income or contract shock rather than a job to job transition.

For the employed that experience a job separation they transition to the unemployed quality state with distribution $Z_e(\epsilon_{t+1})$. There is also the possibility of an immediate return to employment. With probability λ_2 they draw an in period job offer from the unemployed job offer distribution $G_\epsilon(\omega_{t+1}, \delta_{t+1})$, which they can choose to accept or reject.

4.4 Recursive formulation

The household choice problem can be presented in a recursive formulation. For this purpose prime notation is used to denote next period. Households discount the future with discount factor β. There are value functions for the employed, V, and unemployed, U. The state variables for the household are liquid asset holdings, b, beginning of period housing stock, h, and current mortgage, m. Denote the households asset holdings state as $\mathbf{s} = (b, h, m)$. The employed households have the additional state variables wage, ω, and job risk, δ. The unemployed have the additional draw quality state, ϵ.

4.4.1 Labor market expectation operators

Given the range of labor market outcomes it is useful to first define some expectation operators over the stochastic variables. Let the unemployed's expectation over job draw quality be: $\hat{U}_u(\mathbf{s}, \epsilon) = \int U(\mathbf{s}, \epsilon')dZ_\epsilon(\epsilon')$ and the employed's expectation over job draw quality be: $\hat{U}_e(\mathbf{s}) = \int U(\mathbf{s}, \epsilon')dZ_e(\epsilon')$. With these two objects I can now define the expectation of an unemployed household that has received a job offer:

$$\hat{V}_u(\mathbf{s}', \epsilon) = \iint \max\{V(\mathbf{s}', \omega', \delta'), \hat{U}_u(\mathbf{s}', \epsilon)\}dG_\epsilon(\omega', \delta')$$

where the first term in the max operator is the value of accepting the job and the second term is the value of rejecting the job and remaining unemployed. Similarly, the expectation of the employed household that has received a job offer can be defined as:

$$\hat{V}_e(\mathbf{s}', \omega, \delta) = \rho^y \iint \max\{V(\mathbf{s}', \omega', \delta'), V(\mathbf{s}', \omega, \delta)\} dF_{\omega,\delta}(\omega', \delta') +$$
$$(1-\rho^y) \iint V(\mathbf{s}', \omega', \delta') dF_{\omega,\delta}(\omega', \delta')$$

where the first term in the max operator on the first line is the value of accepting the job and the second term is the value of rejecting the job and retaining the current employment state (ω, δ). The second line is the probability of having a forced income change or contract shock.

4.4.2 Employed households

The value function for the employed refinancing household, $V^R(\mathbf{s}, \omega, \delta)$ is:

$$V^R(\mathbf{s}, \omega, \delta) = \max_{c, b', h' \in \mathcal{H}} u(c, \tilde{h}') +$$
$$\beta \Bigg[(1-\delta) \Bigg((1-\lambda_1) V(\mathbf{s}', \omega, \delta) + \lambda_1 \hat{V}_e(\mathbf{s}', \omega, \delta) \Bigg) +$$
$$\delta \Bigg(\lambda_2 \int \hat{V}_u(\mathbf{s}', \epsilon) dZ_e(\epsilon) + (1-\lambda_2) \hat{U}_e(\mathbf{s}', \omega, \delta)) \Bigg) \Bigg]$$

subject to

$$\begin{aligned} c + ph' + b' - m' =& (1 + R(b))b - (1 + r + r^m)m + ph + \omega(1 - \tau^\omega) \\ & - \tau^l + \Psi(h, h') - \Psi^m - r^p h^r \mathbb{1}[h' = 0] \\ b' \geq & \underline{b} \\ m' =& \Theta p h' \end{aligned}$$

The value function for the employed repaying household, $V^P(\mathbf{s}, \omega, \delta)$, is:

$$V^P(\mathbf{s}, \omega, \delta) = \max_{c, b', h' \in \mathcal{H}} u(c, \tilde{h}') +$$
$$\beta \Bigg[(1-\delta)\bigg((1-\lambda_1) V(\mathbf{s}', \omega, \delta) + \lambda_1 \hat{V}_e(\mathbf{s}', \omega, \delta) \bigg) +$$
$$\delta \bigg(\lambda_2 \int \hat{V}_u(\mathbf{s}', \epsilon) dZ_e(\epsilon) + (1-\lambda_2) \hat{U}_e(\mathbf{s}', \omega, \delta) \bigg) \Bigg]$$

subject to

$$\begin{aligned} c + ph' + b' - m' =& (1 + R(b))b - (1 + r + r^m)m + ph + \omega(1 - \tau^\omega) \\ & - \tau^l + \Psi(h, h') - r^p h^r \mathbb{1}[h' = 0] \\ b' \geq & \underline{b} \\ m' =& \min\{\gamma m, \Theta p h'\} \end{aligned}$$

Employed households that exceed the income requirement can choose whether to repay or remortgage, otherwise they repay their current mortgage:

$$V(\mathbf{s}, \omega, \delta) = \begin{cases} \max\Big\{ V^R(\mathbf{s}, \omega, \delta), V^P(\mathbf{s}, \omega, \delta) \Big\} \; if \; \omega > \tilde{\omega} \\ V^P(\mathbf{s}, \omega, \delta) \; else \end{cases}$$

4.4.3 Unemployed households

Unemployed households cannot remortgage so only have one value function. The value function for the unemployed households is:

$$U(\mathbf{s}', \epsilon) = \max_{c, b', h' \in \mathcal{H}} u(c, \tilde{h}') + \beta \bigg((1 - \lambda_0) \hat{U}_u(\mathbf{s}', \epsilon) + \lambda_0 \hat{V}_u(\mathbf{s}', \epsilon) \bigg)$$

s.t.

$$
\begin{aligned}
c + ph' + b' - m' =& (1 + R(b))b - (1 + r + r^m)m + ph + \\
& \kappa - \tau^l + \Psi(h, h') - r^p h^r \mathbb{1}[h' = 0] \\
b' \geq & \underline{b} \\
m' =& \min\{\gamma m, \Theta p h'\}
\end{aligned}
$$

4.5 Labor market

In the labor market each job is a worker-firm pairing. The worker-firm pairing is characterized by a linear production technology $y = A\mu n$, where A is aggregate productivity, n is the labor input and μ is worker-firm specific productivity. I assume competition in the labor market means that workers are paid their marginal product of labor. This assumption combined with the assumption that households inelastically supply a unit of labor means that $\omega = \mu$ and the firm production function can be written as $y = A\omega$. From this perspective a household that receives a job offer, offering a new wage and job risk, can be thought of as a household meeting a new firm which provides an alternative productivity match.

Denote the probability distribution of the employed as $\Lambda^E(\mathbf{s}, \omega, \delta)$ and the probability distribution of the unemployed as $\Lambda^U(\mathbf{s}, \epsilon)$. The distribution over assets for all households in the economy is $\Lambda(\mathbf{s}) = \iint \Lambda^E(\mathbf{s}, \omega, \delta) d\omega d\delta + \int \Lambda^U(\mathbf{s}, \epsilon) d\epsilon$. Denote the marginal distribution of the employed over job types as $\hat{\Lambda}^E(\omega, \delta) = \int \Lambda^E(\mathbf{s}, \omega, \delta) d\mathbf{s}$. Output for the economy is $Y = A \iint \omega \hat{\Lambda}^E(\omega, \delta) d\omega d\delta$.

4.6 Government

The government funds unemployment insurance, κ, and makes government expenditure, $\mathcal{G}$, which has no productivity or utility value. The government also issues bonds, B, which provide the asset in which households can purchase liquid assets. The government pays interest rate r on bonds issued and receives any interest rate wedge paid by households, via an unmodelled financial sector. To fund expenditure the government collects labor taxes τ^{ω} and lump sum taxes τ^{l}. The government budget constraint satisfies:

$$\mathcal{G} + \kappa \iint \sum_{h \in \mathcal{H}} \Lambda^{U}(\mathbf{s}, \epsilon) d\mathbf{s}\epsilon + rB = \underbrace{\tau^{l} + \tau^{\omega} \iint \omega \hat{\Lambda}^{E}(\omega, \delta) d\omega d\delta}_{\text{taxes}}$$
$$+ \underbrace{\int (R(b) - r)b + (r^{m} - r)m\Lambda(\mathbf{s})d\mathbf{s}}_{\text{interest spread revenue}} + \underbrace{B' - B}_{\text{bond issuance}}$$

When the economy is hit by shocks, the government allows bonds to adjust to satisfy changes in the demand for liquid assets. Government spending adjusts to satisfy the government budget constraint.

4.7 Stationary recursive equilibrium definition

I can now define a stationary recursive equilibrium. An equilibrium is a value function for the employed, $V(\cdot)$, and unemployed, $U(\cdot)$, and policy functions for consumption, $c^{i}(\cdot)$, liquid assets, $b^{i}(\cdot)$, housing $h^{i}(\cdot)$, mortgage choice $m^{i}(\cdot)$ and job choice $J^{i}(\cdot)$ for the employed and unemployed $i \in \{E, U\}$. An interest rate schedule, $R(b)$, mortgage price, r^{m} and house price, p; aggregate housing stock $\hat{H}$; government policies $\{\mathcal{G}, \kappa, \tau^{l}, \tau^{\omega}, B\}$; and probability distributions for the employed $\Lambda^{E}(\mathbf{s}, \omega, \delta)$ and unemployed $\Lambda^{U}(mathbfs, \epsilon)$ such that:

1. The value functions and policy functions solve household's optimum problem set out in section 4.4.

2. The probability distributions $\Lambda^{E}(\mathbf{s}, \omega, \delta)$ and $\Lambda^{U}(\mathbf{s}, \epsilon)$ are stationary distributions induced by the policy functions.

3. Markets clear:

(a) the housing market clears $\int h\Lambda(\mathbf{s})d\mathbf{s} = \bar{H}$

(b) the liquid asset market clears $\int (b - m)\Lambda(\mathbf{s})d\mathbf{s} = B$

(c) the government budget constraint A.1 holds, with $B' = B$

4.8 Calibration

4.8.1 Numerical implementation

The model does not have an analytical solution so quantitative methods are used. The household's problem is non-concave due to the housing and refinancing choices and is solved using the Generalized Endogenous Grid method of Iskhakov et al. (2017).[21] This method offers substantial speed improvement relative to value function iteration, allowing for a richer and more accurate specification. I use 700 grid points for liquid assets, 5 grid points for housing, 5 grid points for mortgages, 5 grid points for wages, 7 grid points for job risk and 2 grid points for job draw quality, ϵ. When solving for the ergodic distribution I simulate the distribution rather than simulating a panel of agents, except when annualized variables are required. For the distribution the grid size over liquid assets is reduced to 140 points. The rest of this section discusses the model calibration.

4.8.2 Externally calibrated parameters

A subset of the model's parameters are chosen following commonly used values in the literature or based on external information. A full list of these parameters is provided in Table 4. The felicity utility function is Cobb-Douglas of the form shown in equation 5. The inverse of the intertemporal elasticity of substitution, α, is set to a standard value of 1.5. The discount factor, β is set to 0.99 reflecting the decision to model a period as one quarter.

[21] I thank Giulio Fella for an implementation of this routine that built upon his previous work Fella (2014)

$$u(c, \tilde{h}') = \frac{(c^{\theta}\tilde{h}'^{1-\theta})^{1-\alpha} - 1}{1-\alpha} \tag{5}$$

The unemployment benefit level, κ, is set to $0.4\underline{\omega}$, where $\underline{\omega}$ is the lowest income realization. A number of the financial parameters are also set externally. The maximum loan to value, Θ is set to 0.8 so that the required down payment is 20 percent of the house value. The spread on borrowing in liquid assets, r^b is set to 0.011, to deliver an annual spread of 6.5 percent as in Kaplan and Violante (2014). Also following Kaplan and Violante (2014), the borrowing limit, $\underline{b}$ is set to $0.74E[\omega]$, where $E[\omega]$ is the expected wage draw. The mortgage income constraint, $\tilde{\omega}$ is set so that the lowest income type cannot remortgage. The mortgage refinancing cost, Ψ^m is set to 0.01, to prevent constant refinancing at the maximum loan to value ratio. The mortgage repayment rate, γ, is set to 0.989 to reflect the standard 30 year mortgage typical in the US. With this repayment rate after 15 years the mortgage value will have halved.

In the housing market, the adjustment cost parameter, Ψ, in the function 4 is set to 0.06 a number widely used in the housing and durables literature [22]. The price of a unit of housing in the stationary equilibrium, p, is set to 1. It is assumed that housing is perfectly elastic in the long run such that the housing stock supply, $\hat{H}$, adjusts to meet demand. In response to shocks the housing supply is assumed to be fixed with the price adjusting to keep the housing market in equilibrium.

4.8.3 Labor market calibration

Job risk distribution: The functional form of the job offer distribution is designed to capture a number of features of the data: i) heterogeneity in the wage and job separation rate, ii) persistence in the job separation rate, iii) a decline in income following job loss. I

[22] For example, see: Jose Luengo-Prado (2006), Iacoviello and Pavan (2013), Bajari et al. (2013), Fella (2014) and Berger and Vavra (2015)

assume that the wage and job risk draws are independent. Define the primitives of the job offer distribution as the iid draws from the distributions for wage $F^1(\omega')$ and job risk $G^2(\delta')$.

The unemployed job quality is a two state distribution, $\epsilon = \{\underline{\epsilon}, \bar{\epsilon}\}$, that affects the wage draw. Unemployed in the high state, $\bar{\epsilon}$, draw the wage from the full distribution, $G^1(\omega'|\epsilon = \bar{\epsilon}) = F^1(\omega')$, unemployed in the low state, $\underline{\epsilon}$, draw the lowest wage with probability one, $G^1(\underline{\omega}'|\epsilon = \underline{\epsilon}) = 1$. The unemployed remain in the high state with probability, ρ^ϵ, while the low state is absorbing. I externally set the persistence of the high state to $\rho^\epsilon = 0.5$. All unemployed draw from the job risk distribution $G^2(\delta')$.

The employed all draw the wage from the distribution $F^1(\omega')$. The job risk distribution is persistent. In particular I assume it has the following functional form:

$$F^2_\delta(\delta') = \rho^\delta \tilde{G}^2(\delta'|\delta' \geq \delta) + (1 - \rho^\delta)\tilde{G}^2(\delta'|\delta' < \delta) \tag{6}$$

where $\tilde{G}$ is a rescaled conditional distribution, such that the probability sums to 1 (e.g. $\tilde{G}^2(x|x \geq \delta) = \int_\delta^x dG^2(x) / \int_\delta^\infty dG^2(x)$).[23]. The employed that suffer a job separation shock flow into the high state with probability ρ^ϵ. Given this set up the pdfs for the job offer distribution are: $g_\epsilon(\omega', \delta') = g^1_\epsilon(\omega')g^2(\delta')$ for the unemployed and $f_{\omega,\delta}(\omega', \delta') = f^1(\omega')f^2_\delta(\delta')$ for the employed, with $f^1(\omega') = dF^1(\omega')$, $f^2_\delta(\delta') = dF^2_\delta(\delta')$, $g^1_\epsilon(\omega') = dG^1_\epsilon(\omega')$ and $g^2(\delta') = dG^2(\delta')$.

Job risk calibration: The primitive wage offer is assumed to be normally distributed with standard deviation, σ^2_ω, $F^1(\omega') \sim \mathcal{N}(0, \sigma^2_\omega)$. The standard deviation is chosen to match the standard deviation of annual log wage changes in the PSID, which is estimated as 0.346.[24] Job risk is approximated by a seven state concavely spaced grid with more points at lower values of δ. The lower bound $\underline{\delta}$ is set to 0.005, to represent very low job risk and implies a

[23]Practically, for low risk risk job this is similar to having a persistence parameter on the current state. However, it avoids generating too strong an incentive for unemployed households to reject higher risk jobs to avoid getting "stuck" in a bad draw.

[24]In the PSID I regress log income on age, education and time effect, and take the standard deviation of the residual. I also exclude unrealistically large increases or decreases in the wage. For the model I simulate a panel of agents and aggregate to an annual basis.

job would be expected to last 50 years. The upper bound $\bar{\delta}$ is set such that the average job separation rate is 0.043, as implied by CPS monthly separation rate of 0.0147. Using the same grid spacing as the model, the empirical distribution of job risk is divided up into the same number of bins as the job risk grid approximation. The discretized draw distributions $G^2(\delta')$ can then be calibrated so that the discretized model distribution $\int \hat{\Lambda}^E(\omega, \delta) d\omega$ matches the empirical distribution. The persistence the parameter ρ^δ is chosen to match the correlation in job risk at a quarterly horizon, measured in the CPS. The resulting distribution over job risk is shown in Figure 5 against the empirical target.

Other labor market parameters: This leaves the job offer arrival rates to calibrate. The job offer arrival rate of the unemployed, λ_0, is set so that the unemployment to employment transition rate is 0.662, based on the monthly CPS transition rate of 0.311. In practice most unemployed accept any job offer received. The job offer arrival rate for the employed, λ_1, is chosen to match the rate of job to job transitions. I target a transition rate of 0.076, based on the monthly transition rate of 0.022 in Fallick and Fleischman (2004). For the employed that separate, the probability of a receiving an in quarter job offer, λ_2, is set to 0.280, based on a Markov transition of monthly CPS transition rates to quarterly rates.[25] The probability of being able to reject a job draw, ρ^y, is set to match the correlation between the wage and job security ($log(1-\delta)$) in the CPS, which is 0.375.[26] This gives an estimate of $\rho^y = 0.95$, implying few forced moves.

4.8.4 Remaining calibrated parameters

The rest of the model parameters are calibrated to hit a set of targeted moments. The values for all the calibrated parameters are shown in Table 5 and the targeted moments are

[25] This is the share of households that start the current and next quarter employed but are unemployed in a month between relative to the share of households that begin employed and become unemployed in any period within the quarter.

[26] This wage refers to the average wage of an industry-occupation-state cell in the CPS, based on the same methodology as the estimation of job risk. However, for obvious reasons, for this measure of job risk the control for income is excluded. The wage measure is average weekly earnings. As such this differs from the measure of Cubas and Silos (2017) who find wage compensation for higher variance of permanent shocks, implying a positive correlation between the wage and risk.

presented in Table 6. The consumption share in the utility function, θ, is chosen to match the aggregate ratio of non-durable consumption to the housing stock in the US for the period 1970-2012.[27] The interest rate on liquid assets is chosen to target the ratio of median liquid assets plus housing equity to median income as measured in the 2016 SCF. This gives an annual interest rate of 0.3 percent, similar to the rate seen since the Great Recession, but significantly lower than the historic average return. As is familiar in the literature, here there is trade off to be made between targeting median or mean asset holdings. For the current analysis it is more relevant to target the former.

The mortgage rate is chosen to target the average loan to value ratio of 0.47, conditional on owning a house. This gives a mortgage spread of 2 percent on an annual basis. The rental price r^p is chosen such that 34 percent of the households choose to rent. The housing choice is approximated by five uniformly spaced grid points. The lower bound for the housing choice, $\underline{h}$, is chosen to match the 10^{th} percentile housing size to median income ratio in the SCF. This is the size of the rental house.[28] The upper bound, $\bar{h}$, is chosen such that 10 percent of households choose this value.

Finally, Government expenditures are set to match the average ratio of government expenditures to GDP, which generates a target of 0.216. Taxes are chosen to ensure the government budget holds in the following way. The income tax, τ^ω is set equal to government expenditures and unemployment insurance: $\tau^\omega \iint \omega \hat{\Lambda}^E(\omega, \delta) d\omega d\delta = \mathcal{G} + \kappa \iint \Lambda^U(\mathbf{s}) d\mathbf{s}$ while the lump sum tax, τ^l, is set equal to interest payments on bonds minus revenue from the interest rate spread on borrowing: $\tau^l = rB - \int (R(b) - r)b + (r^m - r)m\Lambda(\mathbf{s})d\mathbf{s}$.

4.8.5 Moments of the income distribution

To assess the fit of the resulting income process, the income process in the model is compared against the higher order moments presented in Guvenen et al. (2015). The stylized

[27] Residential fixed asset over consumption of non-durable goods and services

[28] I experimented with allowing homeowners to own the same size property as the rental property, but in practice few households choose this housing outcome so it was dispensed with for numerical efficiency.

income process does a fairly good job of replicating some of the key facts from the income literature. Variance is slightly lower as the target moment comes from the PSID, rather than the administrative data which does not feature top-coding. The model generates additional kurtosis versus a normal distribution particularly for 1 year changes. It also broadly captures the pattern in the distribution of annual income changes changes by size, although it generates too many small income changes as there are no transitory shocks. The unemployment shocks generate negative skewness in the income process. This is particularly the case at the five year horizon. This is due to the jobs ladder which allows households to reject negative income shocks, leading to an upward skew in income during a period of employment.

4.9 Asset distribution

Figure 8 presents the baseline economy's asset distribution. Panel a presents the conditional distribution over liquid assets for the employed and unemployed. The economy has a significant dispersion over assets with a mass point at zero as a result of the kink in the interest rate schedule. The distribution is shifted slightly left for the unemployed with these households running down their assets when income is low. Despite this there there is a greater mass of employed households at the interest rate kink. The Gini coefficient for liquid assets is 0.62 in the model versus 0.86 in the data. The Gini coefficient for wealth is 0.50 versus 0.77 in the data. [29] Panel c shows that for households that hold housing wealth the distribution is fairly equal and not as concentrated as in the data. This is partly due to the upper limit set on housing such that 10 percent of the economy choose this house size. The model does generate a reasonably good approximation of the loan to value distribution, particularly given the small number of grid points in this dimension (Panel d).[30]

[29] There are a number of known solutions for addressing this discrepancy such as heterogeneity in discount rates (Krusell et al. (1998)), return on assets Benhabib et al. (2017), or a superstar state of income (e.g Castaneda et al. (2003) or Lütticke (2017)). These would be interesting avenues for an extension, but would fundamentally interact with the wage-job risk trade off so are excluded from the baseline model for clarity of exposition.

[30] In the model the maximum loan to value is capped at 0.8 whereas in the data some household exceed this value, these households are allocated to the 0.8 bin

5 Properties of the steady state equilibrium

This section of the paper studies the key features of the steady state equilibrium. It quantifies the feedback role from assets to job choice in the joint determination of asset and labor market outcomes. It also provides model validation demonstrating: i) the ability of the model to replicate the positive relationship between liquidity and job risk and ii) capture the housing response to an unemployment shocks seen in the data. Finally, it highlights the impact of heterogeneity in job risk on household choices, which the impact on the asset distribution and raises the average MPC.

5.1 Policy functions

5.1.1 Asset choice

The household policy function are presented in Figure 6.[31] Panel a presents the policy choices for housing. Lower job risk households choose a larger housing stock. In particular, holding all else constant, a household facing higher current job risk requires larger current liquid assets holdings to increase its housing stock relative to a low risk household. The unemployed make a lower housing choice than the most high risk household. There is also substantial inaction due to the adjustment costs. Panel b presents the consumption policy function. As lower risk households have higher expected future income they also have a higher level of consumption.[32]

Panel c shows the liquidity of next period's portfolio choice, where liquidity is next period's liquid assets over next period's total wealth (b/w). Liquidity is a concave function of current liquid assets. In general it can be seen that low job risk households adopt more illiquid portfolios, reflecting the housing choice shown in Panel a.[33] Panel d presents the

[31] The policies are presented for a household with 5.6 units of housing, 0.5 liquid assets, 0.47 percent equity and the highest income state.

[32] As can be seen, the low job risk consumption function includes a non-linear section due to kinks in tomorrow's value function due to changes in the discrete choice.

[33] The part of the policy where the lowest job risk household has a higher liquidity portfolio than the higher risk household is due to the low risk household extracting equity during this region, reducing illiquid

liquidity choice as a function of the current housing stock. Liquidity is decreasing in the current housing stock. This is due to adjustment costs, which mean the choice of housing tomorrow will be higher. As in Panel c, the liquidity choice is lower for households with lower job risk. It is more clearly seen in Panel d that there is substantial non-linearity in this relationship, with a smaller reduction in liquidity when moving from a high (0.204) to mid (0.055) level of job risk than when moving from a mid to low job risk (0.005).

5.1.2 Job choice

In addition to making a choice over assets, households also make a choice over new job opportunities. Figure 7 shows the indifference curves for a household deciding whether to stay or switch following a job offer. The red dot indicates the current job pairing (ω, δ), the area above the solid line indicates the alternate job offers (ω', δ') the worker would be willing to move to if drawn.

The figure shows how this choice depends on a household's current assets holdings, where assets are end of period holdings before the job offer arrives. In each panel, the solid black line shows the indifference curve for a low liquid asset household whilst the dotted magenta line shows the indifference curve for a high liquid asset households. Panel a presents the case for the smallest equity holdings - a small housing choice and high LTV. Here there is a clear difference in the job offers that will be accepted for high and low liquid asset households. Low liquid asset households have flatter indifference curves, requiring a smaller wage increase to accept a higher risk job. This is due to the desire to move away from the budget constraint, higher income today is more important than a larger expected income that lower job risk delivers.

Panel b shows the case for a household with larger illiquid asset holdings, high housing stock and a low loan to value ratio. Similar choices are evident. The policy function for the high liquid asset household is almost identical. The low liquid asset household retains the

assets and raising the liquidity of its portfolio.

preference for a higher wage over security, although the effect is attenuated. Overall, current asset holdings influences the household wage-job risk trade off.

Counter intuitively, rather than preferring security, lower liquid assets result in a preference for higher job risk over lower current earnings as income is more valuable now than in the future. The cause of this is the slope of the illiquid household's consumption function. The desire to move away from the borrowing constraint increases the value of a higher wage outweighing the precautionary mechanism of a reduced probability of an unemployment spell. The trade off between wage and job risk can also be understood by looking at the derivatives of the value function. Figure C.4 shows that the low liquid asset household values improvements in both job risk and income more than the high liquid asset household. The value of the derivatives are very non-linear in job risk and large at low levels. However, the marginal rate of substitution shows that high liquid asset households value the trade off between security and wage by more than illiquid households (Panel d).

The importance of the feedback from asset to labor market can be analyzed by assessing the impact on the steady state distribution, when non-household state dependent job policy functions are imposed. Table 8 compares moments of the model to tow cases: i) when the job decision rules are set as if all households were asset rich (Rich), ii) when households accept job offers based on the present value of the job (PV).[34]

Changing the job policy function alters the equilibrium. If all households use the Rich job policy functions, following the trade-offs discussed above households now choose lower job risk resulting in a lower unemployment rate. However, as this also increases job duration the average wage actually increases. With the average employed household in a less risky job, liquid asset demand falls (-3.2 percent) and housing demand rises (+1 percent). The more illiquid allocation raises the share of hand to mouth households, which increase by 15 percent.

The largest change in the equilibrium is observed when households accept offers based

[34]Rich means the highest liquid asset choice, the highest housing choice and lowest loan to value. PV is accept whichever job has a greater value of $\omega/(1-\beta(1-\delta))$.

on the present value of the job opportunity. This would be the outcome in the model with linear utility. This further shows that there is an important feedback from the asset position of households to labor market outcomes via preferences. Again in the baseline model the liquidity motive dominates the precautionary motive. When households choose jobs based on the present value of the income stream, they choose less risky jobs that have a larger long term payoff. This reduces the unemployment rate by 8.6 percent and lowers the standard deviation of annual wages. The result is a poorer economy with lower liquid asset and housing holdings. As a result households hold less liquid assets (-7.5 percent) and the hand to mouth share rises (+5.1 percent), though by less than in the Rich economy case.

5.2 Liquidity regressions

I now show that the model generates a relationship between liquidity demand and job risk consistent with that observed in the data. I do this by estimating equation 3 on model generated data. The results are presented in Table 9.[35] The coefficient on job risk is positive and significant, of a similar magnitude and within the 95 percent confidence intervals of the empirical estimate from the PSID. Column (2) shows that the coefficients on the dummy variables for the lower job risk types are negative as in the data.

Columns (3)-(4) then replicate the regressions of Table 2, where the ratio of liquid assets to total wealth is the dependent variable. Again the coefficient is positive and close to that in the data (0.564 vs 0.450). The coefficients of the low job risk dummies are also negative as in column (2). Finally, columns (5)-(6) regress the liquid asset to housing stock ratio on job risk. The relationship is again positive as in the data.

To get a better understanding of the joint determination of assets and labor market outcomes, Figure 9 presents the distribution and portfolio allocation across job types. Panel a shows the distribution of households across wage, ω and job risk, δ.[36] There is relatively

[35] As in the data the ratio is transformed using the inverse hyperbolic sine transformation. Housing equity is the only illiquid asset in the model. To make the magnitudes comparable, average job risk is scaled to match the level in the PSID

[36] There is a mass of households at the lowest wage as unemployed in the low job quality draw state, $\underline{\epsilon}$,

few households in the lowest job risk type and these households tend to have achieved a higher wage draw. This positive correlation between the wage and job security is both a feature of the data and a generated by the model's jobs ladder. Panel b shows a measure of the average liquidity for each job type, the ratio of liquid assets to total wealth (b/w). In the job risk dimension liquidity is increasing in job risk for all but the lowest income type, who hold low illiquid asset stocks. The liquidity demand is non-linear with only above average risk households holding similarly liquid portfolios. [37]

Finally, I also repeat the regressions of hand to mouth type on job risk. The model reproduces the negative coefficient on job risk for the probability of being a wealthy hand to mouth type also observed in the data albeit the elasticity in the model is lower than in the data (-0.388 vs -0.849).

5.3 Unemployment responses

The new empirical consensus is that job separation shocks lead to large and persistent income losses (see for example: Stevens (1997), Davis and von Wachter (2011), Jarosch (2015), Krolikowski (2017), Huckfeldt (2018)). I evaluate the ability of the model's job ladder to replicate these labor market outcomes and at the same time generate the correct housing responses.

I follow the methodology Stevens (1997) and Huckfeldt (2018), using the PSID. Full details are available in the Appendix, Section A.1. The basic specification is:

$$Y_{i,t} = \mathbf{X_{i,t}}\beta + \sum_{j=-2}^{10} d_{i,t}^{j}\delta^{j} + \alpha_i + \gamma_t + \epsilon_{i,t} \tag{7}$$

where $Y_{i,t}$ is the labor market or housing outcome of interest, d^j is a set of dummy variable for j periods since suffering a job separation shock, $\mathbf{X_{i,t}}$ is a set of controls, including a

initially draw the lowest wage type.

[37] Figure C.5 presents complementary information on the MPCs and, tenure and expected duration of each job type

quartic in age, education dummies and family demographics, and γ_t are year fixed effects. To control for unobservable worker characteristics an individual fixed effect, α_i, is included accounting for any systematic differences in the workers likely to lose their jobs, such as lower wages or smaller housing stocks.[38]

Figure 10 compares the results of the model to the data, the data is shown with 64 percent confidence intervals. Panel a shows the model does a good job of capturing the income loss profile. Panel b presents the unemployment response. This is a dummy variable for being unemployed (broader than experiencing a job separation) during the past year. Again the data and model line up fairly closely, indicating a raised probability of a further spell in unemployment in the years following job loss which the model's jobs ladder captures.

Figure 11 presents the main results from the housing market choices.[39] The first observation is that the housing responses are less precisely estimated in the data than the labor market variables. Panel a shows the response of log housing, capturing the intensive margin. The model does a good job of capturing the average reduction in the housing stock size for those that remain homeowners. The average decline in the data is around 1-4 percent. The model generate a decline of 1-3 percent. The mortgage income constraint is important for this results, in its absence almost all households that remain homeowners remortgage rather than reduce their housing stock. Panel d shows the response of the housing level, capturing both the intensive and extensive margin. While the model captures the prolonged decline in the housing stock it exaggerates the magnitude. In the data the average decline is around \$4,000 whilst in the model it is around \$8,900.[40] For the mortgage, the model successfully replicates the data on both the intensive and extensive margin (See Figure C.7).

Finally, I consider the magnitude of the housing response conditioning on the size of the initial income shock.[41] The results are reported in Figure 12. The model does a good job

[38]The definition of a separation shock differs from unemployment used elsewhere in this paper and only includes company closure, layoffs or firing.

[39]Chetty and Szeidl (2007) undertake a similar empirical analysis, but focus on housing services and the responses of those that remain homeowners or remain renters.

[40]The model predicts too many households moving into renting (see Figure C.6)

[41]I split the sample by those that income response in period 0 was more or less than the average response,

of replicating the difference between those that suffered large or small income shocks. For the value of housing, the model captures the significantly larger fall of large wage shock households.

5.4 Role of job risk heterogeneity

A novel contribution of the model in this paper is the introduction of heterogeneity in job risk. The effect of the job heterogeneity on the asset distribution can by observed by comparing the model to the alternative with a single job risk level, which is referred to as the single δ economy. Table 11 compares the baseline model to a recalibrated model with one job risk type. The average household in the baseline model holds more housing and more liquid assets.[42] This is caused by two mechanisms. Firstly, average wages are lower in the single δ economy as there is a lower probability of a long tenure, reducing the opportunity for a high wage to arrive. Secondly, there is higher demand for liquid assets at above average levels of job risk. I also calculate the Marginal Welfare Value of Insurance (MWG). Following Chetty and Szeidl (2007), this is given by:

$$MWG = \int \frac{\delta}{1-\delta} \left(\frac{\mathbf{E}U_b(\mathbf{s}, \epsilon) - \mathbf{E}V_b(\mathbf{s}, \omega, \delta)}{\mathbf{E}V_b(\mathbf{s}, \omega, \delta)} \right) \Lambda(\mathbf{s}, \omega, \delta) d\mathbf{s} d\omega d\delta$$

Despite the lower precautionary savings motive, the MWG is higher in the heterogeneous job risk economy (+5.5 percent), reflecting i) the larger average income loss experienced upon unemployment and ii) the variation in MWG by job risk in the baseline economy. As shown in Figure 13 the MWG is steeply increasing in job risk due to the large probability of job loss for high risk households.

including interaction dummies for the periods $j = 0, ..., 10$

[42] The models are calibrated to target a median wealth measure.

5.4.1 Impact on MPCs

Despite the greater demand for liquid assets the baseline model also features a larger share of hand to mouth household.[43] In the baseline model 9.7 percent of households are hand to mouth, whilst in the model without job risk heterogeneity this falls to 6.6 percent. As a result the aggregate MPC is also higher in the baseline model. The MPC in the baseline model is 0.096, whilst in the model without job risk heterogeneity it is 0.080. [44]

The impact on MPCs can also be assessed by subjecting the economy to a lump sum tax shock. In the experiment all households receive an increase in the lump sum tax, worth 1 percent of average income. The tax then follows an autoregressive process with persistence 0.5. The present value of the shock is worth 2.4 percent of the average post-tax income.[45]. Figure 14 presents the Impulse Response Functions for the baseline and single δ model. On impact consumption in the baseline model falls by 0.23 percent while it falls by 0.18 percent in the single δ case, representing a 22 percent larger response from the model with heterogeneous job risk (Panel a). Panel a of Figure 15 presents the period one response response by job risk. The largest response is for the lowest risk group, only this set of jobs has a large MPC. After this the response declines and is broadly increasing in job risk.

6 Great Recession experiment

I now subject the economy to the labor market shocks meant to emulate those that occurred during the Great Recession and consider how the initial conditions affect the size of the response. This has two purposes. Firstly, by seeing how different initial equilibria

[43]Following the literature, hand to mouth is defined as a household having either negative liquid assets and being less than two weeks of their current wage from the borrowing constraint or having weakly positive liquid assets and having less than two weeks of their current wage of liquid assets. In the model poor hand to mouth is defined as a household that is renting. Wealthy hand to mouth households are homeowners and have positive illiquid asset holdings.

[44]MPCs in the model are at the lower bound of those estimated empirically (for example 0.12-0.30 on a quarterly basis in Parker et al. (2013) and 0.35-0.70 on an annual basis in Fagereng et al. (2018))

[45]As in the single δ case the economy is poorer, the absolute size of the shock is smaller in the single δ economy

respond to equivalent shocks the importance of the joint determination of labor and asset market outcomes and role job risk heterogeneity in generating state dependent responses can be assessed. Secondly, I examine the extent to which the cross sectional variation in the responses, by wage and and job risk, match the data. This provides information on the importance of the interaction between the pre Great Recession asset allocation and specific labor market shocks for the consumption and asset choices during this period. Matching this cross sectional heterogeneity is strong test of the models key mechanism.

The shocks are estimated from CPS data for four groups stratified by wage and risk: high wage, low risk; low wage, high risk; high wage, low risk; high wage, high risk. Further details on how the shocks were estimated can be found in the Appendix, Section A.2. The stylized fact is that the Great Recession was characterized by larger job separation shocks for the high wage types, with the low wage, low risk type experiencing a much smaller increase in job risk. The two groups that saw the largest wage falls were the low wage, high risk and high wage, low risk. The cross sectional paths of the average job separation rate and income level for each group in shown in Figure 16, alongside the data. The actual shocks and persistence parameters are in Table B.5.[46]

6.1 Aggregate responses

The Great Recession is modeled as a set of one time shocks to the job separation rate and wage level. Once the shocks have realized the households have full knowledge of their deterministic path. The economy returns to the stationary equilibrium after the effect of the shocks dies out. The aggregate housing stock is assumed to be fixed, with equilibrium in the housing market achieved through a change in the house price. Government bonds are allowed to adjust to accommodate any changes in liquid assets or mortgages to satisfy

[46]Due to the model's jobs ladder a substantial part of the fall in income is due to the rise in the separation rate which causes agents to suffer and income loss as they are required to climb the ladder again, rather than the wage falls conditional upon remaining in the same job.

demand.[47]

To assess the importance of the conditions prior to the Great Recession I undertake the following experiment. I first find the response of the baseline calibration referred to as the high average separation rate equilibrium or "*high ave.* δ" . Then to capture the period of low job risk before the Great Recession, holding all other parameters fixed I lower the separation rate and find the "pre Great Recession" stationary equilibrium, this approach is in keeping with secular decline in the separation rate seen in Figure 2.[48] As the average separation rate in the economy is endogenous, I reduce the expected job separation rate draw of an unemployed household ($\int \delta dG^2(\delta)$) by 35 percent, matching the decline in the data of the average separation rate in 2007, relative to the average separation rate between 1976 and the beginning of the 1990s recession.[49] Table B.6 in the Appendix compares the asset distributions in these two steady states, the key feature is that households hold larger housing stocks and less liquid assets in the pre Great Recession economy. Further, the average wage is higher as households have longer to climb the jobs ladder and are willing to trade off some of the lower job risk gains for higher wages.

I undertake two experiments to identify different channels of the response. In the first experiment households expect to remain in the pre Great Recession equilibrium after the shocks die out (labeled *Pre-GR, fixed expectation*) in the second experiment households expect to revert to the high average separation rate equilibrium in the long run (labeled *Pre-GR, change expectation*). Full details of how an "equivalent shock" is defined in these economies is provided in the Appendix, section A.3. Figure 17 presents the aggregate response to

[47]Effectively, I do not impose market clearing in the liquid asset market. Given that the interest rate was at the zero lower bound for most of the duration of the Great Recession, this seems a reasonable assumption.

[48]While the Great Moderation was associated with a decline in aggregate volatility, it is not clear from the data that this translated into a reduction in household uncertainty (see Davis and Kahn (2008)). There is a large body of evidence documenting a rise in the volatility of household earnings since the 1970s, although typically these studies find that it has been more stable since the late 1980s (see: Heathcote et al. (2014), Blundell et al. (2008) and Gottschalk and Moffitt (2009))

[49]Using the Shimer adjusted measure of the job separation rate, the average monthly separation rate between January 1976 and June 1990 was 0.041. The average monthly separation rate in 2007 was 0.027. Our quarterly figures do not correspond to these numbers as given in the baseline model I use the monthly separation rate target (not adjusting for employment-unemployment-employment transfers) of 1.4 percent, giving a lower quarterly separation rate.

the combined labor market shocks. Panel a show that under the high average separation rate equilibrium consumption undergoes a 3.6 percent contraction. On impact there is an increase in liquid assets in response to the increase in risk, but during the course of the recession households run down liquid assets to smooth consumption (Panel b). The model generates a decline in the house price. Equity falls as households remortgage to smooth consumption and because of the decline in the value of the housing stock (Panel d).

When the shocks instead hit the economy in pre-Great Recession conditions the effect is amplified substantially. The red line shows the response in the first experiment in which household expect the long run separation rate to return to the pre-Great Recession equilibria. The decline in consumption is now 40 percent larger, declining by 5.1 percent relative to 3.6 percent in the high average separation rate economy. The household equity response is also amplified. This has both a quantity and price aspect, with households taking out more equity to smooth consumption and with housing demand declining by more leading to a larger fall in the house price and decline in the value of household equity holdings. What accounts for this amplification? A key determinant is the change in the wealth and labor market distribution in the pre Great Recession economy. Households in the pre Great Recession equilbria hold less liquid assets, more housing and a greater share are hand to mouth. They also have slightly higher incomes. Therefore, consumption in more sensitive to income shocks, unemployment results in a bigger average decline in household income and households are more dependent on selling housing to smooth consumption in unemployment placing greater downward pressure on the housing market.

A similar amplification result is observed under the alternative assumption on household expectations in the second experiment. The magenta lines shows the response when households expect the separation rate to return to the higher value following the Great Recession (Pre-GR, change expectation). In this experiment households want to return their liquid asset and housing allocations back to the high average separation rate economy. As a result there is a large increase in liquid assets. The desire to reduce the housing stock results in a

8.4 percent decline in the house price.[50] There is also a large reduction in household equity, falling by 18 percent on impact. As in the first experiment this has both a quantity and price decline element to the fall.[51] The two experiments show that there is significant state dependency in the model, with the pre-conditions mattering a great deal to the aggregate response.

The responses in the full model can also be compared to the results when heterogeneity in job risk is switched off, to assess the role of job risk heterogeneity in amplification. Table 12 presents the first period responses for the two models for both the percentage decline in period one and the amplification relative to the high average separation rate equilibrium. The consumption response is always stronger in the model with heterogeneity. This comes from the higher average wage and more illiquid portfolio relative to the model with a single job risk. Relative to the high average separation rate economy, the response of consumption is around 43 percent stronger in first experiment with fixed expectations in both models. In the second experiment, when expectations change, the amplification is slightly larger in the model with job risk heterogeneity. Job risk heterogeneity generates more amplification in the housing market. The amplification to the decline in household equity is larger under both experiments in the model with job risk heterogeneity. From Table 12 it can be seen that this is due to a stronger response of equity in the single job risk model under the high average separation rate equilibrium.

6.2 Cross sectional responses

The cross sectional behavior by job type in response to the shocks faced can also be studied. This provides a test of the extent to which the joint decisions in the asset and labor market

[50]This is still below the 17.5 percent fall observed in the data between December 2007 and December 2009, measured using the Case Shiller national Index or 35 percent, between March 2006 and February 2012. Kaplan et al. (2017) have stressed the role of a change house price growth expectations in delivering the house price decline seen during the Great Recession

[51]Consumption does not fall by much more than the fixed expectations experiment. This is because in period 0 before the shock, households are already consuming on the basis of the policy functions in the high average separation rate economy. If consumption in period 0 was held at the pre-GR equilibrium level, the decline would be -10.5 percent.

matter, in particular it is an indicator of the importance of the interaction between the pre crisis asset allocation by job type and labor market shocks experienced during the Great Recession. Figure 17 compares the group level model responses to panel data responses from the PSID, details on the data definitions can be found in Section A.2. On the left sided panels, model generated responses are presented while on the right sided panels the data from the PSID is shown. For the groups: red lines indicate low wage and blue lines indicate high wage groups. Solid lines are for low job risk, dashed lines are for high job risk.
Starting with consumption, Panel a shows the model does a good job of predicting the consumption responses of the high wage types that saw a large increase in the job separation rate. For households that remain employed this raises their desire for precautionary savings and for the additional workers that lose their job a large reduction in consumption is required due to the persistent income loss. An aspect of the consumption response that fits less well, is the dynamics of the low wage types, reversing the order of the low wage, low risk and low wage, high risk groups.

Figure 17, Panel b presents the housing choice. The model replicates the order of the responses for all four groups. The high wage, high risk group reduce housing by the most. In comparison, for the low wage, low risk type that experience the smallest increase in job risk, housing has become relatively cheap and thus for this group the decline in housing is effectively just the price decline, while increasing their unit holdings. The high wage groups have the largest housing stock in equilibrium and experience larger job separation rate shocks. Their response is to significantly reduce their housing demand. While the total decline does not match the scale in the data, this is mainly due to the model not generating a large enough house price decline. All else being equal, a larger house price decline would scale up these response while retaining the correct ordering produced by the model.[52]

In the Appendix, Figure 18 Panel a presents the response of liquid assets. The broad pattern is captured. Both the model and data imply a large precautionary increase in liquid

[52]There would be additional effects due to the size of the wealth shocks and degree to which groups varied in the probability of ending up underwater following a larger house price decline

assets for the low wage, low risk type and substantial declines for both high risk groups after the initial shock. In the model relative to the data all groups engage in precautionary savings.[53] Panel b presents the equity choice. Similarly to the consumption response, the model does well on the high wage groups that saw a large increase in the job separation rate, with the high wage, high risk group reducing equity by a larger amount than the high wage, low risk. Although the model over predicts the initial fall in the low wage, high risk group, it captures the faster rebound seen for this group in the latter part of data.

7 Conclusion

This paper has investigated the importance of the joint determination of asset and labor market choices and the role of job risk heterogeneity in the emerging liquid and illiquid asset incomplete markets macroeconomic models. The model is able to replicate the relationship between job risk and portfolio liquidity and the housing responses to unemployment shocks seen in the data. Job risk heterogeneity raises the aggregate MPC and thus the aggregate response to transitory income shocks. However, the increase is fairly small. The main reason for this is that liquidity demand is highly non-linear in job risk and the data only calls for a fairly small fraction of very low risk households.

The importance of the joint determination of assets and labor market outcomes is evidenced by the response to the Great Recession labor market shocks. When the shocks hit the economy in pre-Great Recession conditions, characterized by a low job separation rate, the negative response of consumption is increased by 40 percent. This is due to the asset choices of households in equilibrium, choosing a larger housing stock and more illiquid portfolio and by households sorting into higher wage jobs. The addition of job risk heterogeneity also accounts for a rise in the amplification of the housing market responses.

The model replicates cross sectional features of the Great Recession. When feeding in the distribution of labor market shocks that occurred during the Great Recession, the model

[53] Given the biannual nature of the data the initial precautionary effect could be missing

captures the ordering of housing choices across job types. This provides a strong test of the covariance of the pre recession asset allocations and labor market shocks experienced in the Great Recession and suggests that this in an important margin for understanding the crisis. A remaining puzzle is the relatively weak response of the low wage, low risk group that experienced a small job separation shock but exhibited a strong consumption response in the data.

A limitation of this paper is that households are only able to allocate between job types by waiting for an improved offer to arrive following the stochastic arrival rate. It would be interesting to consider how more active sorting might affect the results, such as by varying search intensity or in a directed search setting. It is anticipated that these features would strengthen the interaction. This is beyond the scope of this paper and left for future research.

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Tables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Job risk (δ)	0.928***		0.875***	0.890***	-0.052	0.907**	0.830***	0.536**
	(0.168)		(0.225)	(0.211)	(0.238)	(0.418)	(0.196)	(0.222)
$\delta :\leq 1^{st} pc.$		-0.147***						
		(0.045)						
$\delta :\leq 5^{th} pc.$		-0.098***						
		(0.025)						
$\delta :\leq 10^{th} pc.$		-0.056**						
		(0.023)						
$\delta :\leq 25^{th} pc.$		-0.013						
		(0.014)						
Income	0.195***	0.200***	0.235***	0.146***	0.200***	0.055***	0.200***	0.210***
	(0.011)	(0.011)	(0.014)	(0.016)	(0.012)	(0.012)	(0.012)	(0.013)
Core			✓					
Risk pref.				✓				
Ind & Occ					✓			
FE						✓		
IV							δ_{t-2}	δ_{t-6}
N	33,932	34,629	23,717	22,212	33,932	34,814	29,342	22,429
R^2	0.046	0.046	0.048	0.090	0.052	0.010	0.050	0.052

Notes: Dependent variable is the transformation of the ratio of liquid assets to illiquid assets. δ Percentiles are dummy variables with $\delta :\leq 1^{st} pc.$ referring to the 1^{st} percentile, $\delta :\leq 5^{th} pc.$ referring to 1^{st} percentile $< \delta \leq 5^{th}$ percentile etc. Core refers to use of only core PSID sample, Risk pref. includes controls for stock market exposure, insurance purchases and total assets. Ind & Occ includes industry and occupation dummy in main specification. FE is panel specification with individual fixed effects. IV uses lagged job risk. *Statistically significant at 10%; **statistically significant at 5%; ***statistically significant at 1%

Table 1: Ratio of liquid assets to illiquid assets

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Job risk (δ)	0.450***		0.543***	0.352**	1.367***	0.162	0.374**	0.718***
	(0.120)		(0.161)	(0.154)	(0.169)	(0.276)	(0.150)	(0.185)
$\delta :\leq 1^{st} pc.$		-0.014						
		(0.032)						
$\delta :\leq 5^{th} pc.$		-0.040**						
		(0.019)						
$\delta :\leq 10^{th} pc.$		0.003						
		(0.015)						
$\delta :\leq 25^{th} pc.$		-0.007						
		(0.009)						
Income	-0.084***	-0.082***	-0.082***	-0.123***	-0.086***	-0.046***	-0.079***	-0.068***
	(0.006)	(0.006)	(0.008)	(0.009)	(0.007)	(0.007)	(0.008)	(0.009)
Core			✓					
Risk pref.				✓				
Ind & Occ					✓			
FE						✓		
IV							δ_{t-2}	δ_{t-6}
N	46,664	47,680	30,439	29,872	46,664	47,885	38,207	27,526
R^2	0.052	0.050	0.043	0.055	0.056	0.048	0.043	0.035

Notes: Dependent variable is the transformation of the ratio of liquid assets to total assets. δ Percentiles are dummy variables with $\delta :\leq 1^{st} pc.$ referring to the 1^{st} percentile, $\delta :\leq 5^{th} pc.$ referring to 1^{st} percentile $< \delta \leq 5^{th}$ percentile etc. Core refers to use of only core PSID sample, Risk pref. includes controls for stock market exposure, insurance purchases and total assets. Ind & Occ includes industry and occupation dummy in main specification. FE is panel specification with individual fixed effects. IV uses lagged job risk. *Statistically significant at 10%; **statistically significant at 5%; ***statistically significant at 1%

Table 2: Ratio of liquid assets to total assets

	PHTM			WHTM		
	(1)	(2)	(3)	(4)	(5)	(6)
Job risk (δ)	0.522***	1.223***	0.659***	-0.849***	-1.263***	-0.995***
	(0.056)	(0.088)	(0.070)	(0.067)	(0.100)	(0.088)
Ind & Occ		✓			✓	
IV			δ_{t-2}			δ_{t-2}
N	51,469	51,469	41,562	51,469	51,469	41,562
R^2	0.233	0.240	0.223	0.019	0.024	0.016

Notes: PHTM: poor hand to mouth. WHTM is wealthy hand to mouth. *Statistically significant at 10%; **statistically significant at 5%; ***statistically significant at 1%

Table 3: Hand to Mouth status

α	β	Θ	γ	$\tilde{\omega}$	r^k (an.)	$\underline{h}$	p	Ψ	Ψ^m	ρ^ϵ
1.5	0.99	0.8	0.989	0.5	0.065	3.7	1.0	0.06	0.01	0.5

Table 4: Externally calibrated parameters

Labor market:							
$\bar{\delta}$	λ_0	λ_1	σ_ω	ρ^δ	ρ^y		
0.204	0.662	0.185	0.245	0.830	0.950		
Other:							
θ	r (an.)	r^m (an.)	r^p (an.)	$\bar{h}$	$\mathcal{G}$	τ^l	τ^ω
0.947	0.002	0.013	0.012	14.2	0.26	0.001	0.24

Table 5: Calibrated parameters

Moment	Parameter	Data	Model
Labor market:			
Average δ	$\bar{\delta}$	0.043	0.042
UE transition rate	λ_0	0.662	0.661
EE transition rate	λ_1	0.076	0.076
$\sigma(\Delta \log(w_{an}))$	σ_ω	0.346	0.346
$Corr(\delta, \delta')$	ρ^δ	0.912	0.916
Other:			
C/H	θ	0.137	0.133
med $b + eq$: med income	r	3.45	3.52
LTV	r^m	0.472	0.465
Share of renters	r^p	0.344	0.345
Share holding $\bar{h}$	$\bar{h}$	0.100	0.111
$\mathcal{G}/Y$	$\mathcal{G}$	0.216	0.225

Table 6: Targeted moments

Moment	Data	Model
Variance: 1yr change	0.26	0.16
Skewness: 1yr change	-1.07	-0.69
Skewness: 5yr change	-1.25	-0.14
Kurtosis: 1yr change	14.93	10.53
Kurtosis: 5yr change	9.51	5.13
Frac. 1yr change $<$ 10%	0.49	0.62
Frac. 1yr change $<$ 20%	0.67	0.68
Frac. 1yr change $<$ 50%	0.83	0.86

Table 7: Earnings process

Moment	Baseline	%Δ Rich	%Δ PV
Unemployment rate	0.044	-3.7	-8.6
E-E transition rate	0.076	+0.8	+2.7
E-U transition rate	0.030	-4.0	-8.7
Av. δ	0.042	-4.0	-8.7
Av. wage	1.206	+0.1	-0.8
$\sigma(\Delta\log(wage))$	0.346	-1.6	-4.3
$\rho(\log(\omega),\log(1-\delta))$	0.369	-1.0	+9.1
b	1.642	-3.2	-7.5
h	5.201	+1.0	-1.7
eq	2.839	+0.2	-4.5
$\rho(b,h)$	0.291	-2.8	5.3
% renters	0.345	-1.1	+4.0
HTM	0.097	+15.0	+5.1

Table 8: Impact of job choice on equilibrium

Notes: Rich is model ergodic distribution using highest liquid asset, housing choice and lowest loan to value job choice policy function. PV is model ergodic distribution when all jobs of a higher present value are accepted.

	b/eq		b/w		b/h	
	(1)	(2)	(3)	(4)	(5)	(6)
Job risk (δ)	1.239***		0.564***		0.749***	
	(0.002)		(0.001)		(0.000)	
$\delta_1(6\%)$:		-0.535***		-0.367***		-0.317***
		(0.001)		(0.000)		(0.000)
$\delta_2(27\%)$:		-0.368***		-0.242***		-0.242***
		(0.000)		(0.000)		(0.000)
$\delta_3(67\%)$:		0.019***		-0.021***		-0.021***
		(0.000)		(0.000)		(0.000)
Income	0.392***	0.555***	-0.535***	-0.421***	0.452***	0.549***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
R^2	0.043	0.175	0.142	0.208	0.142	0.296
PSID	0.928***		0.450***		0.084	
	(0.168)		(0.120)		(0.076)	

Notes: Dependent variable is the transformation of the stated ratio. *Statistically significant at 10%; **statistically significant at 5%; ***statistically significant at 1%

Table 9: Model portfolio regressions

	PHTM	WHTM
Job risk (δ)	-0.131***	-0.388***
	(0.001)	(0.001)
R^2	0.038	0.030
PSID	0.522***	-0.849***
	(0.056)	(0.067)

Notes: *Statistically significant at 10%; **statistically significant at 5%; ***statistically significant at 1%

Table 10: Model Hand to Mouth status

Moment	Baseline	Single δ	
	level	level	%Δ
Av. wage	1.206	1.112	-7.8
c	0.862	0.790	-8.3
b	1.642	1.559	-5.1
h	5.201	4.735	-9.0
$\rho(b, h)$	0.291	0.421	+44.9
PHTM	0.029	0.031	+4.5
WHTM	0.068	0.035	-48.5
HTM	0.097	0.066	-32.5
% PHTM	0.303	0.468	+54.7
MPC (+ ve.)	0.097	0.080	-16.1
MPC (- ve.)	0.085	0.080	-15.1
MPC (an.)	0.228	0.205	-10.1
MWG	0.036	0.034	-5.5

Notes: HTM is hand to mouth share; PHTM is poor hand to mouth; WHTM is wealthy hand to mouth; MPC is marginal propensity to consume. MWG is marginal welfare gain of insurance

Table 11: Role of job risk heterogeneity

		Heterogenous δ			Single δ		
			experiment			experiment	
		Hi $E(\delta)$	1	2	Hi $E(\delta)$	1	2
C	*% decline*	-3.6	-5.1	-5.3	-3.4	-4.9	-5.0
	% amplification		**43.1**	**51.1**		**43.6**	**47.0**
EQ	*% decline*	-5.8	-9.5	-18.1	-8.2	-11.7	-19.7
	% amplification		**63.8**	**213.5**		**42.7**	**139.7**
P	*% decline*	-2.1	-3.9	-8.4	-2.4	-4.6	-8.1
	% amplification		**81.9**	**288.7**		**90.4**	**237.9**

Notes: Heterogenous δ is the baseline model. Single δ is the model with no heterogeneity in job risk. *% decline* is the percentage decline in period one. *% amplification* is the additional decline in the experiment relative to the baseline.
Hi $E(\delta)$ is the baseline calibration with a higher expected separation rate. *Experiment 1* is the shock to the economy in pre-Great Recession conditions with no change in the the long run separation rate. *Experiment 2* is the shock to the economy in pre-Great Recession conditions with an increase in the expectation of the long run separation rate. See section A.3 for full details.

Table 12: Period one Great Recession response

Figures

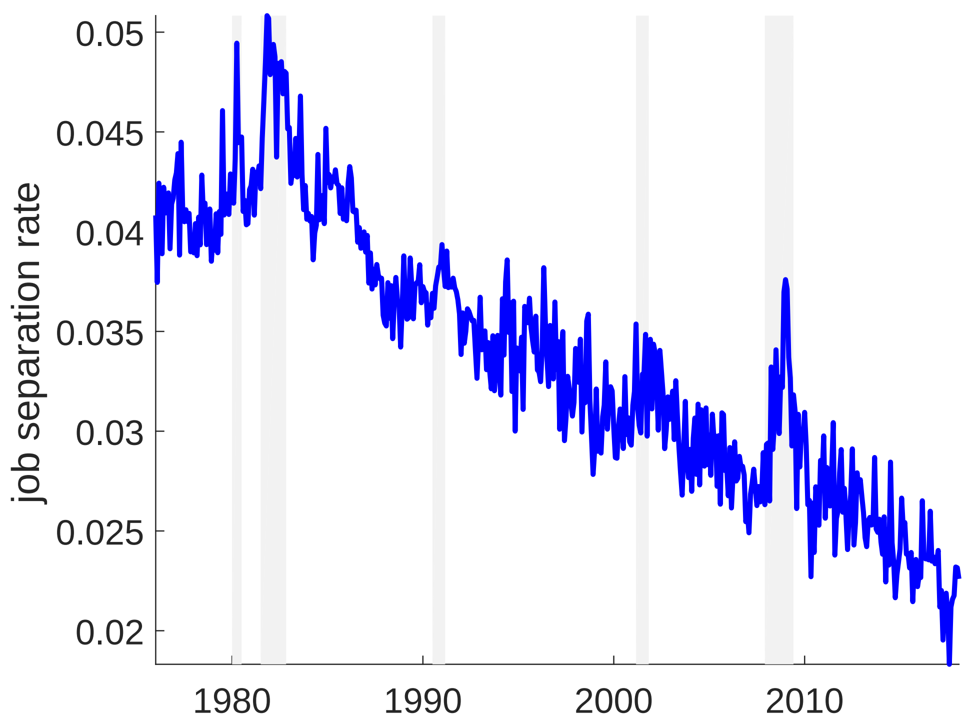
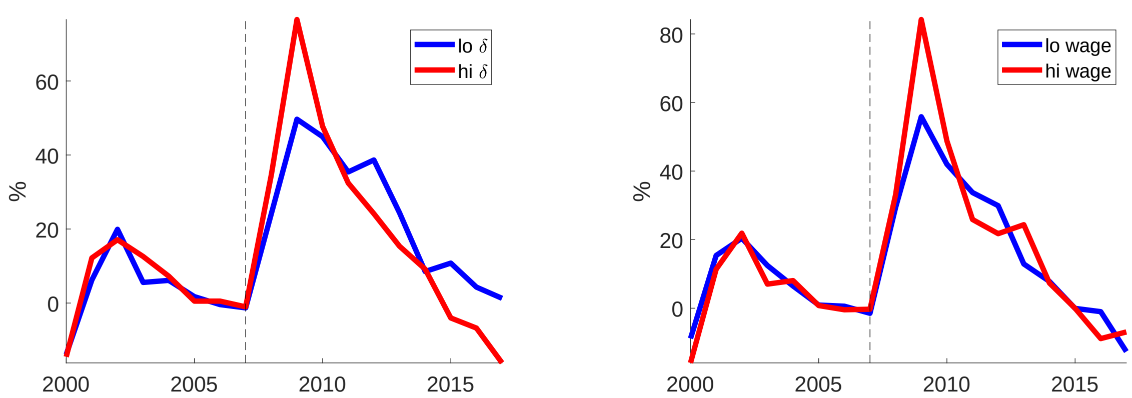


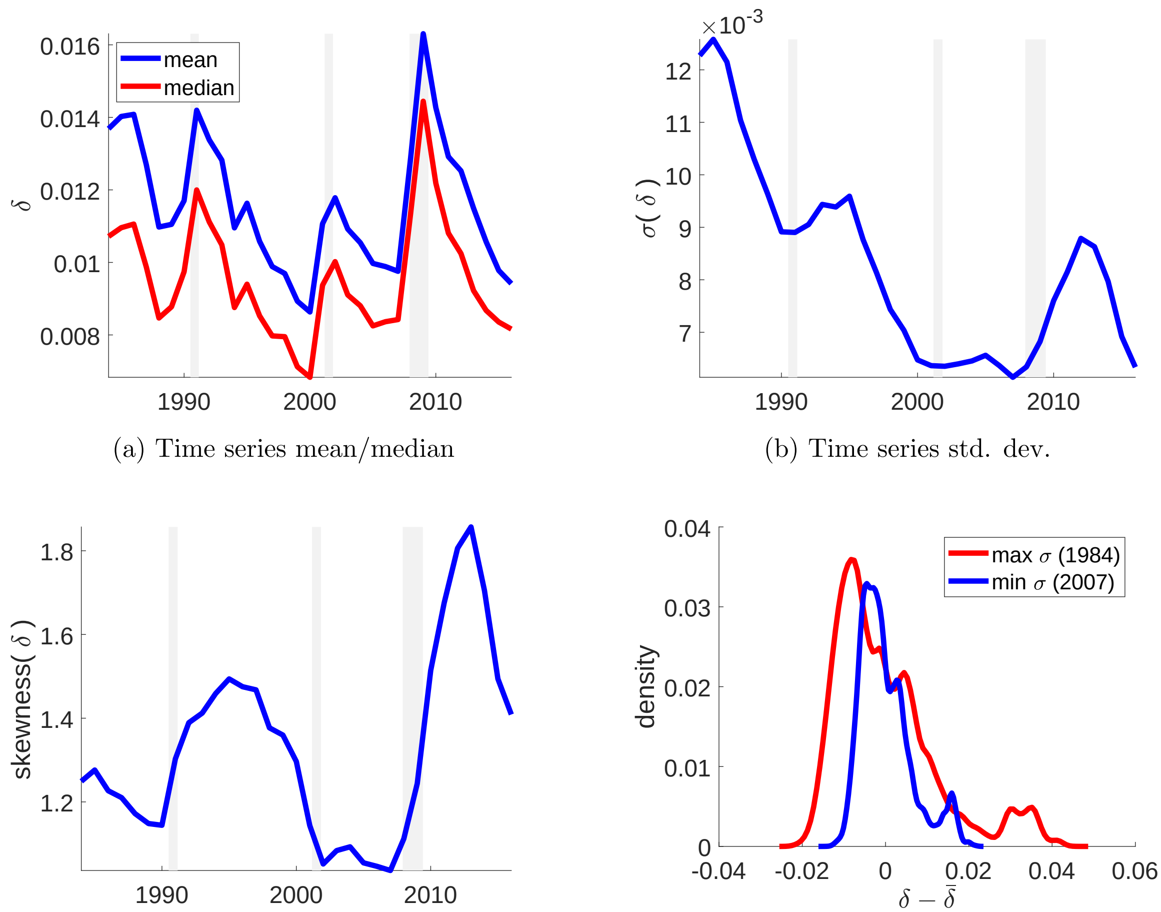
Figure 2: Job separation rate



(a) By job risk

(b) By income

Figure 3: Job separation rate in Great Recession



(a) Time series mean/median

(b) Time series std. dev.

(c) Time series skewness

(d) Max vs min std. dev.

Figure 4: Time series variation in job risk distribution

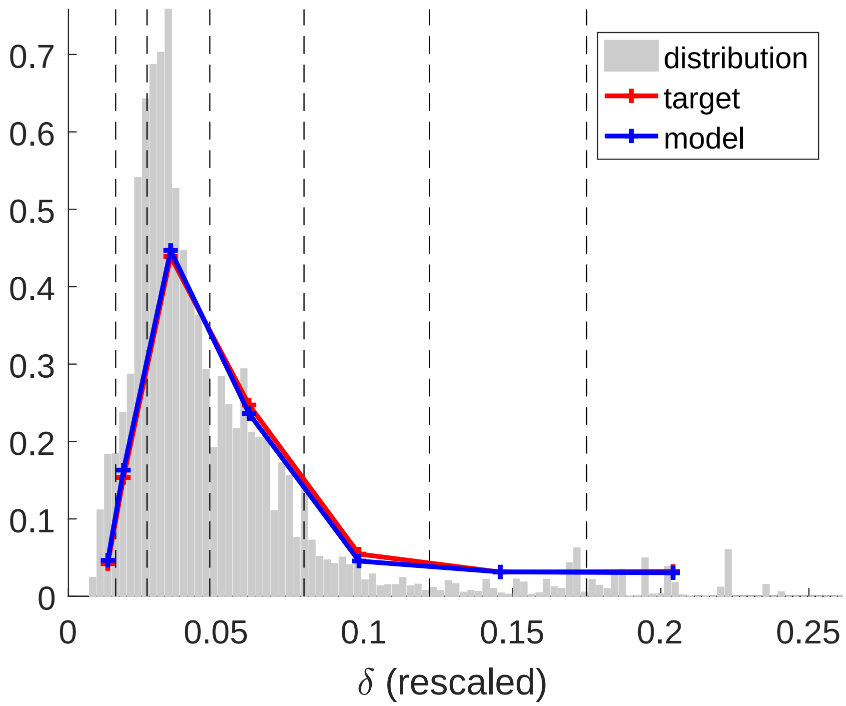
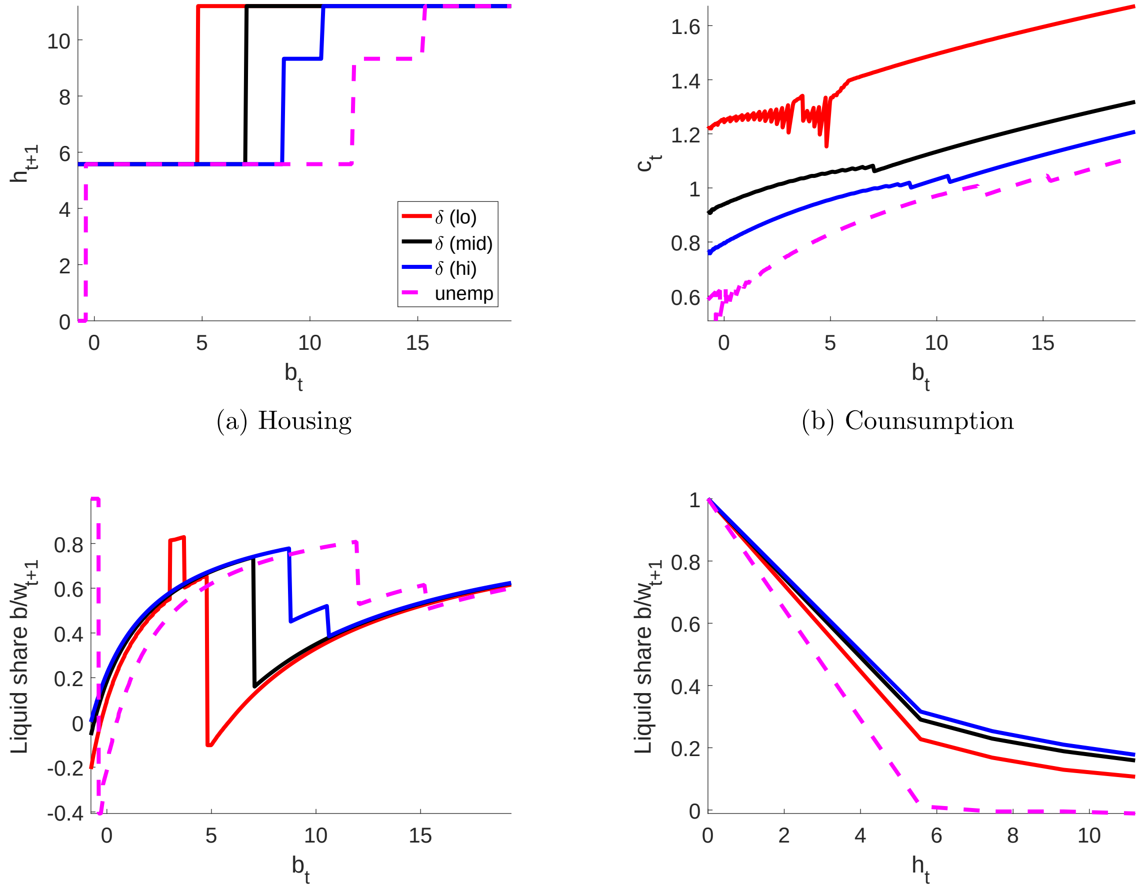


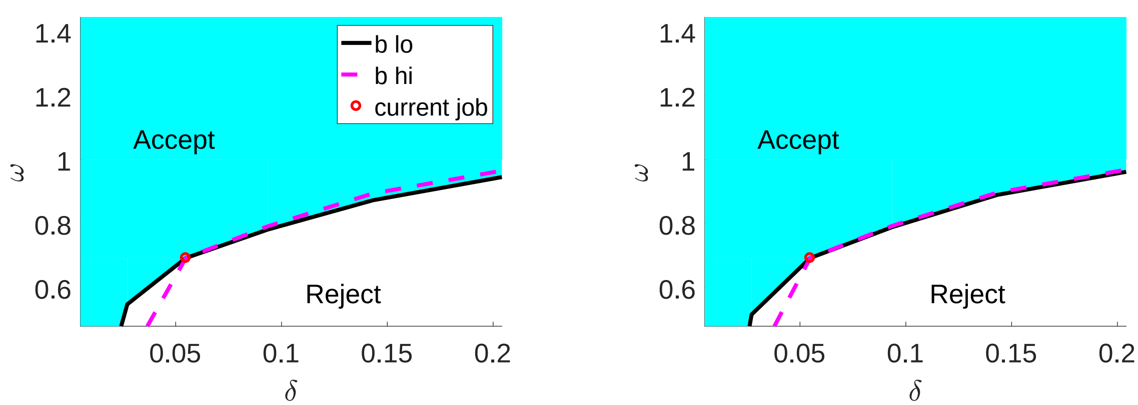
Figure 5: Calibrated job distribution



(a) Housing (b) Counsumption

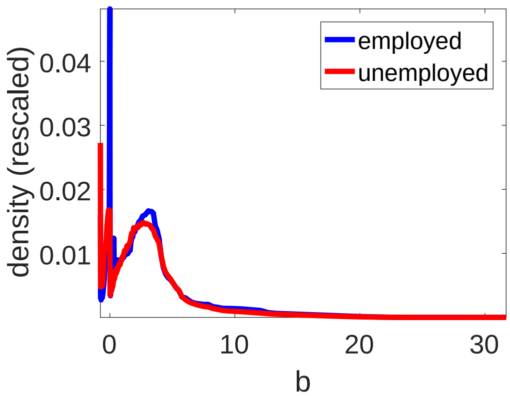
(c) Liquidity — b (d) Liquidity — h

Figure 6: Policy functions

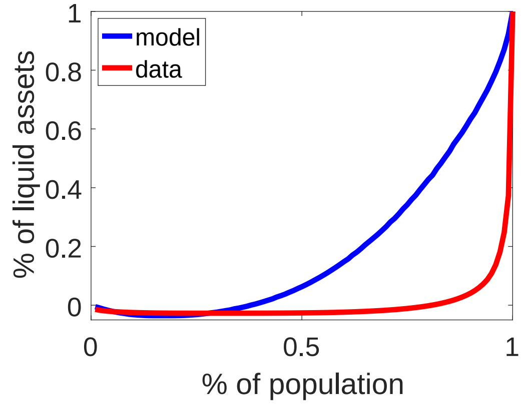


(a) h lo, LTV hi (b) h hi, LTV lo

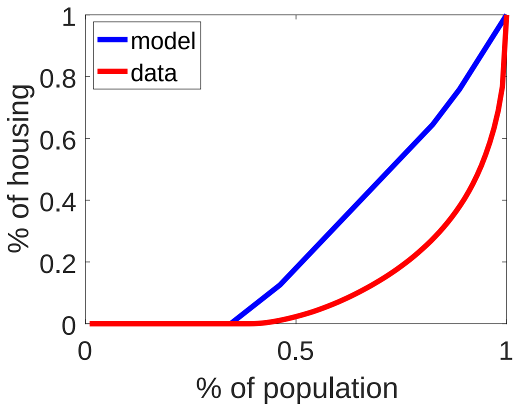
Figure 7: Job offer indifference curve



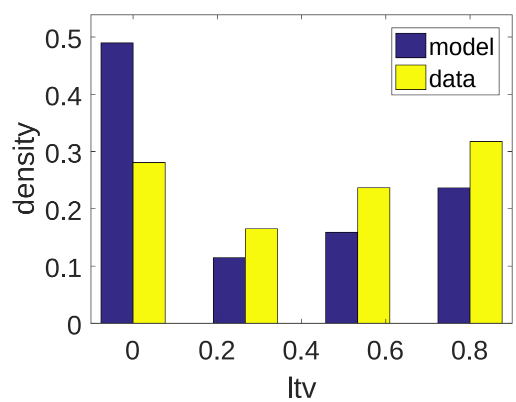
(a) Liquid assets



(b) Liquid asset Lorenz curve

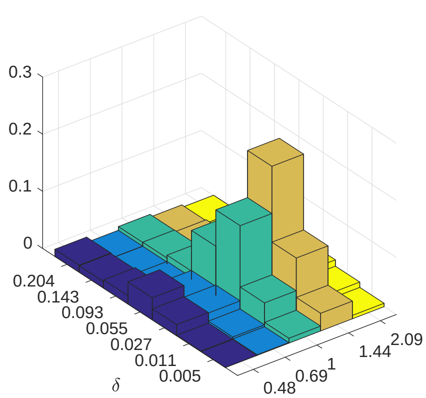


(c) Housing Lorenz curve

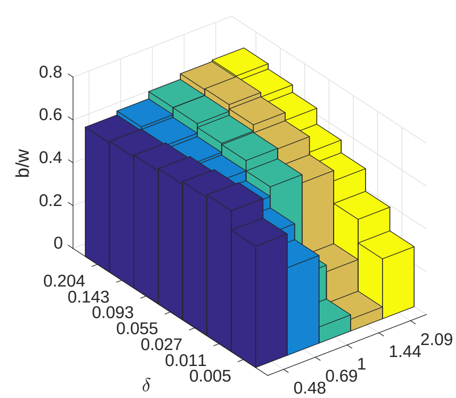


(d) Loan to value

Figure 8: Asset distributions

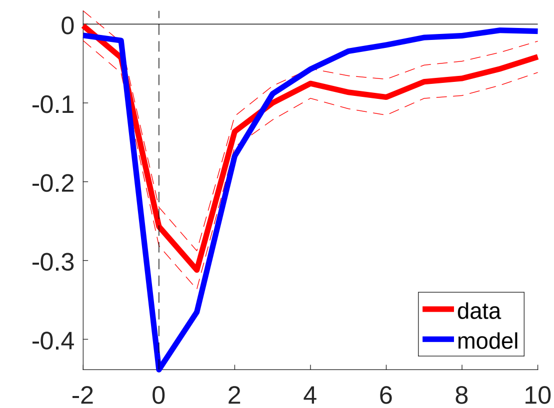


(a) Density

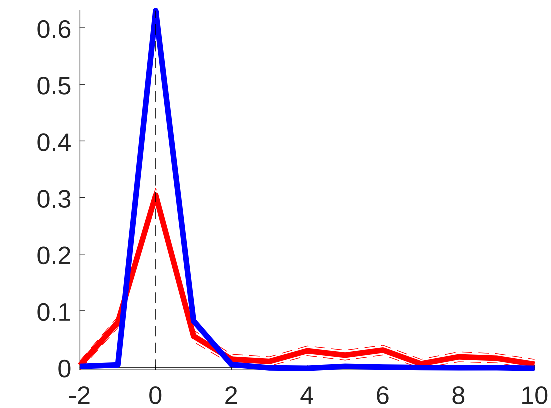


(b) Average b/h

Figure 9: Job distributions

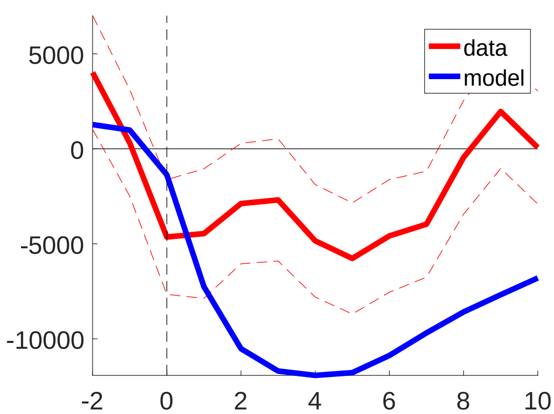


(a) Log. Income

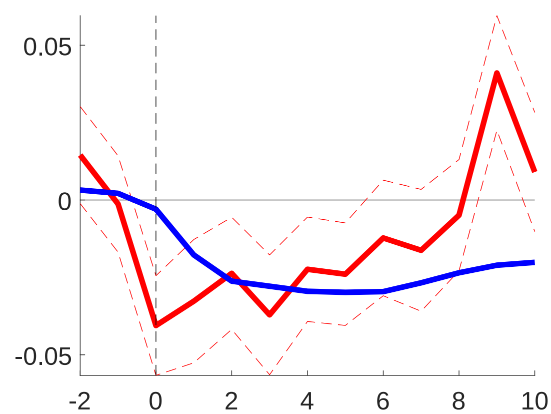


(b) Unemployment

Figure 10: Labor market response to unemployment shock

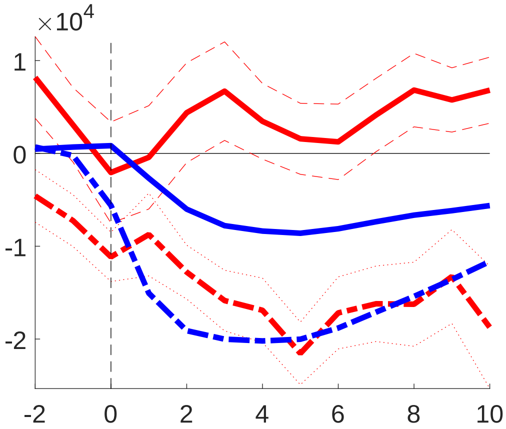


(a) Housing

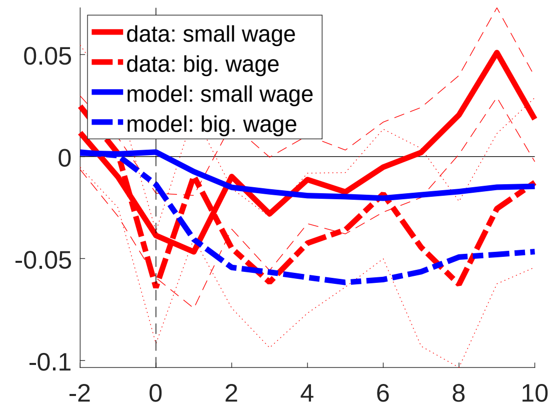


(b) Log. Housing

Figure 11: Housing response to unemployment shock



(a) Housing



(b) Log. Housing

Figure 12: Housing response to unemployment shock, by size of income shock

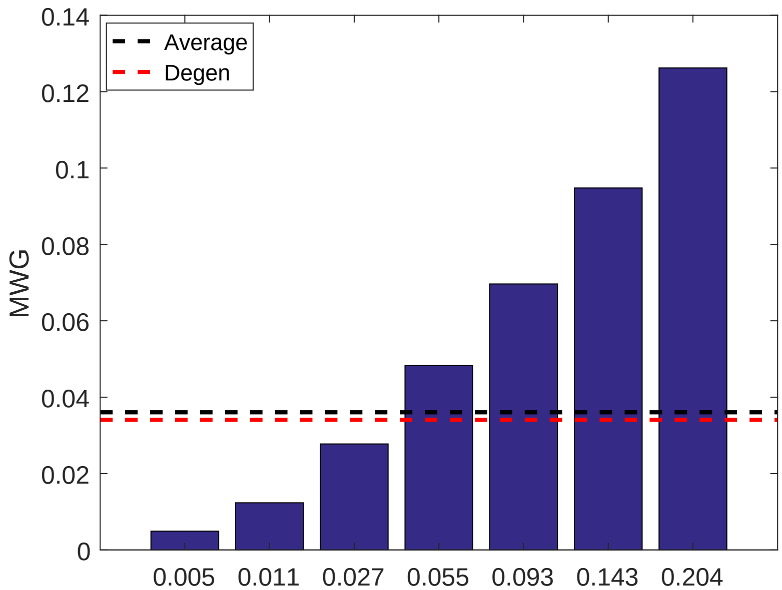
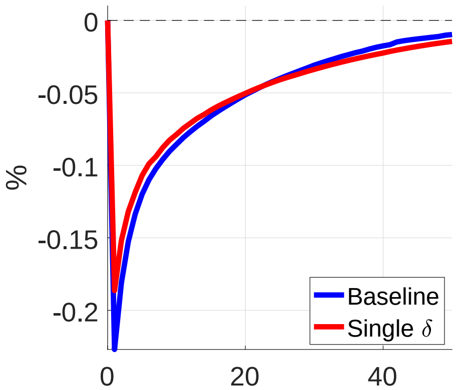
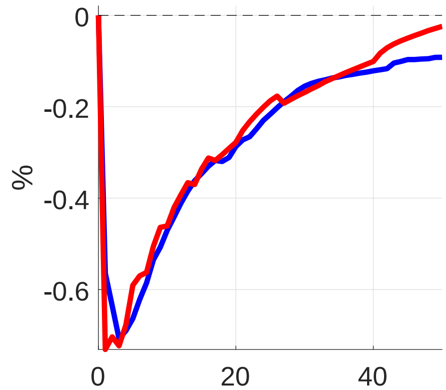


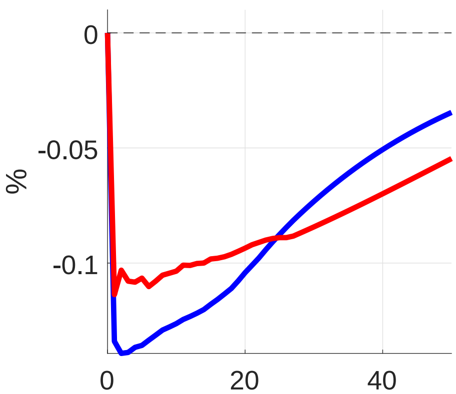
Figure 13: Marginal Welfare Gain from Insurance



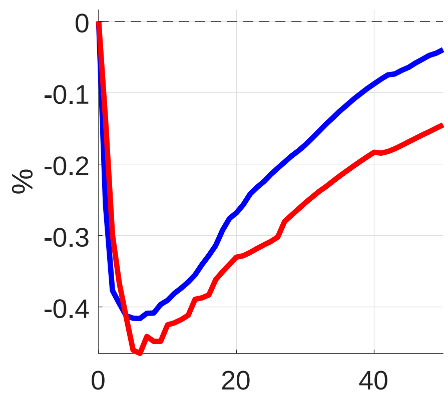
(a) Consumption



(b) Liquid assets

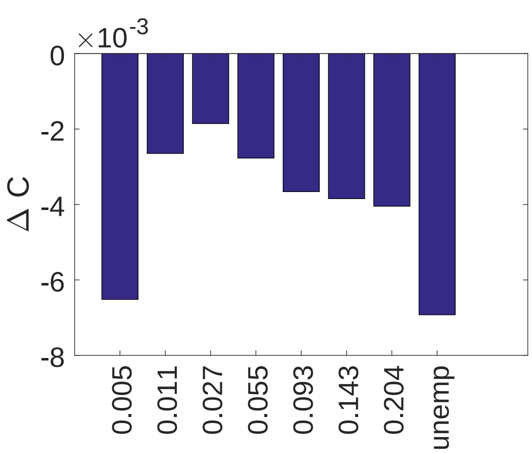


(c) House price

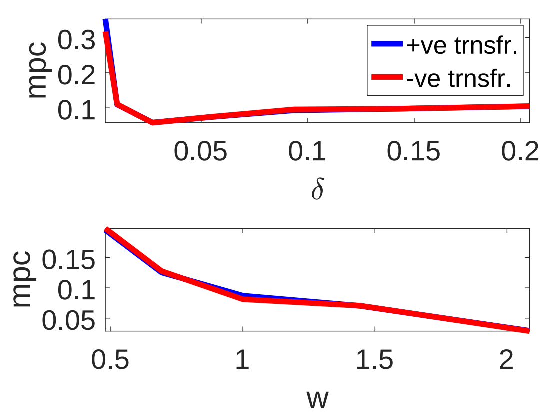


(d) Equity

Figure 14: IRF to lump sum tax shock

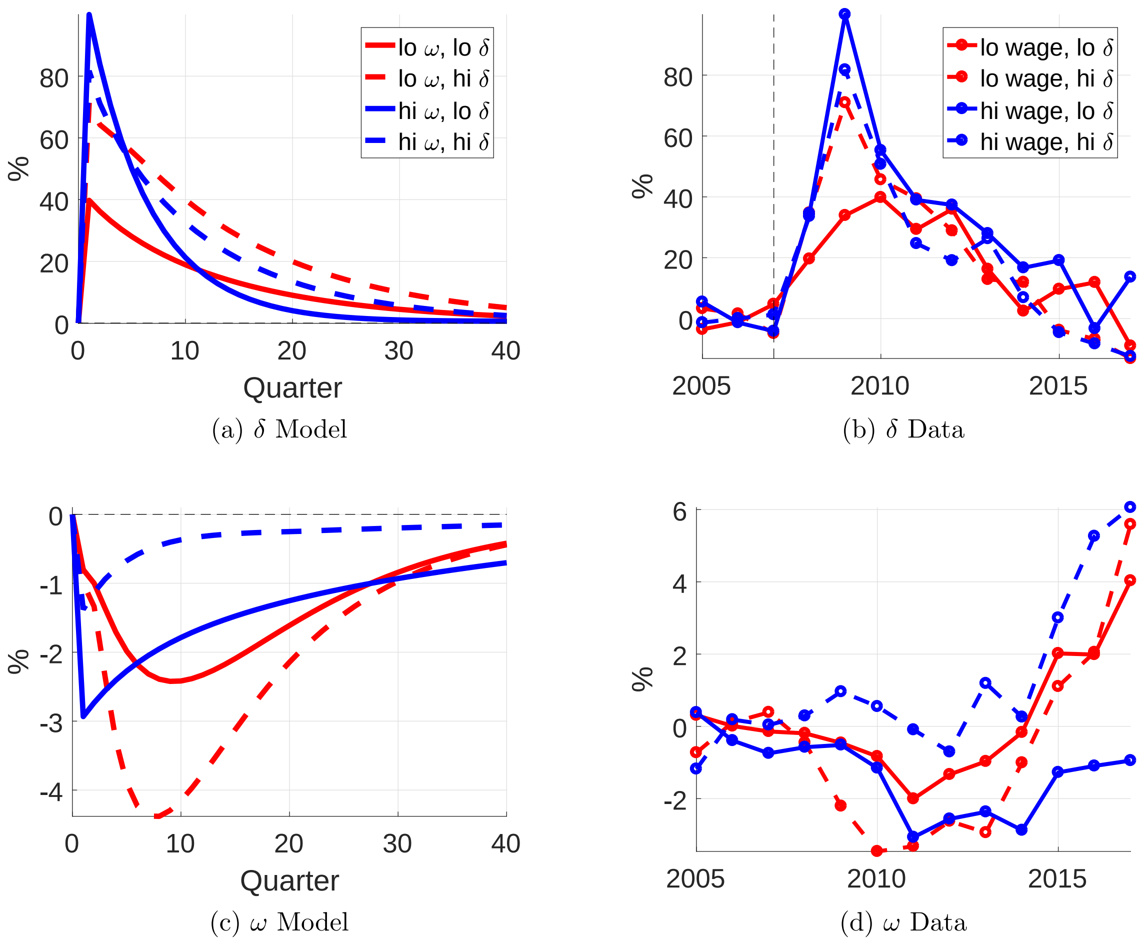


(a) Period one response



(b) MPC

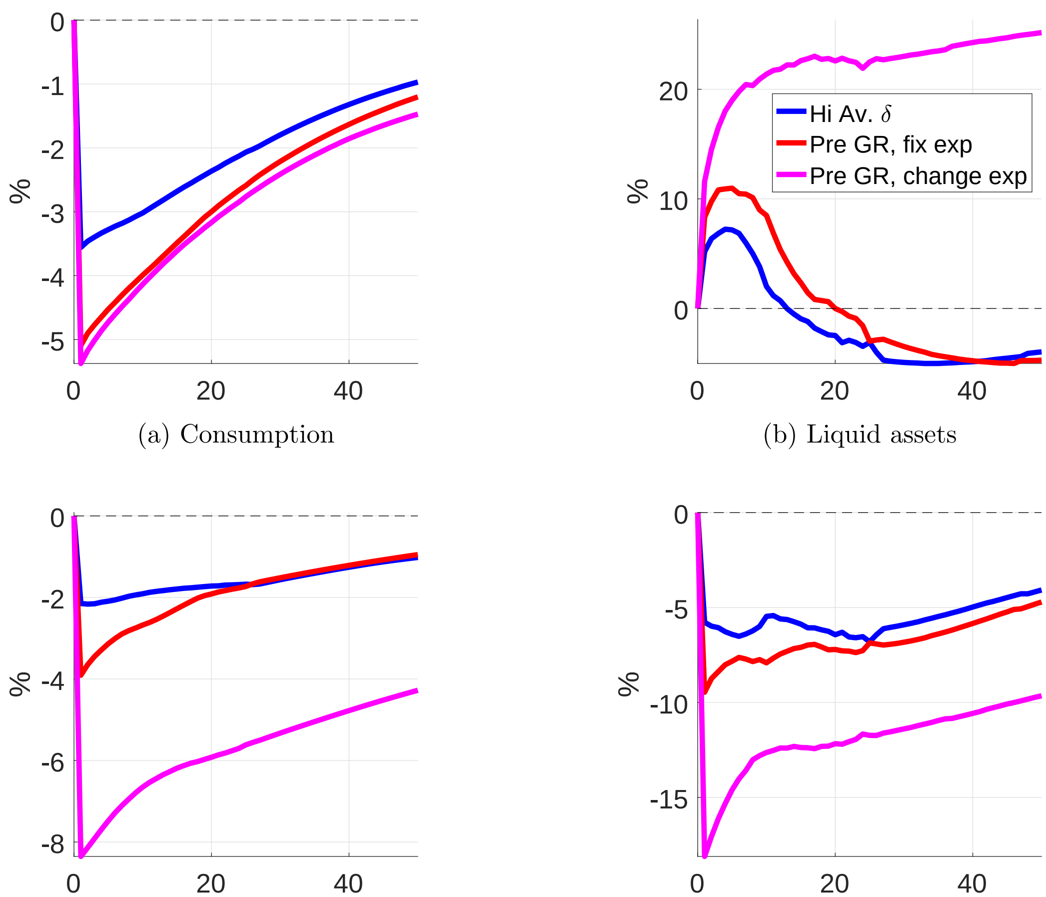
Figure 15: Role of job risk in response



(a) δ Model (b) δ Data

(c) ω Model (d) ω Data

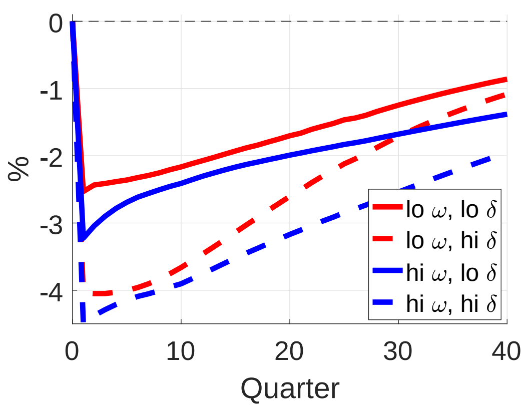
Figure 16: Great Recession shocks



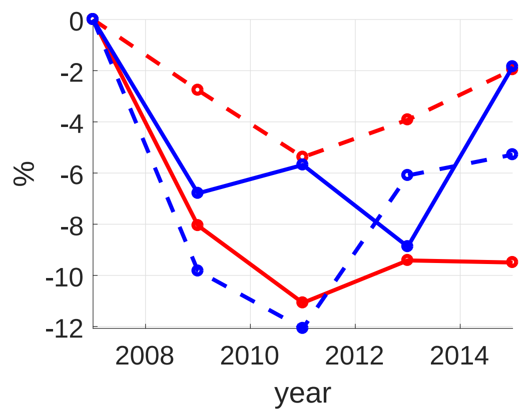
(a) Consumption (b) Liquid assets

(c) House price (d) Equity

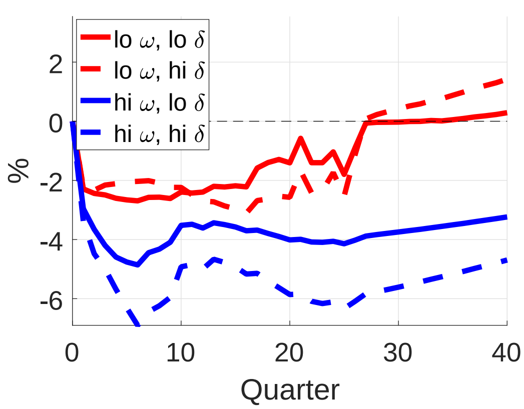
Figure 17: IRF to Great Recession shock



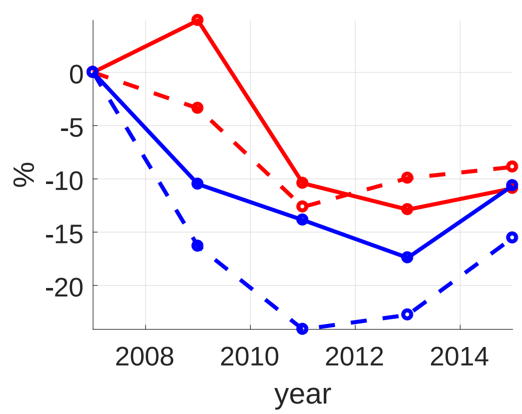
(a) Consumption (model)



(b) Consumption (data)



(c) Housing (model)



(d) Housing (data)

Figure 18: Group responses to Great Recession shock

A Appendix: Additional material

A.1 Unemployment response methodology

To compare the model to the data I make use of the PSID, following Stevens (1997) and Huckfeldt (2018). These papers seek to find the impact of an involuntary job loss on future income. The PSID includes a question asking respondees whether they started their job in the last year. As with the previous literature I define a job loss as a separation due to company closure, layoff or firing. I also include those unemployed that report having lost their last job to have finished due to the same criteria (company closure, layoff or firing) and that report having worked in the last year.

The sample is restricted to the pre-1999, Core sample of the PSID. I focus on head of household aged between 19-64 and drop self employed. Households that report a job loss in the past 10 years in the the first year of the PSID are also dropped, as the year of separation is not determined. As in Huckfeldt (2018) I include households not present throughout the entire study.

To estimate the effect of a job separation dummy are used for the period pre- and post- the separation event. More precisely, if the separation takes place in year t, let d_t^j be a dummy variable is the household experience a job separation j periods ago. Separation dummies are included for $j = -2, ..., 10$.[54]. The empirical specification is then:

$$Y_{i,t} = X_{i,t}\beta + \sum_{j=-2}^{10} d_{i,t}^{j}\delta^{j} + \alpha_i + \gamma_t + \epsilon_{i,t}$$

where, X is a set of controls, including a quartic in age, education dummies and family demographics, and γ_t are year fixed effects. To control for unobservable worker characteristics an individual fixed effect is included, accounting for any systematic differences in the workers likely to lose their jobs such as lower wages or smaller housing stocks.

To estimate the response in the model the same equation is estimated on simulated data.[55] A panel of workers is simulated at the quarterly model frequency and aggregated to annual observations. For housing I use end of period housing stock, following the PSID design. As the minimum period for the unemployed that do not immediately find a job is one quarter,

[54]Pre separation dummies are important to include as the methodology does not allow precise identification of the timing of separation

[55]The are no age, demographic or time controls in the model estimating equation as these features are absent from the model

before aggregating to annual observations I set income during the quarter unemployed to be 50 percent of the wage next period. For households not employed in the following quarter this is zero. To compare absolute values to the data the housing, equity and mortgages are rescaled so that the ratio of mean labor income in the PSID to mean labor income in the model. In the model a job separation is any household that was employed at the beginning of period $t-1$, but was separated (with probability δ) during the period. This includes households that immediately find employment in period and start period t employed.

A.2 Great Recession shocks and data

The Great Recession shocks are estimated from the CPS. As in equation 1, a Probit regression is run to estimate the job separation risk of an industry-occupation-state cell. In this case I do not control for income as the groups and stratified by weekly earnings. A second regression is run to find the predicted log. average weekly earnings of each industry-occupation-cell. For this exercise I use data for 2000-2007 to capture the pre-Great Recession distribution.

The job cells are separated into low wage and high wage groups, with low wage job cells being those with a predicted wage below the median predicted wage. Within the wage groups the jobs are further separated by low risk and high risk with low risk being jobs with a job separation rate below the median job separation rate conditional on being in the given wage group. Therefore, each group accounts for 25 percent of the sample.

Having assigned an ordering of jobs I follow the outcome of these jobs during the recession period. I look at the average monthly job loss rate of individuals assigned to a given group and calculate the effect of the recession relative to a baseline of the average job loss rate for the group between 2005 and 2007. To reduce measurement error and noise I calculate the effect at an annual frequency.

For the wage I look at the average log weekly earnings of each sub-group. I estimate the effect of the recession as the deviation from a group specific linear trend between 2000 and 2008. In the CPS the decline in wages occurs some time after the NBER recession date.

For the consumption and asset data I use the PSID. I use the job risk and wage estimates from the CPS, but recalculate the groups based on the distribution of jobs in the PSID, using the the years 2001-2007. Whereas for the shocks in the CPS cross sectional estimates are used, in the PSID I make use of the panel structure. I assign households to a group based upon the job they held in 2007 and follow the average for those households over the course of the recession. Responses are taken relative to the average group value in 2007.

The assets are as described in the paper. For consumption food, utilities, transport, education, childcare, repairs, furniture, clothing, trips and entertainment is included. This definition of consumption is available since 2005.

To calculate the shocks in the model I match the cross sectional increase in job risk and maximimum decline in earnings to the data for each group. I also match the persistence of the shocks. The shocks are shown in Table B.5. It is necessary computationally to do this in an auxiliary model that does not feature asset choices. For the low income groups in the model, a significant fraction of the wage decline is accounted for by a change in the composition of the groups with the increase in recently unemployed households starting at the bottom of the jobs ladder reducing the average wage of this group.

For the consumption and asset response I replicate the data by following a panel of workers allocated to a group in the steady state. I calculate the response as deviations from the path of asset and consumption choices in the absence of a shock.

A.3 Great Recession experiment details

The definition of what constitutes "equivalent Great Recession shocks" is not entirely straightforward in the two stationary equilibrium, so I undertake two exercises that capture different assumptions about the household's expectations.

Experiment 1: Firstly, I feed the shocks into the pre-Great Recession equilibrium. However, because the unemployment rate is lower in this economy if exactly the same shock were fed, in the size of the income decline would be smaller in the pre Great Recession economy. Therefore, in *experiment 1* I rescale the size of the job separation shocks to achieve the same percentage aggregate income decline. These responses are labeled "Pre-GR, fixed expectation". The shocks to the job seperation rate are essentially scaled by the decline in the job seperation rate. This makes the percentage point increase in the unemployment rate the same in both cases. In this experiment households expect to return to the lower pre-Great Recession separation rate once the shocks has died out.

Experiment 2: Secondly, I take the distribution of agents from the pre-Great Recession equilibrium feed in exactly the high average separation rate economy shocks and use the policy functions from the high average separation rate economy. One way to think about this experiment is that households wake up understanding job risk has risen permanently and are then additionally hit by a further temporary shock. However, in fact in period 0 the high average separation rate policy functions are used, so a more accurate way of thinking about this is experiment is that it replicates the additional effect of the out of equilibrium asset choices. In this experiment it is also necessary to rescale. In particular, I rescale the share of employed and unemployed to match the high average separation rate equilibrium, but leave the pre-Great Recession distribution over job types - in (ω, δ) space. I rescale the unemployment rate so that in the absense of the Great Recession shocks there would not be a large increase in the unemployment rate, although there is some adjustment as households return to the high average separation rate (ω, δ) distribution. These responses are labeled "Pre-GR, change expectation". As the aggregate housing demand is lower in the high average separation rate equilibria than the pre-Great Recession equilibria in this experiment I allow the housing stock to linearly decline over the transition period (250 periods). In this experiment households expect to return to the higher job separation rate once the shocks have died out.

B Appendix: Additional tables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Job risk (δ)	3.904***		5.154***	5.911***	-0.075	0.565	3.736***	3.339**
	(0.966)		(1.163)	(1.225)	(3.250)	(1.687)	(1.296)	(1.545)
$\delta :\leq 1^{st} pc.$		-0.058						
		(0.042)						
$\delta :\leq 5^{th} pc.$		-0.040*						
		(0.024)						
$\delta :\leq 10^{th} pc.$		-0.125***						
		(0.024)						
$\delta :\leq 25^{th} pc.$		-0.026*						
		(0.014)						
Income	0.207***	0.207***	0.247***	0.159***	0.201***	0.056***	0.215***	0.213***
	(0.011)	(0.011)	(0.014)	(0.016)	(0.012)	(0.012)	(0.012)	(0.013)
Core			✓					
Risk pref.				✓				
Ind & Occ					✓			
FE						✓		
IV							δ_{t-2}	δ_{t-6}
N	33,953	34,629	23,742	22,234	33,953	34,834	28,726	22,005
R^2	0.046	0.046	0.0485	0.090	0.052	0.012	0.049	0.051

Notes: Dependent variable is the transformation of the ratio of liquid assets to illiquid assets. δ Percentiles are dummy variables with $\delta :\leq 1^{st} pc.$ referring to the 1^{st} percentile, $\delta :\leq 5^{th} pc.$ referring to 1^{st} percentile $< \delta \leq 5^{th}$ percentile etc. Core refers to use of only core PSID sample, Risk pref. includes controls for stock market exposure, insurance purchases and total assets. Ind & Occ includes industry and occupation dummy in main specification. FE is panel specification with individual fixed effects. IV uses lagged job risk. *Statistically significant at 10%; **statistically significant at 5%; ***statistically significant at 1%

Table B.1: Ratio of liquid assets to illiquid assets, CPS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Job risk (δ)	-1.396**		-1.385**	-1.554**	10.593***	0.261	-1.980**	-0.876***
	(0.670)		(0.786)	(0.883)	(2.220)	(1.417)	(0.968)	(1.284)
$\delta :\leq 1^{st}pc.$		-0.067**						
		(0.038)						
$\delta :\leq 5^{th}pc.$		-0.018						
		(0.017)						
$\delta :\leq 10^{th}pc.$		0.023						
		(0.015)						
$\delta :\leq 25^{th}pc.$		0.006						
		(0.010)						
Income	-0.082***	-0.082***	-0.080***	-0.122***	-0.082***	-0.046***	-0.074***	-0.057***
	(0.006)	(0.006)	(0.008)	(0.009)	(0.007)	(0.007)	(0.008)	(0.009)
Core			✓					
Risk pref.				✓				
Ind & Occ					✓			
FE						✓		
IV							δ_{t-2}	δ_{t-6}
N	46,699	47,680	30,477	29,904	46,669	47,919	37,050	26,859
R^2	0.052	0.050	0.043	0.055	0.055	0.048	0.041	0.034

Notes: Dependent variable is the transformation of the ratio of liquid assets to total assets. δ Percentiles are dummy variables with $\delta :\leq 1^{st}pc.$ referring to the 1^{st} percentile, $\delta :\leq 5^{th}pc.$ referring to 1^{st} percentile $< \delta \leq 5^{th}$ percentile etc. Core refers to use of only core PSID sample, Risk pref. includes controls for stock market exposure, insurance purchases and total assets. Ind & Occ includes industry and occupation dummy in main specification. FE is panel specification with individual fixed effects. IV uses lagged job risk. *Statistically significant at 10%; **statistically significant at 5%; ***statistically significant at 1%

Table B.2: Ratio of liquid assets to total assets, CPS

	PHTM			WHTM		
	(1)	(2)	(3)	(4)	(5)	(6)
Job risk (δ)	0.541***	1.118***	0.580***	-0.765***	-1.101***	-0.773***
	(0.073)	(0.120)	(0.091)	(0.092)	(0.146)	(0.121)
Ind & Occ		✓			✓	
IV			δ_{t-2}			δ_{t-2}
N	31,794	31,794	26,472	31,794	31,794	26,472
R^2	0.185	0.190	0.169	0.017	0.022	0.018

Notes: *Statistically significant at 10%; **statistically significant at 5%; ***statistically significant at 1%

Table B.3: Hand to Mouth status, Core

	PHTM			WHTM		
	(1)	(2)	(3)	(4)	(5)	(6)
Job risk (δ)	1.034***	10.289***	1.148***	-1.333***	-10.945***	-2.031***
	(0.365)	(1.139)	(0.541)	(0.410)	(1.285)	(0.654)
Ind & Occ		✓			✓	
IV			δ_{t-2}			δ_{t-2}
N	51,508	51,508	40,058	51,508	51,508	40,058
R^2	0.232	0.238	0.210	0.016	0.023	0.014

Notes: *Statistically significant at 10%; **statistically significant at 5%; ***statistically significant at 1%

Table B.4: Hand to Mouth status, CPS

Moment	lo ω, lo δ	lo ω, hi δ	hi ω, lo δ	hi ω, hi δ
Job risk (δ)				
shock %	0.3165	0.7164	1.2092	0.7689
persistence	0.9226	0.9357	0.7994	0.9189
Wage (ω)				
shock %	-0.0050	-0.0105	-0.0382	-0.0065
persistence	0.8972	0.8290	0.9720	0.7184

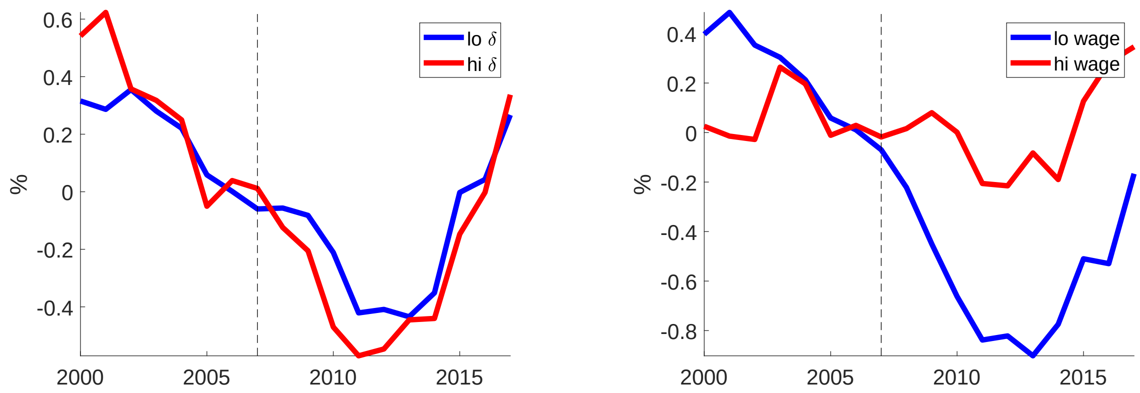
Table B.5: Great Recession shocks

	Base	Pre GR		Single δ
Moment			$\Delta\%$	$\Delta\%$
E-U transition rate	0.030	0.020	-34.8	-34.8
Av. δ	0.042	0.027	-99.3	-34.8
$E(\delta\|U)$	0.096	0.060	-37.2	-34.8
Av. wage	1.206	1.264	+4.8	+5.6
$\sigma(\delta)$	0.040	0.024	-41.3	n/a
c	0.862	0.973	+6.0	+6.9
b	1.642	1.322	-19.5	-20.4
h	5.201	5.87	+13.2	12.9
eq	2.839	3.098	+9.1	+13.0
LTV	0.465	0.487	+4.8	+0.3
% renters	0.345	0.275	-20.3	-21.1
HTM	0.097	0.153	+57.3	+20.3
MPC (+ve)	0.096	0.12	+20.8	+11.7

Pre GR is the pre-Great Recession equilibria implemented by reducing the separation rate. The single δ column shows the equivalent change for the economy with no heterogeneity in job risk.

Table B.6: Comparison of Baseline and Pre-Great Recession Equilibria

C Appendix: Additional figures



(a) By job risk

(b) By income

Figure C.1: Weekly earnings in Great Recession

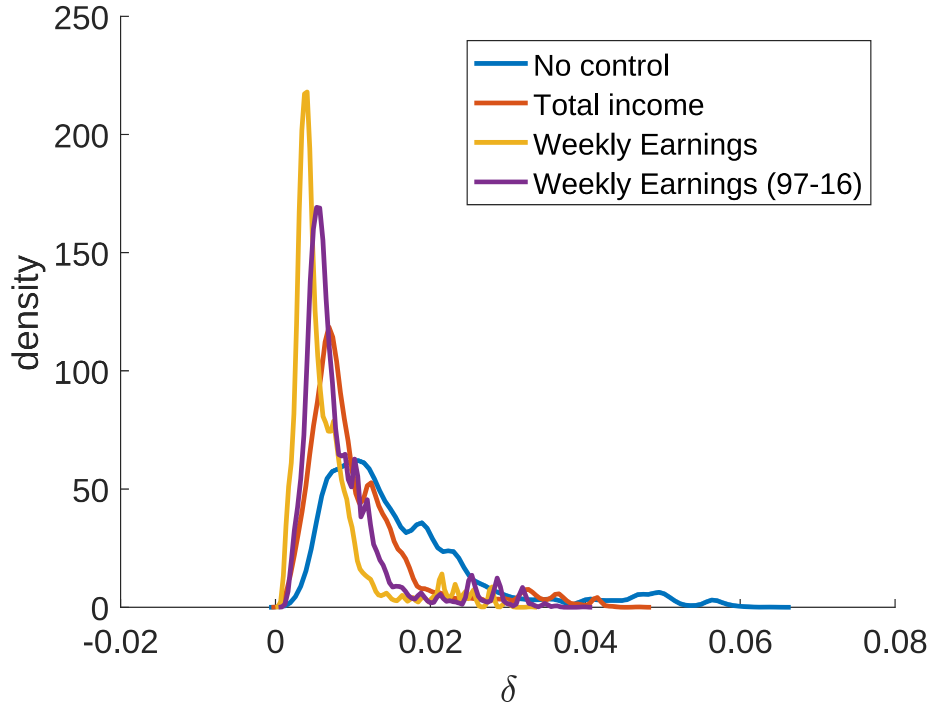


Figure C.2: Job risk distribution with alternative income controls

The alternative specification are no income control; lagged total income; and weekly earnings over the more recent time period, 1997-2016. Lagged total income is total pre-tax total income. This variable is available annually in the Annual Social and Economic Supplement (ASEC) of the CPS and refers to income accured over the past year, with each individual featuring in two ASEC surveys. To avoid the income measure being affected by periods of unemployment, only monthly observations that occur in the same month or after the ASEC are included.

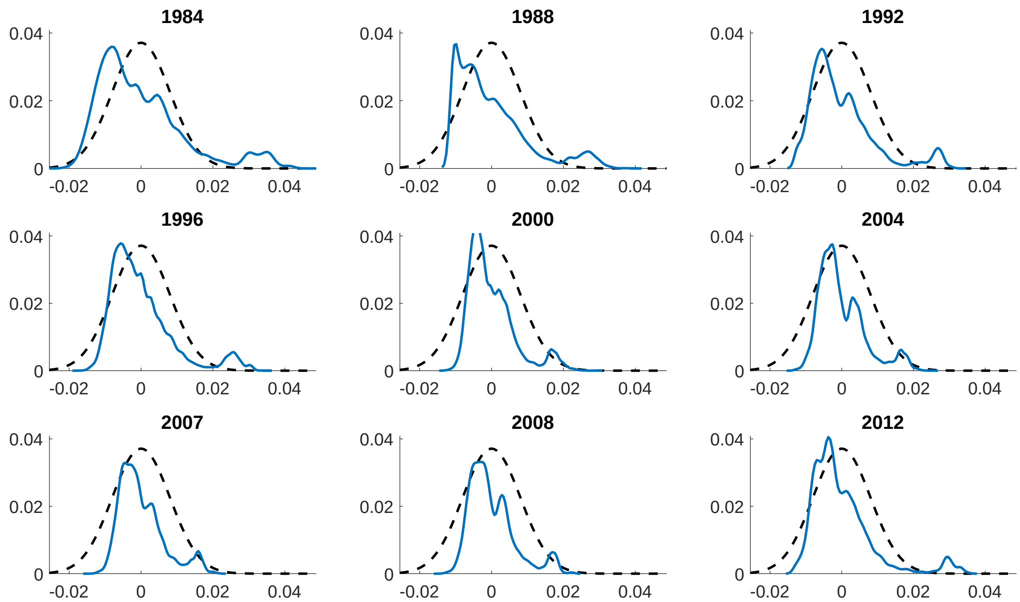


Figure C.3: Distribution of US job risk by year

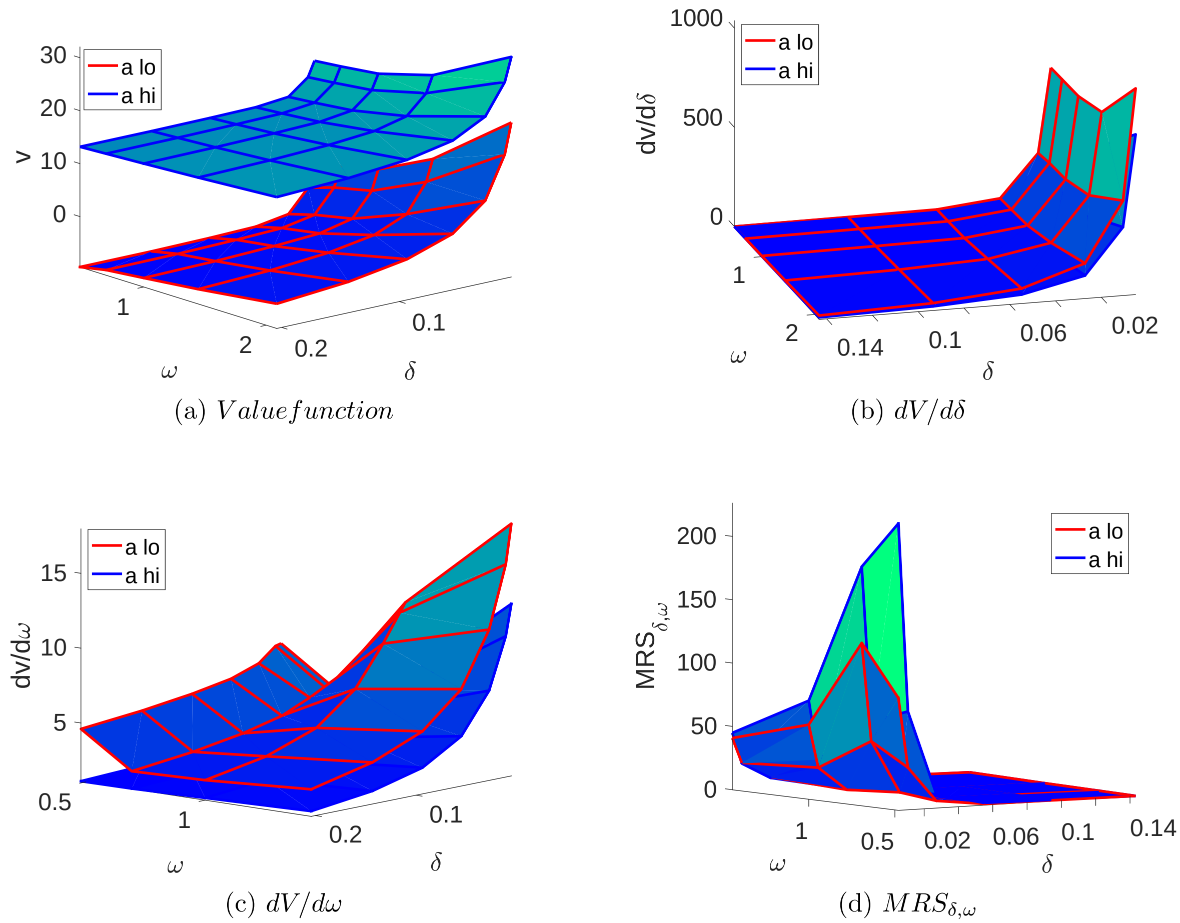
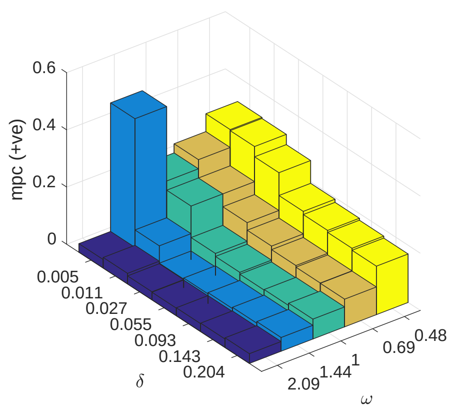
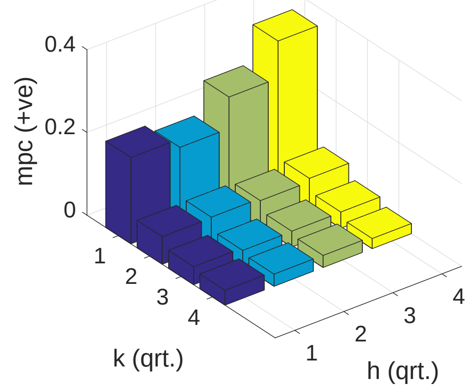


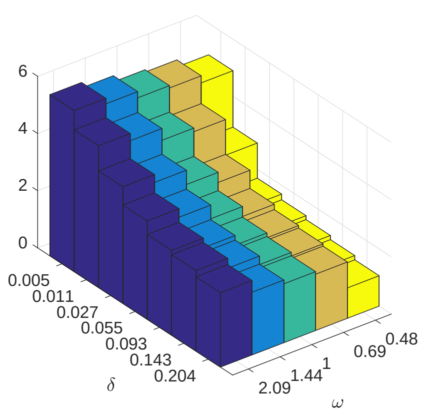
Figure C.4: Value function in (ω, δ) space



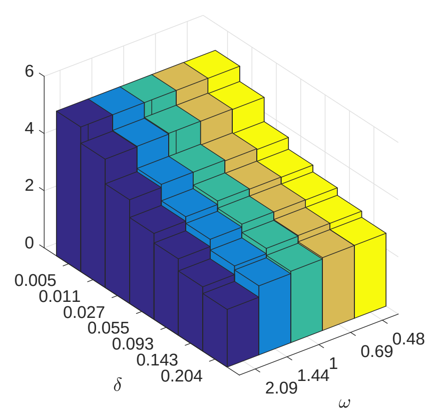
(a) MPC by job



(b) MPC by asset

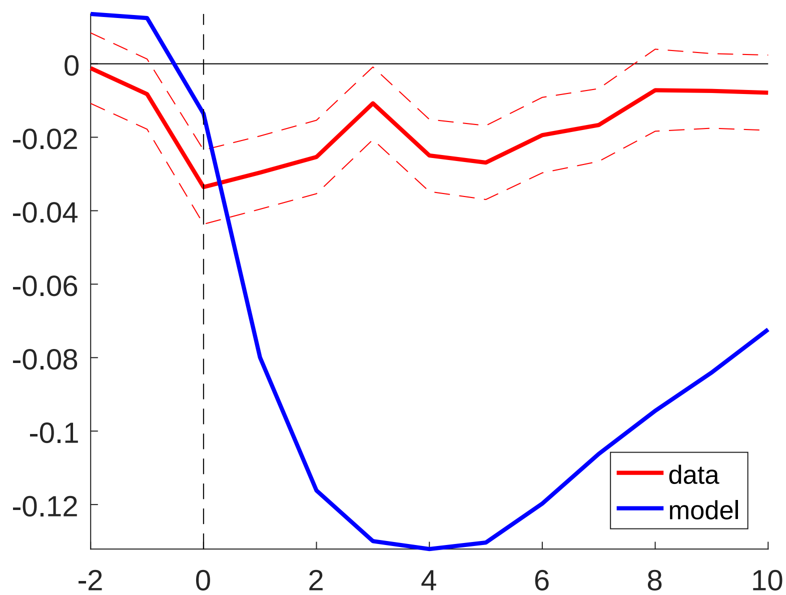


(c) Log. average tenure



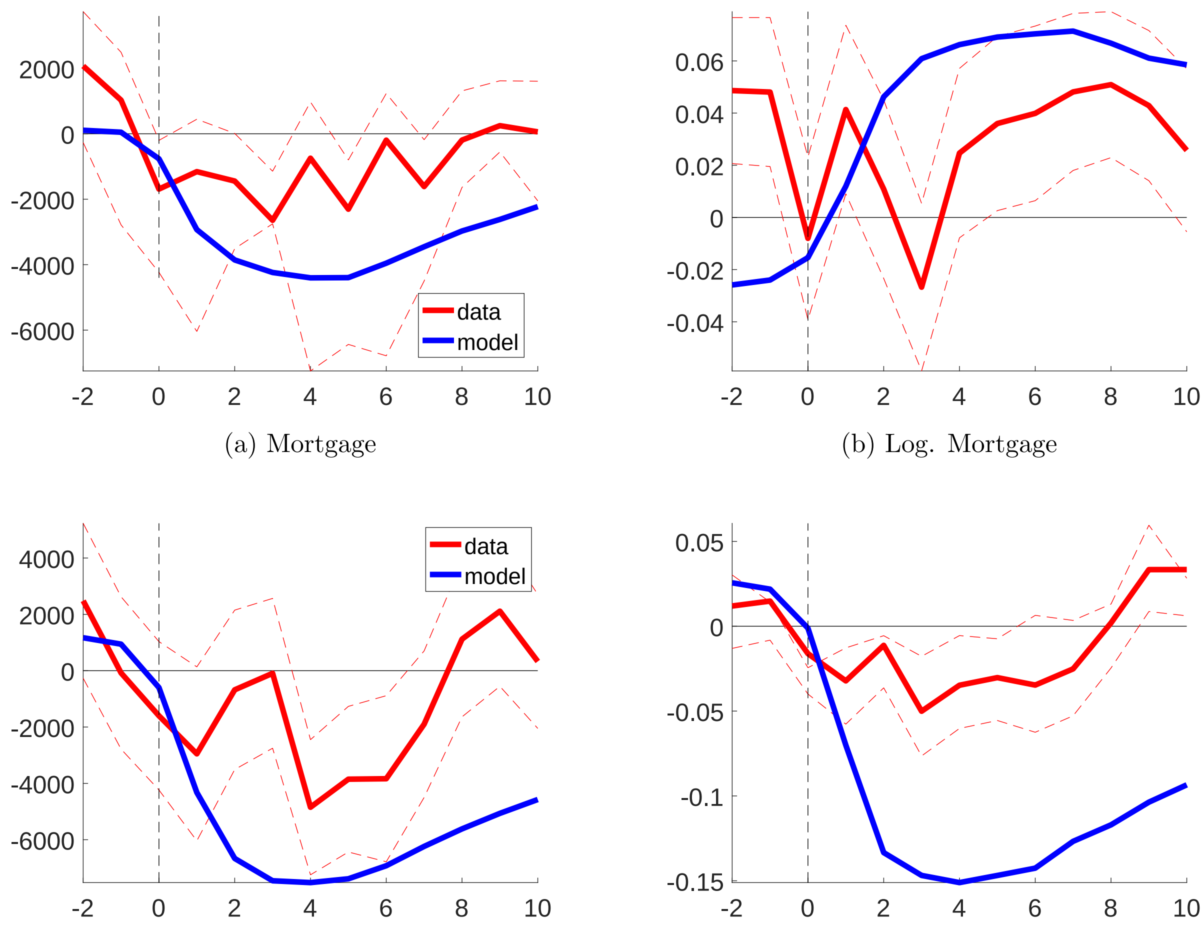
(d) Expected log. duration

Figure C.5: Role of job risk in MPCs



(a) Housing status

Figure C.6: Housing status response to unemployment shock



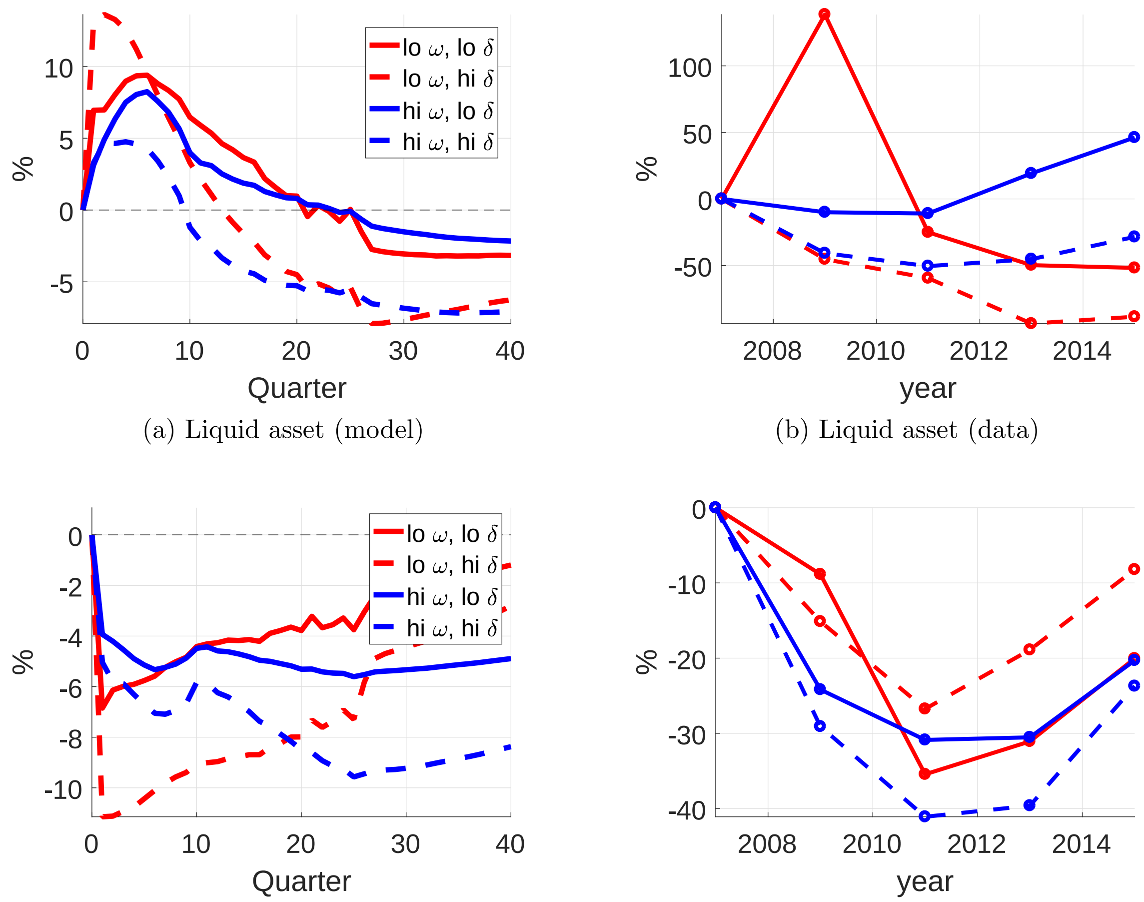
(a) Mortgage

(b) Log. Mortgage

(c) Equity

(d) Log. Equity

Figure C.7: Other asset responses to unemployment shock



(a) Liquid asset (model)

(b) Liquid asset (data)

(c) Equity (model)

(d) Equity (data)

Figure C.8: Group responses to Great Recession shoc, other response