Consumer Bankruptcy, Mortgage Default and Labor Supply*

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Abstract

We specify and estimate a lifecycle model of consumption, housing demand and labor supply in an environment where individuals may file for bankruptcy or default on their mortgage. Uncertainty in the model is driven by house price shocks, education specific productivity shocks, and catastrophic consumption events, while bankruptcy is governed by the basic institutional framework in the U.S. as implied by Chapter 7 and Chapter 13. The model is estimated using micro data on credit reports and mortgages combined with data from the American Community Survey. We use the model to understand the relative importance of the two chapters (7 and 13) for each of our two education groups that differ in both preferences and wage profiles. We also provide an evaluation of the BAPCPA reform. Our paper demonstrates that Bankruptcy reform policies have important distributional effects.

Keywords: Lifecycle, Bankruptcy, Housing, Mortgage Default, Labor Supply, Consumption, Education, Insurance, Moral hazard.

JEL Codes: G33, K35, J22, J31, D14, D18, D52, D53, E21

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1 Introduction

A number of countries, including the U.S. and the UK, have bankruptcy legislation allowing a fresh start for people who are unable to repay debts. Such legislation is an attempt to balance the legitimate rights of creditors with the need to offer a degree of insurance for adverse events in a world with incomplete markets. The legislation is complex and treats secured and unsecured debt differently. The U.S. even offers alternative choices for filing for bankruptcy. For example, under certain conditions one can choose to file under Chapter 7, which completely clears all outstanding debt, in return for the individual foregoing their assets, such as housing. Alternatively, one can file under Chapter 13, keeping all assets but agreeing to a gradual repaying scheme for at least part of the debt, clearing the rest. Chapters 7 and 13 offer different levels of protection and target the insurance provided by the system to different needs and populations. The tradeoff between Chapter 7 and Chapter 13 is crucial and varies depending on other institutional features, such as the level of homestead exemption in the particular state or the level of recourse. The homestead extension is the extent to which housing equity has to be used to repay outstanding unsecured debts following bankruptcy and varies widely across U.S. states from 0% to the entire level of housing equity. Recourse legislation defines the extent to which non-housing assets can be used to repay debts following residential mortgage default. The design of the system implies a tradeoff between insurance and incentive and will have important distributional implications, not just between creditors and borrowers but also between different types of borrowers, in terms of their risk profile and level of (permanent) income.

Understanding the effects of the institutional framework requires a model of the household that encompasses the complex interactions of various decisions such as labor supply, savings, house purchase, and the decision to file for bankruptcy and/or to default on a mortgage. Together these decisions help capture the many margins of household adjustment and thus the costs and benefits of bankruptcy legislation. Furthermore, the effects of such legislation need to be considered in an equilibrium framework to account for the feedback effect of its implications on the price of credit.

In this paper we investigate the impact of bankruptcy legislation on different education groups by specifying and estimating a microeconomic life-cycle model that generalizes the Aiyagari (1994) economy.[1] Specifically, in the model individuals choose to buy a house of a certain size or to rent, save in a separate liquid asset, and supply labor. Their labor productivity is subject to shocks, which, together with house price

[1] Our model is closest to that of Mitman (2016), but with a number of differences that we discuss below.

volatility[2] and the random arrival of infrequent but catastrophic spending shocks (such as medical expenses), can lead to financial distress and an inability to service existing loans or mortgages. Thus, at each period individuals may file for bankruptcy and/or default on their mortgage. Lenders set interest rates for unsecured debt and for mortgages taking into account borrowers' probability of filing for bankruptcy and/or default.

To estimate the model we use the simulated method of moments (SMM, see McFadden, 1989; Pakes and Pollard, 1989) combined with the Markov Chain Monte Carlo method (MCMC) adapted for SMM by Chernozhukov and Hong (2003). This approach makes estimation tractable and at the same time avoids problems with moments that may not be differentiable with respect to parameters, as is often the case when simulation methods are used.

Our model is estimated using U.S. data including those drawn from the Federal Reserve Bank of New York Consumer Credit Panel/Equifax Data (CCP) and based on the period before the implementation of the Bankruptcy Abuse and Prevention Consumer Protection Act (BAPCPA reform) in October 2005.[3] We use anonymized microeconomic data that records all loan and mortgage activity as well as bankruptcies. We combine U.S. county level information on house price variability, bankruptcy and mortgage default rates with information from the census. The final data allow us to estimate a rich model of individual consumption and labor supply with differences across education groups. The latter is important because individuals with lower education have lower income and lower accumulated housing wealth and are more likely to find themselves in financial difficulty. Moreover, they are more likely to benefit from filing under Chapter 7 both before and after BAPCPA because of their low assets.

We use the estimated model to study the value of insurance offered by the system. Specifically, we examine the impact of shutting down either Chapter 13 or Chapter 7 filings, consider the impact of changing the probability of a deficiency judgment for those who default on their mortgage, and examine the impact of the BAPCPA reform which introduced a means test for Chapter 7 bankruptcy filing, among other changes.

Our paper builds on Oswald (2015), and has a number of common features with Mitman (2016).[4] Both papers allow for Chapter 13 and Chapter 7 filing as well as mortgage default and both use an equilibrium setting, which is of particular importance for this type of problem as the price feed back effect plays an important role in households' default and bankruptcy decisions. Both also model explicitly a rental market.

[2] See Sullivan et al. (1999) pp. 128 for an account of the importance of housing shocks as drivers of bankruptcy.
[3] BAPCPA: The Bankruptcy Abuse and Prevention Consumer Protection Act on the Department of Justice website.
[4] Our respective projects started independently at about the same time.

However, our model differs in several substantive ways. First, we allow for labor supply; this is important because by varying labor supply an individual can change the probability of bankruptcy (by increasing labor income) and because it allows us to capture the labor market implications of post-bankruptcy repayment plan; the anticipation of such an event can itself change effort levels, possibly limiting bankruptcy; and ex post the type of filing and the actual settlement can affect work incentives. Second, our model features a finite-horizon life-cycle setup, which implies a life-cycle structure on assets and borrowing. For instance, a mortgage contract has a finite maturity and the loan to value ratio declines as borrowers age. This is important, since mortgage vintage, which is highly correlated with borrower age, is a strong predictor of default and bankruptcy. Third, we allow households to differ by education, an important source of heterogeneity for income risk as well as preferences.

In addition to Mitman (2016), a number of other papers have addressed the effects of institutional arrangements on bankruptcy. Important examples include Pavan (2008), who investigates the effect of exemption levels on bankruptcy and durable purchases and finds that welfare gains from greater insurance are canceled out by losses due to tighter credit constraints, making the impact of homestead exemptions small. Hintermaier and Königer (2016) arrive at a similar conclusion but approach the problem differently. They use a calibrated model of housing, collateralized and uncollateralized debt, and show that variations in homestead exemptions have little impact on the price and amount of unsecured debt because, in equilibrium, individuals with large unsecured debt typically don't own housing. Based on reduced form analysis Gropp et al. (1997) find that homestead exemptions tend to favor high asset households and make credit more expensive harming lower income groups. Fay et al. (2002) provide evidence of strategic bankruptcy, which is central for our approach, since households in our model can choose to file and indeed the availability of filing will affect their borrowing and housing decisions. Since bankruptcy laws affect available insurance they can be expected to crowd out other insurance mechanisms available. Thus Traczynski (2011) notes that more generous bankruptcy laws reduce the risk sharing advantages of marriage and based on within state variation of exemption levels, finds substantial effects of generous exemption levels on divorce rates.

More broadly, our paper extends the Aiyagari (1994)-type economy where borrowing is allowed only up to an amount the consumer can repay with probability one, to one where bankruptcy and mortgage default laws effectively permit the violation of the life-cycle budget constraint. The theoretical foundation of this is laid out in Chatterjee et al. (2007); examples of applications to different aspects of risk-sharing and welfare

implications are Athreya and Simpson (2006) and Athreya et al. (2015), who examine the interaction of bankruptcy with social insurance, Li and Sarte (2006), who model bankruptcy chapter choices explicitly and Livshits et al. (2007) and Athreya (2002) who calibrate a life-cycle model to investigate welfare differences of alternative bankruptcy schemes.

In a recent paper Chen and Zhao (2017) analyze labor supply and bankruptcy choices in a partial equilibrium search and matching model. They use the model to infer the value of Chapter 7 bankruptcy. Their model does not consider housing, however, and predicts that higher wage earners prefer Chapter 7 over Chapter 13. Given that high wage earners are more likely to be homeowners, who in turn are more likely to file for Chapter 13, we reach different conclusions. Han and Li (2007) estimate the effects of bankruptcy on labor supply using an instrumental variable approach. They find no impact, which they interpret as reflecting the opposing impacts of wealth effects of the debt write-off and the incentive provided from the fresh start aspect of bankruptcy. Dobbie and Song (2015) consider the ex post effects of being granted Chapter 13 bankruptcy protection conditional on filing; when judges (assumed to be randomly assigned) deny protection many do not take this further and others file under Chapter 7. With respect to such a comparison group, they find important effects on earnings, foreclosure and even mortality. Our model abstracts from the possibility of being denied protection, given formal eligibility, but does allow randomness in the terms offered under Chapter 13. Li et al. (2011) study the effects of the BAPCPA reform on mortgage default and find that the reform caused prime and subprime mortgage default rates to rise. Finally, Albanesi and Nosal (2018) also study the BAPCPA reform. They find that the reform reduced Chapter 7 filings and increased insolvency, but did not increase Chapter 13 filings due to liquidity constraints and the increased costs of filing. Our model does allow for such costs and for liquidity constraints, shown to be important by this work and others.

The rest of the paper proceeds as follows. In Section 2 we present the data and some descriptive facts about bankruptcy, default and the institutional context. We then present our model in Section 3, followed by Section 4 on estimation. Section 5 discusses the implications of the model and Section 6 reports counterfactuals. Finally Section 7 concludes.

2 Data and Descriptive facts

Our data come from several sources. We use the proprietary Federal Reserve Bank of New York Consumer Credit Panel/Equifax data (CCP) data merged with the Black Knight data also known as LPS

Mortgage Loan Level Data or the "McDash" data (Black Knight) data to compute bankruptcy and default rates at county level. We supplement this with county level house prices obtained from Zillow Research,[5] and county level demographic and economic characteristics from the American Community Survey (ACS).

The CCP is a 5% random sample representative of those with a credit history and includes details of various types of debt as well as loan-level detailed anonymized information on mortgages they have taken out.[6] It also contains anonymized information on various demographic characteristics, such as age, zip code, and Equifax Risk Score.[7] The Black Knight data includes detailed anonymized information at the time of origination, such as the loan amount, estimated house prices, interest rate and termination date and reasons for termination.[8] We match the CCP data with the Black Knight data[9] thus creating a data set that allows for a detailed study of mortgage defaults.[10] We then merge county level information on education and employment using the American Community Survey (ACS) anonymized Public Use Micro Data Sample. Finally, we use the Panel Study of Income Dynamics (PSID) data to estimate the life-cycle profiles and associated stochastic processes for income, as well as hours worked and homeownership rates for each education group. We present summary statistics for data from PSID in Table 1 by educational attainment.

Table 1: Hours and Ownership Summary Statistics

	Low Educ			High Educ		
	mean	sd	median	mean	sd	median
Hours Worked	1810.66	981.83	2024.00	2082.44	841.29	2100.00
Ownership	0.56	0.50	1.00	0.71	0.45	1.00
Age	42.05	10.34	42.00	43.17	10.63	43.00

Source: Authors' calculations based on data from PSID 2000-2006. All variables refer to the household head between age 25 and 60. Observations: Low Education 10407; High Education 6961.

[5] We use the Zillow House Value Index for All Homes at County level, see http://www.zillow.com/research/data/.

[6] Such information includes loan origination date, amount, current balance, requested payment amount or term of the loan, credit limit (on HELOCs), individual/joint account and payment status, whether GSE guaranteed, whether for a mobile home, whether second mortgage, and whether the account was closed in bankruptcy or foreclosure.

[7] A detailed description of the panel can be found at http://www.newyorkfed.org/research/staff_reports/sr479.pdf.

[8] The termination types include paid off, foreclosure and other negative termination events such as REO sale. The data includes among other variables, the loan amount, house price, documentation status, source of the loan (e.g., whether it was broker-originated), property location (zip code), type of loan (fixed-rate, ARM, prime, subprime, etc.), the prepayment penalty period (if any).

[9] The match is based on mortgage loan origination date, origination amount, the zip code of the property, purpose of the mortgage (purchase versus refinance), lien status (first lien versus second lien or home equity), type of mortgage (agency loans or not)) and occupancy type (primary residence, second homes or investment properties).

[10] This data have been used extensively over the past few years to study mortgage defaults. See, among others, Demyanyk and Hemert (2011), Li and White (2009), and Meta Brown and Zafar (2015).

2.1 Institutional Features

Individuals can file for bankruptcy either under Chapter 13, or if eligible, under Chapter 7. Those filing under Chapter 13 get to keep all their assets but have to agree to a repayment plan typically over five years and as a function of their earnings. After that period all debt will be discharged. By contrast those filing under Chapter 7 have all their debt immediately discharged but have to give up their assets, including their home equity. However, the way this is done varies by state; each state defines a homestead exemption, which is an amount of protected home equity that creditors cannot access. If the equity is below the exemption the individual keeps the house. If it is above, then the house is sold and the remaining equity after any mortgage has been repaid and after the exemption is accounted for is handed over to the creditors as repayment of the unsecured debt. Homestead exemptions vary across the states from zero to an unlimited amount.

BAPCPA limited the eligibility for Chapter 7 to those with incomes below the state median income. Finally, the other key feature of the institutional set up is the extent to which mortgage lenders can access other financial assets to repay any equity not covered by the sale of a house under repossession by obtaining a Deficiency Judgment or mortgage lender Recourse (see Ghent and Kudlyak, 2011; Li and Oswald, 2017, for instance). These features make mortgage default and bankruptcy interrelated and their design provides alternative tradeoffs between the insurance value of bankruptcy and the disincentive to work or save they induce. The institutional details across the U.S. are given in Appendix Table D.2.

2.2 Descriptive Facts on Bankruptcy

Table 2 presents the annual non-business bankruptcy and mortgage default rates in our sample. About 1% of individuals file for bankruptcy, and in our sample period three quarters of those file under Chapter 7. About 2.1% of mortgage borrowers default on their mortgage.

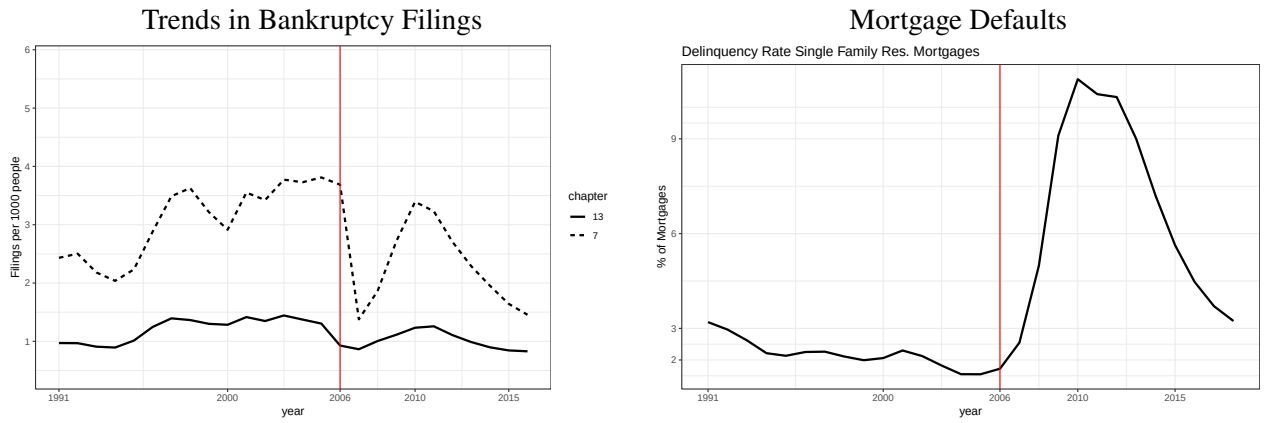
Table 2: Average Bankruptcy and Default Rates

Chapter 7 (‰)	Chapter 13 (‰)	Total bankruptcy (‰)	Mortgage Default (%)
7.634	2.210	9.222	2.130

Notes: Number of observations=21822. Mortgage default is defined as 60 days or more past due. This is an average over county-level data for years 2000-2006. Authors' calculations based on CCP and Black Knight data.

Time trends in personal bankruptcy filings and mortgage defaults are depicted in Figure 1. The speedy decline in Chapter 7 bankruptcies after 2005 is associated with the introduction of the BAPCPA reform, which introduced a means test for filing under Chapter 7. Our model will be fit to the period before the implementation of this reform; amongst other counterfactuals we will also offer our version of the impact of this reform. The years after 2007 are marked by the Great Recession and the associated upheaval in the housing and mortgage market, which is beyond the scope of our paper.

Figure 1: Bankruptcies by Chapter and Mortgage Default over Time



Note: The vertical red line indicates enactment of the BAPCPA reform in October 2005. Authors' calculations based on CCP and Black Knight data

We now study how the bankruptcy and mortgage default relate to individual characteristics and the institutional framework via a regression. Since we do not observe individual level education in the CCP or Black Knight data, we run the regression at the county level using the log-odds ratio as a dependent variable:

$$\log\left(\frac{y_{jt}}{1-y_{jt}}\right) = \gamma_0 + \gamma_1 \text{College}_{j,2010} + \beta X_{jt} + \varepsilon_{j,t}, \tag{1}$$

where $y_{j,t}$ represents in turn overall bankruptcy rate, Chapter 7, Chapter 13 and mortgage default in county j and period t. We define two education groups, a high level which includes all those with a college degree and more and a lower level, comprising the rest. Hence, $\text{College}_{j,2010}$ is the percentage of the population in county j in year 2010 with a college degree or more. X_{jt} is a set of control variables. At county-year level we include the Zillow house price index, the default rate, and when explaining default behavior on mortgages, the bankruptcy rate. At county level but fixed to 2010, we include the homeownership rate. Finally, the state legal environment is captured by whether the state offers lender recourse, whether homestead exemption is

unlimited, and if not, the size of the homestead exemption. We report the regression results in Table 3.

Table 3: Association of Bankruptcy and Mortgage Default with Institutional and Other Characteristics

	Bankruptcies	Chapter 7	Chapter 13	Default
House Price	-0.060***	-0.052***	-0.121***	-0.101***
	(0.004)	(0.005)	(0.007)	(0.005)
Default Rate	1.113***	0.677*	2.290***	
	(0.259)	(0.308)	(0.504)	
Ownership Rate	-0.127	0.135	0.906***	-0.939***
	(0.114)	(0.125)	(0.194)	(0.124)
Recourse	-0.048+	-0.051	-0.080	-0.107***
	(0.028)	(0.032)	(0.050)	(0.031)
Homestead Exemption ($)	0.002	0.007**	-0.007*	0.002
	(0.002)	(0.002)	(0.004)	(0.002)
Unlimited Exemption	-0.285	-0.727**	0.473	-0.093
	(0.207)	(0.229)	(0.351)	(0.229)
% College or More	-0.026***	-0.028***	-0.043***	-0.037***
	(0.001)	(0.001)	(0.002)	(0.001)
Bankruptcy Rate				0.057***
				(0.009)
# Obs.	5846	5391	2642	4994
R2	0.196	0.174	0.371	0.330

Note: Annual County-level data between 2000 and 2006, hence an observation is a county-year pair. The dependent variables are the log-odds ratios of the respective bankruptcy or default rates by county and year. As a result, the analyses exclude county year observations with zero bankruptcies or defaults. House price is the Zillow house value index at county-year level; Ownership Rate is by county but fixed at 2010 Census level; Recourse classifies states into having mortgage recourse for lenders; Homestead Exemption is in 10000 dollars; and Unlimited exemption is a dummy equal to one if the state has unlimited homestead exemption and zero otherwise. Bankruptcy and defaults are authors' calculations based on CCP and Black Knight data. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

More generous bankruptcy provisions increase the demand for credit but the amount of credit supplied declines, pushing up interest rates, reducing the equilibrium amount of unsecured debt. This interplay between insurance offered by generous provisions and moral hazard is central to the motivation of our paper and lies at the heart of discussions in Gropp et al. (1997) and Mitman (2016), and is demonstrated in the table: The size of the homestead exemption is not associated with higher or lower rates of bankruptcy, implying increased moral hazard is fully counteracted by reduced supply of credit. When we consider the states with unlimited exemption, which effectively allow people to borrow and shelter the assets into housing, we find reduced levels of bankruptcy reflecting an even stronger reaction in the supply of credit. The next

two columns show opposing associations for Chapters 7 and 13. Interestingly, the difference across chapters carries over to the unlimited exemption, which is positively associated with the rate of Chapter 13 bankruptcy but negatively with the rate of Chapter 7 filings. Whether a state allows for recourse is not significantly associated with bankruptcy, but as we expect, it reduces the default rate (last column), as it becomes more costly to the individual since their other assets can be seized to pay for the uncovered loan.

Education Education is an important factor that drives both behavior towards bankruptcy and the risks that people face. Higher education individuals earn more but their income is subject to higher variance shocks (for example, Meghir and Pistaferri, 2004). These differences will imply different borrowing and savings behavior and different resilience to shocks. In understanding the value of alternative bankruptcy arrangements and how well they are targeted it is thus important to allow for this heterogeneity.

Table 3 demonstrates a strong association between education bankruptcy filing rates and mortgage default rates. To quantify the effect, Table 4 shows how the coefficients in the regression translate to different predicted rates of bankruptcy and default, which we use for estimation: the rates of bankruptcy and default are more than fifty percent higher for the low education group.

Table 4: Predicted Rates of Bankruptcy and Default by Education

Rate	High Education	Low Education
Total Bankrupty Filing Rates (‰)	7.72	11.40
Chapter 7 Filing Rate(‰)	5.79	8.79
Chapter 13 Filing Rate (‰)	2.08	3.96
Mortgage Default Rate (%)	1.67	2.88

Note: Prediction of bankruptcy filing rates and mortgage default rates by educational achievement in county-level data. We take the group of counties with % of college below the 25-th percentile as reference level for low education and compute the predicted value for a high educated county (above the 75-th percentile) using the estimate for γ_1 in (1), as shown in Table 3.

3 Model

3.1 Overview

Individuals are life cycle expected utility maximizers. The active life period starts at age 25 and lasts until age $T = 60$ with each model period representing one year.[11] Individuals differ in their completed level of schooling, but are identical in all other respects ex ante. They face persistent wage rate and house price uncertainty. Given this, in each period they decide how much to consume, work and save. They can either rent a house or buy one of a range of different sizes. Selling a house is subject to transaction costs. Houses are financed by a long term mortgage contract of a finite number of periods and secured against the value of the house. The mortgage interest rate depends on the probability of defaulting on the mortgage. Individuals can also obtain unsecured loans at an interest rate that is a function of the probability of bankruptcy and is set so that the expected profits of making the loans are zero.

Finally, indebted individuals can file for bankruptcy under Chapter 7 or Chapter 13. Depending on the institutional arrangements in place they may have to give up their house to repay some of the delinquent debt, if they file under Chapter 7. Under Chapter 13 they will have to agree on a repayment scheme, deducted at source from their wages for a random number of periods of fixed expected duration. In addition to filing for bankruptcy they can separately decide to default on their mortgage. In this case, the recourse legislation in place governs the extent to which they have to use their other assets to cover the remaining mortgage.

We next describe the essential elements of the model and provide examples of some of the value functions and choices. A detailed description of the model is provided in Appendix A.

3.2 Preferences

Households derive utility from consumption of a composite non-durable consumption good c, leisure, and housing good h.[12] Labor supply decisions are modeled as choices from a set of five hours values $l \in \{l_1, l_2, \ldots, l_5\}$ where $l_1 = 0$ hours and $\mathbf{P} \equiv \mathbf{1}[l > 0]$ and L is maximal leisure time. Houses come in H sizes, $h \in \{\underline{h}, h_1, \ldots, h_H\}$ and $\mathbf{H} = \mathbf{1}[h > \underline{h}]$. Only the smallest type $\underline{h}$ is also available for rent.[13] The

[11] The assumption of maximum life expectancy is made for computational purposes and helps focus the model on periods where housing decisions and mortgage repayment are central.

[12] We use "individuals", "households", and "agents" interchangeably.

[13] This simplifying assumption follows Mitman (2016) and many others in the literature.

per-period utility function for individuals of education level e is

$$u_e(c,l,h) = \frac{\left(c^{\omega_e}\left(L-l-\mathbf{P}\theta_{Pe}\right)^{1-\omega_e}\right)^{1-\gamma}}{1-\gamma}\exp\left(\theta_{He}h\right)+\mu_e\mathbf{H}h, \tag{2}$$

where θ_{Pe} denotes the fixed cost of working. The additive term $\mu_e\mathbf{H}h$ makes preferences nonhomothetic, and the sign of μ_e governs whether housing is a necessity or a luxury as in Attanasio et al. (2012).

3.3 House Prices

Following Mitman (2016), we normalize the unit price of housing to be 1 at the time of purchase and thereafter, and assume house prices follow an autoregressive process with idiosyncratic shocks ϵ_{it}:

$$p_{it} = \rho_p p_{it-1} + \epsilon_{it-1} \text{ with } p_{i0} = 1 \text{ and } \epsilon_{it} \sim N(0,\sigma_p^2). \tag{3}$$

We abstract from aggregate shocks, which lead to a number of complications that are beyond the scope of this paper.

3.4 Labor Productivity

Log hourly wages of an individual with education level e grow deterministically with age t and are subject to idiosyncratic shocks as follows,

$$\ln y_{it} = e_i + f^e(t) + w_{it}^e, \tag{4}$$

where $f^e(t)$ is an education specific polynomial in age (t) and w_{it}^e follows an age-t-dependent Markov chain of order one, where – importantly – *both state space and transition matrix* of the Markov chain depend on age and education level e. We interpret w_{it}^e as the wage residual, and include it in the consumer's state space. We take this representation of the wage process from De Nardi et al. (2020) and estimate it on PSID data following their procedure (see Appendix B). We suppress the index for education e henceforth but note that all preference parameters are separately estimated for each group. In case of a labor supply choice of $l = 0$, the individual receives benefits b instead of labor income $y \times l$.

3.5 Catastrophic Spending Shocks

In addition to wage and house price shocks, the individual is also subject to the arrival of catastrophic spending shocks. As pointed out in Sullivan et al. (2000), the main reasons cited for consumer bankruptcy are job loss (67.5% of respondents), family issues like divorce (22.2%), and medical expenses (19.3%). We introduce an independently distributed spending shock to capture the latter two categories, over and above our income and price shocks. We adopt the setup and calibration in Livshits et al. (2007), which estimate dollar values for spending shocks from individual level medical spending data. We denote the spending shock by $\underline{a} \in \{0, 32, 102\}$ (in \$1000), and the probability of spending shock $\underline{a}$ arising by $\pi_a(\underline{a})$ (see Table 5).

3.6 Institutions Governing Bankruptcy and Mortgage Default

Under Chapter 7, all non-exempt assets are seized to help repay the debt and the remaining debt is discharged. The extent to which housing equity has to be used for debt repayment is regulated by the state's homestead exemption (ξ), which varies from zero to the entire value of the house. Under Chapter 13, by contrast, filers keep their house regardless of the exemption level but they sign up for a repayment plan stipulating debt repayments for as long as they are in the *bankruptcy punishment state*. In our model exit from such a state is random with a probability of 20% each year leading to an average duration of 5 years.[14] Note that Chapter 13 is an option only if the creditor can expect to recoup at least as much as under a Chapter 7 liquidation. Associated with filing for bankruptcy are certain costs: First, the individual is excluded from financial markets for the duration of the punishment. Second, bankruptcy incurs a chapter specific psychic costs, $\lambda_{je}, j = 7, 13$, associated with the stigma of a bad credit record.

Homestead exemption is a legal clause which exempts a certain amount of home equity from liquidation. As a result, if an owner finds himself with unsecured debt and at the same time has equity in the home below the exemption level, he could file for bankruptcy without risking losing his home in a forced sale, since the unsecured lender is prevented from claiming the exempt equity. If an owner in excess of the exemption limit files for Chapter 7, he loses the house, which is sold at market price, but he gets to keep the exemption level from the proceeds of the sale.

The second institution concerns default on mortgage debt. An owner may default if the mortgage debt

[14] We set the exit to be random so as to avoid introducing an extra state variable in the model.

is higher than the value of the house, although even then he may decide not to because defaulting is costly.[15] Additionally, after default the owner becomes a renter and the house is sold to recover the debt. In all but seven U.S. states a lender may lay claim to a fraction of other assets via recourse (we denote the probability of success of a resulting deficiency judgment as $\psi \in [0,1]$) to cover remaining outstanding debt after default (Ghent and Kudlyak, 2011).

3.7 Financial Market

In our model financial institutions borrow at a fixed interest rate r from the world market and issue unsecured debt and mortgages ensuring zero profits on each type of debt. We now describe the terms under which this debt is supplied.

3.7.1 Mortgage Market

A mortgage is a loan of a fixed initial amount $m_0 = (1-\chi)p_0 h$, depending on the value of the house on which it is secured ($p_0 h$), and bearing a fixed interest rate r_m, leading to constant payments $\kappa(m_0)$, computed using the standard amortization formula, over its exogenously given term $T_m < T$ years.[16] The term χ represents the mandatory downpayment. Using the prime to denote the next period, the loan amount evolves according to

$$m' = (1+r_m)m - \kappa(m_0) \tag{5}$$

To adjust the loan for the individual default risk over the term we define a price that will ensure zero profits on each individual mortgage contract (see Kaplan et al., 2020). Thus, the individual will be making repayments based on the nominal value of the loan $m_0 = (1-\chi)p_0 h$ but will receive only $(1-\chi \times q_{m_0})p_0 h$, where q_{m_0} is the price of the loan. To see how this is set, define as $d(x)$ the default indicator at state of the world x, which includes wages, the house value, and the outstanding mortgage as well as net financial assets. The mortgage price is then determined according to the recursive formulation

$$q_m(m|S) = \frac{1}{m(1+r_m)} \mathbb{E}_{w'|w,p'|p,\underline{a}} \left\{ d' \left(\delta_d p' h' \right) + (1-d') \left[\kappa + q_m(m'|S')m' \right] \right\}, \tag{6}$$

[15] see Bajari et al. (2008) and Guiso et al. (2009) for discussions of these issues

[16] The standard amortization formula is $\kappa(m) = m \frac{r_m(1+r_m)^{T_m-t}}{(1+r_m)^{T_m-t}-1}$.

where $\mathbb{E}_{w'|w,p'|p,\underline{a}}$ is the expectation operator taken over all future states, included in the full state space S, introduced below, m' is the outstanding loan at the beginning of the period before the default decision. The curly bracket in (6) describes the repayment to the mortgage lender in case of default ($d' = 1$), when the house is sold in foreclosure at a discount $\delta_d < 1$, and in the case of continuing mortgage payments: The value to the lender in that case is the next payment κ plus the next period's pricing function times the remaining mortgage debt $m' = (1 + r_m)m - \kappa$.

3.7.2 Unsecured Debt Market

Individuals can take out one year unsecured loans, which they can choose to repay or file for bankruptcy as in Chatterjee et al. (2007) or Athreya (2008). The equilibrium cost of the loan needs to take into account the possibility of bankruptcy filing under Chapter 7 or 13. Under Chapter 13, a 5-year repayment plan is set, where the amount repaid each year is equal to a fifth of the amount owed. In the model we place a cap of 15% of annual earnings, reflecting the practice in courts. Alternatively, if the individual files under Chapter 7 (subject to eligibility) no repayments are made from future income but any available assets above an exemption level (housing in our case) are seized to repay as much of the debt as possible with the rest discharged. We define this as *non-exempt equity*, given by $\nu = \max((1-\phi)(ph - m) - \xi, 0)$, with ϕ a proportional transaction cost when selling the house and ξ the homestead exemption. In either case, the amount an individual can borrow depends on the expected repayment for the lender next period. Thus, the implicit bond price for a one-period loan is given by

$$q_a(a'|S) = \frac{1}{(1+r)(-a')}\left[-a'(1 - \pi_7(a', S) - \pi_{13}(a', S)) + \pi_7(a', S)\nu\zeta + \pi_{13}(a', S)\bar{y}T_{bk}\right], \quad (7)$$

where $\pi_j(a', S)$ is the probability of filing for Chapter j, given a savings choice a'. The squared bracket denotes the expected repayment amount for the lender, where $\zeta < 1$ parametrizes inefficiency in the bankruptcy technology of the lender; that is, the lender recovers only $\zeta\nu$ from a Chapter 7 bankruptcy. Hence, expression (7) for a renter (or an owner with only exempted equity, such that $\nu = 0$) implies a smaller unsecured loan than for an owner with $\nu > 0$, all else equal. Notice that decreasing homestead exemption ξ will increase ν, and therefore ceteris paribus will lead to larger unsecured borrowing. Finally, note that equation (7) reduces to the familiar $q_a(a'|S) = \frac{1}{1+r}$ if the probability of bankruptcy is zero.

3.8 Consumer Choice

The household maximizes lifetime utility given by

$$U_e = E_0 \sum_{t=1}^{T-1} \beta^t u_e\left(c_t, l_t, h_t\right) + \beta^T V_{Te}(a, h, p, m, \tau) \tag{8}$$

with respect to sequences $\{c_t, h_t, l_t, d_t\}_{t=1}^{T}$ of consumption, housing, labor supply, and a set of discrete choices d relating to bankruptcy and default decisions. The term $\beta < 1$ is the discount factor and V_{Te} is the terminal value function, which depends on the amount of home equity at the end of the active life cycle and the start of retirement. The expectation is taken with respect to contingent paths of wages, house prices, and spending shocks.

The optimization is subject to a budget constraint, which we discuss later together with value functions. The flow of labor income is endogenous and depends on labor supply.There exists a basic insurance b, set at 23% of median income, so that even when the individual is unemployed a low level of consumption is guaranteed. In addition, we allow for basic consumption support $\underline{c}$ equal to 10% of median income, which is applicable following a catastrophic consumption shock once the individual has filed for bankruptcy. Neither of these amounts varies by education.

The timing within a period is as follows: First, wage, house price and spending shocks are resolved. Then, optimal savings, housing, labor and discrete choices are made. When $t < T - 1$, in addition to the consumption decision, a renter in the non-bankruptcy state chooses the maximal value among three discrete choices: rent, buy, and file for bankruptcy under either Chapter 7 or Chapter 13. A owner in the non-bankruptcy state chooses between staying in the existing house, selling it, defaulting on the mortgage, and filing for bankruptcy under one of the two chapters. If the owner is in the punishment state due to an earlier bankruptcy, he chooses between staying, selling or defaulting on the mortgage.

In what follows we illustrate key features of the choice problem in several cases that are central to our problem. We omit the education subscript e without loss of clarity for simplicity.

3.8.1 The Choice of Renters

A renter is characterized by his holding of liquid assets a, wage w, and age t. The corresponding optimal value function is $W(a, w, t)$. If he has filed for bankruptcy before then ther value function is $\tilde{W}_j(a, w, t)$, for

$j = 7, 13$. Let $\text{med}(y)$ denote the state median income, the renter's problem in the post BAPCPA period is then:

$$W(a,w,t) = \begin{cases} \max\left(W^{\text{rent}}, W^{\text{buy}}, W^{\text{file.7}}, W^{\text{file.13}}\right) & \text{if } a < 0, yl < \text{med}(y); \\ \max\left(W^{\text{rent}}, W^{\text{buy}}, W^{\text{file.13}}\right) & \text{if } a < 0, yl \geq \text{med}(y); \\ \max\left(W^{\text{rent}}, W^{\text{buy}}\right) & \text{if } a \geq 0. \end{cases} \tag{9}$$

The restriction on the discrete choice set of the renter in (9) makes explicit that one files for bankruptcy only if there exists unsecured debt. Moreover, when simulating the BAPCPA version of the model, we implement the means test by preventing individuals with labor income above $\text{med}(y)$ to file for Chapter 7. The pre-BAPCPA model corresponds to setting $\text{med}(y) = \infty$. We define the conditional value functions next.

Value of Buying As an illustration, consider the value of buying (W^{buy}) for a renter not currently in bankruptcy. A prime denotes the next period and V denotes the owner's value:

$$W^{\text{buy}}(a,w,t) = \max_{a',h,l} u(c,l,h) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[V(S')\right] \tag{10}$$

subject to

$$\begin{aligned} S' &= (a' - \underline{a}, w', p', n', h, t+1), \\ c + a' q_a(a'|w,p,\bar{n},h) &= yl + a - \kappa((1-\chi)p_{i0}h) - \Gamma(p_0,h,w,t), && (11) \\ \pi_7(a'|w,h) &= \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[\mathbf{1}\left[V^{\text{file.7}}(S') > V^{-\text{file.7}}(S')\right]\right], && (12) \\ \pi_{13}(a'|w,h) &= \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[\mathbf{1}\left[V^{\text{file.13}}(S') > V^{-\text{file.13}}(S')\right]\right], && (13) \\ n' &= \bar{n} - 1, \\ w_{t+1}|w_t &\sim \Pi_w(t), && (14) \\ p'|p &\sim \Pi_p. && (15) \end{aligned}$$

The state space of the owner S contains liquid assets, wage shock, house price, mortgage vintage, house size and age. The maturity of the mortgage is denoted by $n \in \{\bar{n}, \bar{n}-1, \ldots, 0\}$, where $n = 0$ indicates a paid-off mortgage.[17] The budget constraint of the buyer (11) includes the first mortgage payment κ and the

[17] Given (h,p), there is a one-to-one mapping between n and m in the model

downpayment $\Gamma \equiv (1 - q_{m_0}(1-\chi))p_0 h$, where q_{m_0} is the price of the loan given by (6).[18] The function q_a, reflecting the cost of unsecured debt, depends on mortgage debt and the house size, (m, h), and is defined in (7). The respective probabilities of bankruptcy, which drive the cost of unsecured debt, are defined in (12) and (13). Finally, equations (14) and (15) denote the transition matrices associated with the discretizations of wage and house price processes in (4) and (3). See Appendix A for details on the value functions listed in equation (9), and on computation.

3.8.2 The Problem of the Owner

The problem of an owner not in a bankruptcy state is complex and is given by

$$V(S) = \begin{cases} \max\left(V^{\text{stay}}, V^{\text{sell}}\right) & \text{if } a \geq 0, hp_t - m_t \geq 0; \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{def}}\right) & \text{if } a \geq 0, hp_t - m_t < 0; \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{file.7}}, V^{\text{file.13}}\right) & \text{if } a < 0, hp_t - m_t \geq 0, yl < \text{med}(y); \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{file.13}}\right) & \text{if } a < 0, hp_t - m_t < 0, yl \geq \text{med}(y); \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{def}}, V^{\text{file.7}}, V^{\text{file.13}}, V^{\text{file.def}}\right) & \text{if } a < 0, hp_t - m_t < 0, yl < \text{med}(y); \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{def}}, V^{\text{file.13}}, V^{\text{file.def}}\right) & \text{if } a < 0, hp_t - m_t < 0, yl \geq \text{med}(y), \end{cases} \tag{16}$$

where *def* denotes default, $a \geq 0$ indicates non-negative financial assets, and $hp_t - m_t$ is home equity. Note that not all discrete choices are available everywhere on the state space, as can be seen from the restrictions for each case. For example, the admissible chapter of bankruptcy depends on labor income lying below the threshold $\text{med}(y)$, as before (whenever BAPCPA is active). The default choice is an option only if home equity is negative. In other words we assume that a person who has difficulty repaying a mortgage (say because of a negative income shock) but has positive equity in the house will always choose to sell. Owners with home equity in excess of the exemption level face eviction should they file for bankruptcy under Chapter 7. The level of homestead exemption determines whether an owner filing under Chapter 7 stays on in the house or is evicted. We define the sub-problems in Appendix A, but we illustrate the value of default here.

Value of Default The default value is similar to the value of selling exception that once defaulted, the individual cannot borrow unsecured debt and must incur a one-time utility penalty. Regarding recourse legislation, we introduce $\psi \in [0, 1]$ to capture the probability with which negative equity $((1-\phi)(ph - m))$

[18] Note the i.i.d. spending shock $\underline{a}$ appears only in the future state of assets, hence is part of the expectations operator.

will be rolled over into post default life. Notice that the future value is that of a renter, but the asset state takes into account any remaining mortgage debt $\hat{d} \leq 0$ brought forward.

$$V^{\text{def}}(S) = \max_{a'>0, l \in L} u(c, l, \underline{h}) + \beta \mathbb{E}_{w'|w,\underline{a}} \left[W(\hat{d} + a' - \underline{a}, w', t+1) \right] \tag{17}$$

subject to

$$\begin{aligned} c + \frac{1}{1+r} a' &= yl + a, \\ \hat{d} &= \psi((1-\phi)ph - m). \end{aligned}$$

Owner in Bankruptcy State An owner who has declared bankruptcy but has kept his home can either remain a home owner (stay), sell, or default on the mortgage. Thus his valuation is

$$\tilde{V}_j(S) = \max \left(\tilde{V}_j^{\text{stay}}, \tilde{V}_j^{\text{sell}}, \tilde{V}_j^{\text{def}} \right), j = 7, 13.$$

In the case of default, the amount of assets that the person carries over to the next period depends on the recourse and the mortgage debt. His financial assets must be nonnegative as he cannot borrow. If he receives a negative spending shock or a deficiency judgment, his flow utility will be $u(\underline{c}, l_1, \underline{h})$, i.e. he will consume the safety-net consumption, full leisure and the smallest house in the concerned period.

Leaving the rest to Appendix A, we show next the value for the case when the owner keeps his home

$$\tilde{V}_j^{\text{stay}}(S) = \max_{a'>0, l \in L} u(\lambda_j c, l, h) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}} \left[(1-\delta) \tilde{V}_j(S') + \delta V(S'^*) \right] \tag{18}$$

subject to

$$\begin{aligned} S' &= (\max(a' - \underline{a}, 0), w', p', n', h, t+1), \\ S'^* &= (a' - \underline{a}, w', p', n', h, t+1), \\ c + \frac{1}{1+r} a' &= a + yl - \mathbf{1}[j = 13] \bar{y} - \kappa(p_0 h, r_m, T_m), \\ j &= 7, 13, \end{aligned}$$

where δ is the probability of exiting the state of bankruptcy, $\bar{y}$ is the loan payment agreed under Chapter 13 and λ_j is the psychic cost of a bad credit record, which depends on chapter (j).

3.8.3 Terminal Value Function

We model the active part of the life cycle until a mandatory retirement age. At that point we specify a terminal value function of the form

$$V_T(a,h,p,m) = \theta_W \log(a + ph - m) - \theta_{BK}\mathbf{1}\left[\text{in bankruptcy state}\right], \tag{19}$$

where θ_{BK} is a penalty if one enters the last period in bankruptcy (BK) state.

4 Parameterization and Estimation

We limit parameter estimation to the states in group 5 in Table D.2, which we observe annually from years 2000 to 2006. The states in group 5 have similar institutions governing bankruptcy and mortgage default; in particular, they are in the same quartile of homestead exemption relative to state median income, and they allow for mortgage deficiencies.[19] A number of parameters are set based on earlier results from the literature and are shown in Table 5 with the exception of safety net and unemployment benefits which we chose to be very small numbers; our model simulations are not sensitive to our choices.[20]

The estimation of the age-specific wage process after De Nardi et al. (2020) is detailed in Appendix B. The remaining parameters are estimated using the simulated method of moments (SMM, see McFadden, 1989; Pakes and Pollard, 1989) combined with the Markov Chain Monte Carlo method (MCMC) adapted for SMM by Chernozhukov and Hong (2003). This approach makes estimation tractable and at the same time avoids problems with moments that may not be differentiable with respect to parameters, as is often the case when simulation methods are used.

[19] In principle we could estimate the model for all groups, but it would add significant computational burden.

[20] Athreya and Simpson (2006) find that the interactions of social benefits with bankruptcy are quantitatively non-negligible. Their paper abstracts from Chapter 13 choices, mortgage defaults, as well as labor supply decisions.

Table 5: Preset Parameters

Description	Symbol	Value	Source
Prob of exit from bankruptcy state	δ	0.2	legal
Risk free gross interest rate	$1+r$	1.02	data
Spending shock grid (1000 dollars)	$\underline{a}$	[0.0, 32.00, 102.00]	Livshits et al. (2007)
Spending shock probabilities	π_a	[0.925, 0.070, 0.005]	Livshits et al. (2007)
Discount factor	β	0.99	literature
Rental price of housing	p_r	0.0	normalization
Proportional selling cost	ϕ	0.06	data
Probability of deficiency judgment	ψ	0.1	Li and Oswald (2017)
Downpayment ratio	χ	0.1	data
Constant relative risk aversion	γ	2.1	Mitman (2016)
Foreclosure sale discount	δ_d	0.78	Kaplan et al. (2020)
Mortgage interest rate	r_m	0.06	See note below
Annual hours worked full time	1_L	2277	French (2005)
Annual leisure endownment (hours)	L	4466	French (2005)
House price shock persistence	ρ_p	0.96	Mitman (2016)
House price shocks SD	σ_p	0.1	Mitman (2016)
2003 Median household inc. (1000$)		43	Census Bureau
Avergage Length of Ch. 13 repayment	T_{bk}	5	legal
Max. repayment to inc. ratio in Ch. 13		0.15	legal
Bankruptcy technology	ζ	0.5	Mitman (2016)
Ch. 7 filing cost post BAPCPA (1000$)	f_7	0.6	US Government Accountability Office (2008)
Ch. 13 filing cost post BAPCPA (1000$)	f_{13}	1.7	US Government Accountability Office (2008)
Safety net: fraction of median income	$\underline{c}$	0.1	assumption
Unemployment benefit (1000$)	b	10	assumption

Freddie Mac, 30-Year Fixed Rate Mortgage Average in the United States $[MORTGAGE30US]$, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/$MORTGAGE30US$.

4.1 Estimation Results and Model Fit

The estimates together with their asymptotic standard errors are presented in Table 6.[21] The education groups display very different preferences for housing and for work (fixed costs). The stigma effects associated with bankruptcy $\lambda_{7,13}$ and with default λ_{def} are high. For example, the stigma of Chapter 7 bankruptcy for college graduates reduces period consumption by 51% (1 - 0.49). Similarly, the parameter for final period bankruptcy θ_{BK} is large for the low educated group, which is required to deter them from ending life in bankruptcy. The other preference parameters reflect the patterns in the data, and in combination with the budget constraint determine the fit of the model, to which we now turn.

[21] For the low education group the hessian of the GMM objective function is flat in several dimensions at the optimum, resulting in four poorly identified parameters. We surpess the corresponding standard error estimates for this reason.

Table 6: Parameter Estimates by Education Group

		High Education		Low Education	
		Estimate	Standard Error	Estimate	Standard Error
Utility: c, l and h					
Housing (warm glow)	μ	0.501	0.045	3.05	0.596
Housing (multiplicative)	θ_H	-0.1	0.035	-0.9	0.895
Consumption Exponent	ω	0.4	0.608	0.44	–
Fixed Cost of Work	θ_P	998.541	1.051	2013.93	26.899
Bequest Weight	θ_W	7.91	0.006	6.614	0.272
Utility: Bankruptcy and Default					
Stigma Ch. 7	λ_7	0.49	0.027	0.42	–
Stigma Ch. 13	λ_{13}	0.695	0.006	0.535	–
Stigma Default	λ_{def}	0.76	0.002	0.59	–
Period T BK penalty	θ_{BK}	0.0	0.234	213.9	5.701

Model Fit Table 7 displays model and data moments on bankruptcy filing rates by chapter, mortgage default rates, homeownership rates, and annual hours worked for each education group and for households on average and near retirement, respectively. Overall, the model does a good job at matching bankruptcy filing rates and mortgage default rates for both education groups and for the near retirement age group though we overpredict Chapter 13 bankruptcy filing rates for the low education group. In terms of homeownership rates, our model slightly underpredicts relative to the data for both education groups. The average number of hours worked is a bit higher in the model than in the data for both education groups, likely a consequence of not modeling disability that pushes hours down from the age of 45 (see Meghir and Pistaferri, 2011; Low et al., 2010).

Table 7: Model Fit by Education Group

	High Education		Low Education	
	Model	Data	Model	Data
Bankruptcy 7 (‰)	6.926	5.794	7.144	8.787
Bankruptcy 13 (‰)	3.151	2.079	8.446	3.957
Bankruptcy Filing rate (age 50-60) (‰)	8.126	9.883	11.911	9.883
Default rate (%)	1.208	1.668	1.661	2.88
Homeownership	0.712	0.727	0.573	0.605
Homeownership (age 59)	0.889	0.867	0.714	0.783
Annual hours worked	2186	2057	2053	1822

5 Model Implications

5.1 Defining Consumption Equivalent Welfare

In what follows, we use ι to denote the willingness to pay as a proportion of consumption c for a consumer to be indifferent between the baseline and an alternative scenario. We define the equalizing willingness to pay for the group of individuals indexed by initial simulation condition Ω as

$$\iota(\Omega) = 1 - \left(\frac{E_0 U_0(\Omega) - E_0 \left(\Sigma_t \beta^t \mu \hat{\mathbf{H}}_{\mathbf{it}}(\Omega) \hat{h}_{it}(\Omega) + \beta^{T-1} \hat{V}_{iT}(\Omega) \right)}{E_0 \Sigma_t \beta^t \left(\frac{\left(\hat{c}_{it}(\Omega)^{\omega} \left(L - \hat{l}_{it}(\Omega) - \hat{\mathbf{P}}_{\mathbf{it}}(\Omega) \theta_P \right)^{1-\omega} \right)^{1-\gamma}}{1-\gamma} \exp\left(\theta_{\hat{H}_{it}} \hat{h}_{it}(\Omega) \right) \right)} \right)^{\frac{1}{\omega(1-\gamma)}}, \tag{20}$$

where E_0 is the expectation with respect to information in the initial period. Thus $E_0 U_0(\Omega)$ is the ex-ante baseline lifetime utility, given initial condition Ω. Choice variables under the counterfactual policy are shown with a hat. We compute the weighted average over all $\iota(\Omega)$, where the weights are the empirical frequencies of the initial conditions, drawn for asset position, ownership status, and initial wage shock.[22]

5.2 Policy Functions

As an example of the tradeoffs involved in households' decisions, consider Figure 2, where we illustrate a set of discrete choice policy functions from the baseline model. In the figure, we depict owners in the top row and renters in the bottom row. We project the high-dimensional policy function into wage-unsecured debt space, shading areas of certain discrete choices with different colors. Starting thus with an owner at young age in Figure 2a, we observe that at moderate levels of unsecured debt and relative high hourly wage, the owners optimally stays in the house (northeast in the plot). As we traverse the picture going southwest, hence increasing unsecured debt and decreasing wage, there is first a region with optimal sale and last a region where filing for Chapter 7 is the optimal choice.

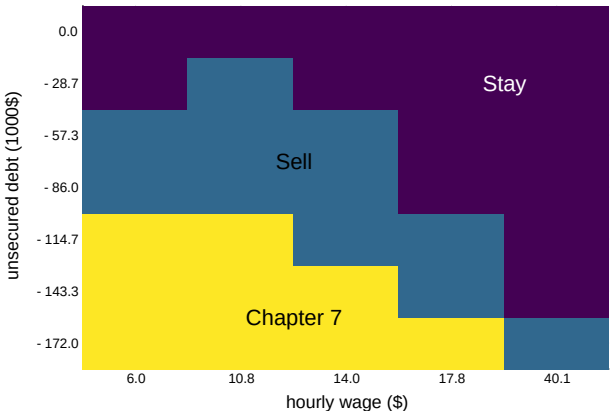
In Figure 2b we examine what happens to the owner at the same stage in the life cycle, but upon receiving a negative house price shock. A young home owner has little equity in the house, which turns

[22] We report the measure in terms of percent, such that $\iota = 1.1$ means that the average consumer is willing to pay 1.1% of consumption (hence prefers the policy scenario), whereas $\iota = -2.1$ means the consumer has a negative willingness to pay for the policy, i.e. would demand an increase of 2.1% of consumption in order to be indifferent.

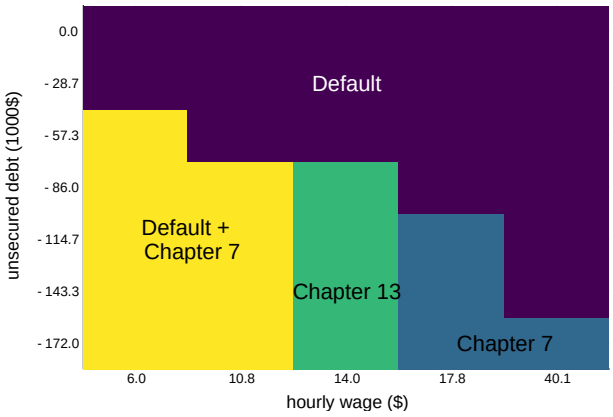
quickly negative after the price shock – hence mortgage default becomes the optimal action in the northeastern region. As accompanying unsecured debt increases and as wages change, there are different regions where the owner will either file for Chapter 7, Chapter 13 or a combination of default and Chapter 7 in the southwest corner. The choice between Chapter 7 and Chapter 13 involves whether the house would be lost in a Chapter 7 bankruptcy (which is not the case here, as there is no excess equity, hence nothing to gain for the mortgage lender), and the wage rate, which determines the required Chapter 13 repayments in the repayment plan. Here, too high a wage rate deters the owner from choosing Chapter 13, because Chapter 7 offers the same benefits (keep the house), without the associated costs (future wage garnishments).

Figure 2c presents decisions made by a young renter after receiving a negative spending shock in the first period of life. Note that receiving a spending shock is the only way for an individual to have unsecured debt in the first period of life as we assume individuals start life with non-negative assets. At high hourly wage levels, the renter will buy. However, as unsecured debt grows larger and wages smaller, the renter first decides to keep renting, and finally file for bankruptcy under Chapter 13. In the adjacent Figure 2d, which depicts the renter at period 20 (age 45), hence with a substantially higher wage rate, we see that buying a house is an option that is optimal on a larger subset of the state space, and that the choice of bankruptcy chapter has changed to Chapter 7 - a result of the higher wage as he would incur larger Chapter 13 repayments.

Figure 2: Discrete Choice Functions (High Education Group).

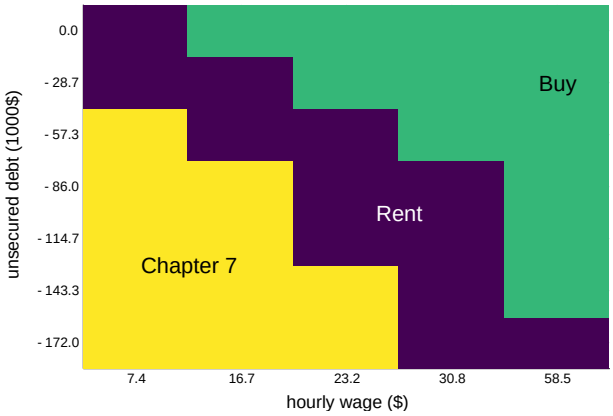


(a) Owner at age 26, with a 1-year-old mortgage.



(b) Owner at age 26 with adverse house price shock.

(c) Renter in first period (age 25) with a spending shock.



(d) Renter discrete choices at age 45.

5.3 The Role of Price and Wage Risk

Our model includes many complex interactions. To better understand them, in this section we derive elasticities in several economic outcomes as well as welfare effects with respect to various risks, emphasizing differences across education groups. Specifically, in Table 8 we show the elasticities in bankruptcy filing rates, interest rates, mortgage default rates, homeownership rates, and hours worked with respect to changes in the standard deviation of the house price shock and of the wage shock. It is important to note that when we perturb risk, we arrive at a new equilibrium with different interest rates. Moreover, changes in risk cause wealth effects, which we do not compensate for. This is particularly the case here, because the bankruptcy system, together with the safety net provisions we have allowed for, insures against the worst outcomes.

Table 8: Elasticities to House Price Risk and Wage Risk

Elasticities to Risk Changes				
	High Education		Low Education	
	House Price (p)	Wage (w)	House Price (p)	Wage (w)
Bankruptcy	0.135	−1.056	0.877	0.584
Bankruptcy 7	0.167	−1.917	1.078	0.846
Bankruptcy 13	0.066	0.835	0.707	0.362
Interest	0.031	−0.101	0.04	0.083
Ownership	0.043	0.12	−0.034	0.231
Default	−0.038	−0.75	0.40	−0.858
Hours	−0.012	−0.033	−0.002	−0.174
Initial Mortgage Rate	−0.007	0.004	0.006	0.013
Hours Renters	−0.005	0.001	0.01	0.025
Hours Owners	−0.009	−0.04	−0.003	−0.231
Hours Renters (in ch. 7)	−0.10	−0.081	0.026	0.275
Hours Owners (in ch. 7)	−0.024	0.093	−0.046	−0.091
Hours Renters (in ch. 13)	−0.0143	−0.0114	0.0003	0.286
Hours Owners (in ch. 13)	−0.026	−0.19	0.059	–

Note: The elasticities are calculated as the percent change in an outcome as a result of a one percent change in the standard deviation of the house price shock or the wage shock. There are no low-educated owners filing for Chapter 13 in the high wage variance model.

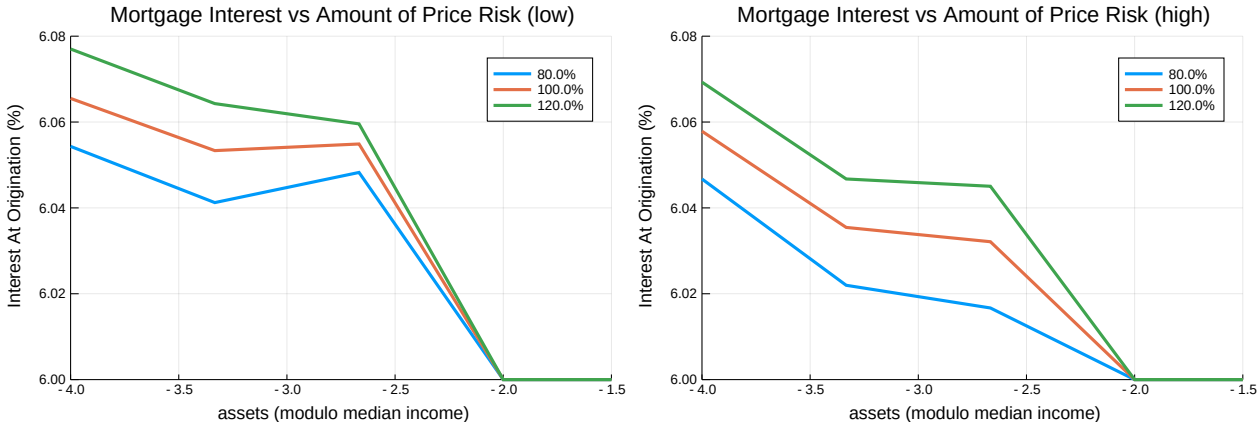
The elasticities are reported in Table 8. There are three takeaways from the table. First, Chapters 7 and 13 bankruptcies are sensitive to increases in house price risk, especially for the low education group, while the mortgage default rates are not sensitive to house price risk. Second, the interest rate elasticity with respect to house price risk is positive and higher for the low education group than for the high education group. Finally, hours worked are not sensitive to house price risk except for low education homeowners in Chapter 13 workout. One of the important drivers of these results is that the wealth effects are stronger for low education group than for the high education group.

Turning to wage risk, the importance of distinguishing between education groups becomes evident. For higher education households an increase in wage risk leads to a decline in overall bankruptcies, while the opposite is true for low education households. Moreover, within the high education group there is a large shift away from Chapter 7 towards Chapter 13, mortgage default rates decline and homeownership rates rise. Initial mortgage rates, on the other hand, change little. For the low education group both Chapter filings rise and particularly for Chapter 7. Consistent with these changes, equilibrium interest rates for unsecured

debt decline for the high education group but increase for the low education group. Finally, hours worked for the low education households decline with increased wage risk, reflecting in part the resulting wealth effects. This is driven by owners while renters increase their hours worked. For high education individuals, homeowners also work somewhat less particularly those in Chapter 13 bankruptcy.

To provide further understanding of the underlying equilibrium, Figure 3 demonstrates how the cost of a mortgage changes with assets (relative to median income) as well as with the amount of house price risk. Noe that the cost is forward looking and accounts for the possibility of unsecured debt being accumulated following the issue of the mortgage. Overall, mortgage rates do not vary very much, reflecting the importance of collateral. The little variation that exists is more driven by the amount of unsecured debt at origination than by house price risk. The rate quickly converges to the low risk rate as unsecured debt declines. In addition the interest rate faced by lower education individuals is higher at all levels of assets than that faced by high education individuals, reflecting the higher probability of an income shock leading to bankruptcy for this group of people.

Figure 3: Mortgage Interest Rate by House Price Risk and Assets at Origination



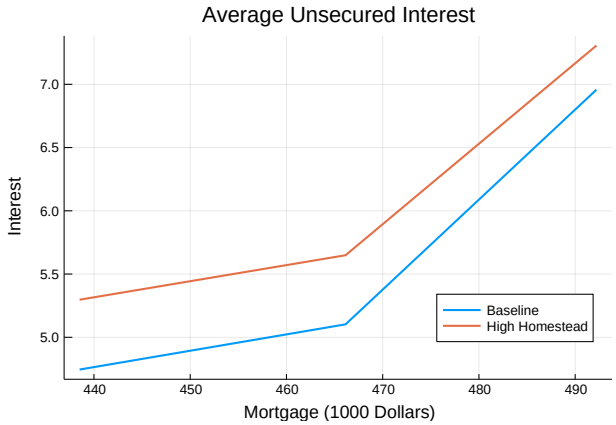
(a) Initial Mortgage Rates for Low Educated Buyer.

(b) Initial Mortgage Rates for High Educated buyer.

Note: House price risk is set at 80% of baseline, at baseline (100%), and at 120% of baseline.

Finally, Figure 4 shows the close relationship between unsecured borrowing and the level of the mortgage loan for a group of high risk owners. All else equal, a higher mortgage loan implies an increased risk of default, which can then trigger bankruptcy when there is recourse. Moreover, with some of the home equity protected by homestead exemption, a large mortgage loan may also lead to bankruptcy so that the households can have their unsecured debt discharged and thus have more resources to service the mortgages.

Figure 4: Median Interest Rates as a Function of Mortgage debt. In this figure we condition on owners at relative higher risk of bankruptcy, hence relatively young, not high wage, and not in a high house price environment – in practice, we set state variables $(t \in \{1,2,3\}, n > 12, h = 2, p < 4, w < 4)$. For this group, the average mortgage debt is 484 thousand Dollars at ages $t \in \{1,2,3\}$, and is monotonically declining in age. The high risk group accounts for 34% of their corresponding age and mortgage size cohort, i.e. the group $(t \in \{1,2,3\}, n > 12, h = 2)$



5.4 Labor Supply, Assets and Consumption Before and After Bankruptcy Filing

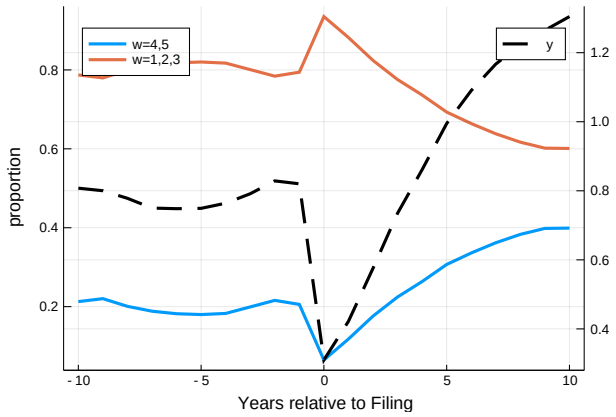
Labor supply offers a mechanism for individuals to mitigate adverse income shocks and potentially to stave off bankruptcy. Shocks to wages, however, can lead to bankruptcy or even mortgage default and discourage work effort. The implicit earnings tax induced by the repayment scheme under Chapter 13 can add to these disincentives. Next we present an event study of labor supply and wage rates before and after a bankruptcy event. In interpreting the results it is important to note that the vast majority of bankruptcies in the model are caused be a large negative wage shock, only occasionally accompanied by spending shocks: 93% for the higher education people and 95% for the low. The main role of the catastrophic spending shocks is to force unsecured borrowing, which then makes people vulnerable to such wage/employment shocks.

In Figure 5a we present the fraction of individuals receiving adverse wage shocks ($w = 1,2,3$) versus positive ones ($w = 4,5$) leading up to bankruptcy. Figure 5b presents the movements of assets, consumption, and labor income. As is evident the adverse shocks dominate and (not shown) there is a shift towards the worst shocks within the adverse group as we approach the date of filing. Labor income, the product of the shocks and endogenous labor supply, remains relatively stable. This is due to the increase in labor supply seen in Figure 5c for those who will eventually choose to file under Chapter 7 and Figure 5d for Chapter 13 filers. On one hand, those who eventually file for bankruptcy work much fewer hours than average in the ensuring five years of bankruptcy filing. On the other hand, they did increase labor supply in their attempt

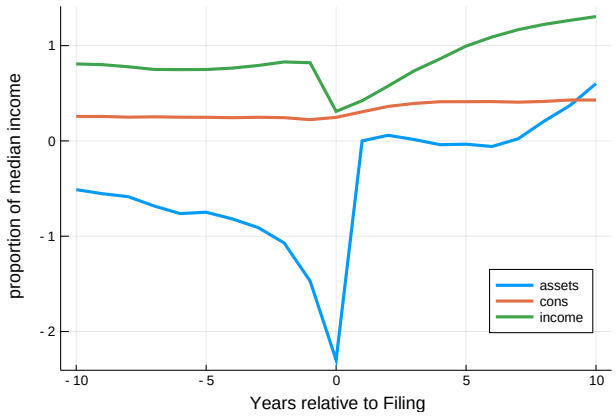
to avoid bankruptcy filing 2-3 years before the event, despite the decline in wages. Consumption remains remarkably stable, demonstrating the amount of insurance provided by bankruptcy and the safety net.

Figure 5: Event Study Around the Point of Bankruptcy Filing for High Education Individuals

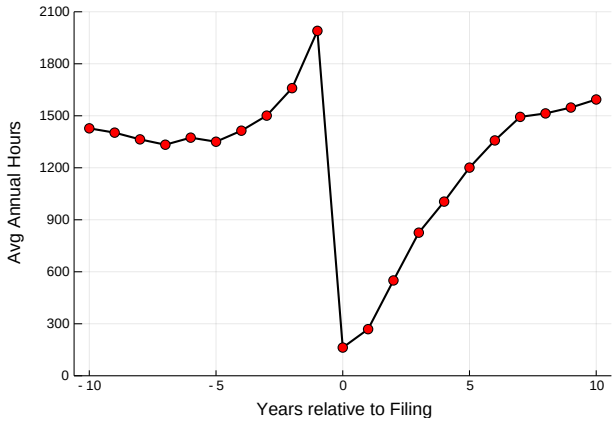
(a) Proportion receiving negative wage shocks ($w = 1, 2, 3$) versus positive ($w = 4, 5$) and labor income (y)



(b) High educated event study: assets, consumption and income.



(c) Hours of work: Chapter 7 filers



(d) Hours of work: Chapter 13 filers.

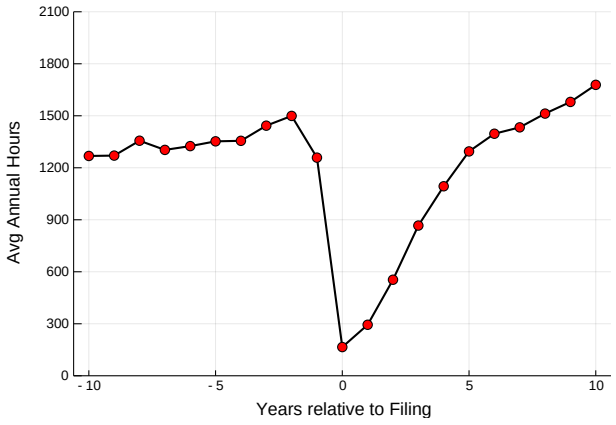
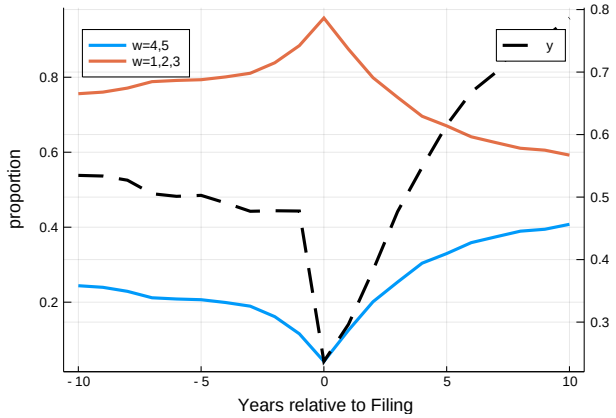


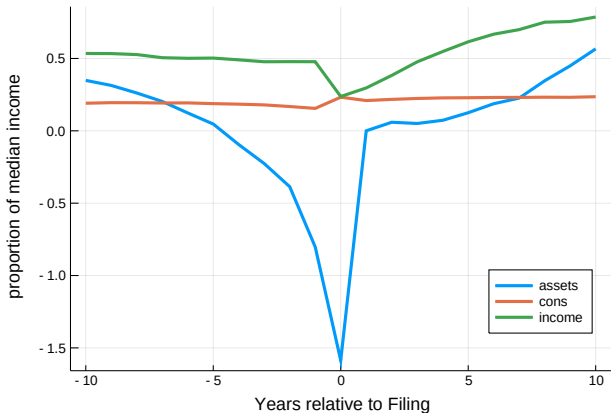
Figure 6 reports the same information but for the lower education group. Two observations stand out. First, bankruptcy filers work much fewer hours than their high education counterparts, due to the lower wages they face despite the fact their hours increase rapidly in the year immediately before filing for Chapter 7 bankruptcy. Second, the recovery in income and hours is protracted.

Figure 6: Event Study around the Point of Bankruptcy Filing for Low Education Individuals

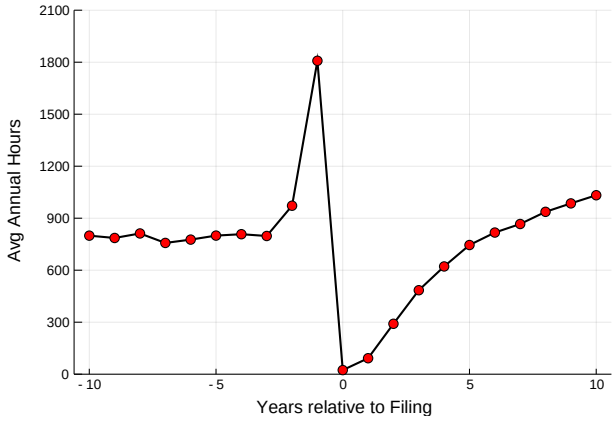
(a) Proportion receiving negative shocks ($w = 1, 2, 3$) versus positive ($w = 4, 5$) and labor income (y)



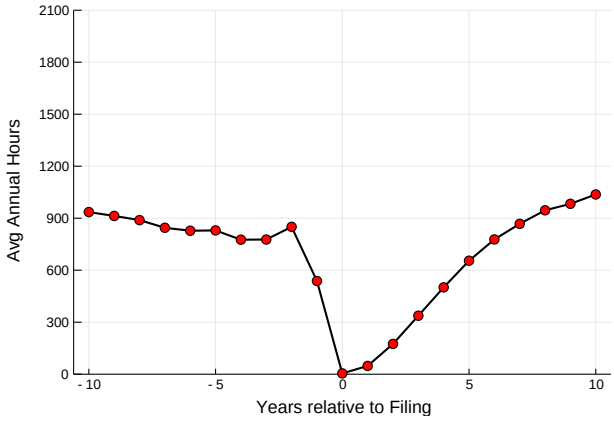
(b) Low educated event Study: Assets, Consumption and income.



(c) Chapter 7 filers' hours



(d) Chapter 13 filers' hours



6 Policy Counterfactuals

We now examine the impact of alternative structures of bankruptcy law. We start with an analysis of the value of bankruptcy protection. Then we conduct our evaluation of BAPCPA reform as in Mitman (2016), amongst others, with added discussion on the heterogeneity based on education and labor market outcome.[23]

[23] In Appendix D.1 we report the impact of different levels of recourse, relative to our baseline, providing some comparability with Mitman (2016). We find that increasing recourse tends to increase bankruptcy filings and interest rates for unsecured debt, but decreases mortgage default. Hours worked are not sensitive to this change, except for those with low education filing under Chapter 7. Welfare decreases as we move from no recourse to 20% recourse, reflecting the fall in insurance protection.

6.1 The Value of Bankruptcy Protection

Chapter 7 and Chapter 13 differ substantially in the insurance they offer and in their moral hazard implications. Their value is likely to be very different depending on the level and volatility of income and on preferences for work and housing. In this section we quantify these differences across education groups, which differ in these dimensions. In doing this we demonstrate important distributional implications of such policies. To achieve this we shut down each of the chapters in turn and assess the implications. A complete abolition of all bankruptcy provisions in the presence of catastrophic consumption shocks would require introducing other forms of consumption support and consequently entails a degree of arbitrariness.[24]

The results are reported in Table 9. For the higher educated group the complete abolition of Chapter 7 leads to a dramatic decline in bankruptcies and as a result a fall in interest rates for unsecured debt. Mortgage defaults also decline significantly. While hours worked do not change on aggregate, the hours of those filing under Chapter 13 increase by about five weeks a year. The net effect is an increase of welfare equivalent to 10% of consumption. This large effect is due to the almost complete elimination of moral hazard, making unsecured borrowing much cheaper, while still offering some necessary protection via Chapter 13.

Focusing on the lower education group, while bankruptcy declines substantially, interest rates actually increase a bit for those who borrow because the composition of borrowers shifts towards individuals with a higher risk of filing. Mortgage default also declines substantially because of the reduction in unsecured debt, the decline in overall bankruptcies and the elimination of Chapter 7. Hours worked decline, particularly for renters. The reduction in hours worked partially reflects the decline in ownership and hence the reduced need to accumulate for a down payment. By contrast, hours worked by Chapter 13 filers increase by about three weeks a year. There is also a substantial decline in homeownership. The net effect of all these changes is a large decline in welfare of 12%, stemming from the large decline in insurance for this group. The overall aggregate welfare effect accounting for the relative size of the groups,[25] however, is a moderate loss of -0.06%. In other words this policy has strong distributional effects, but little aggregate effect on the economy.

When Chapter 13 is abolished and only Chapter 7 is available, for the higher education group this reduces bankruptcy only slightly. But since creditors lose more we observe a large increase in interest rates.

[24] In some countries such as the UK, bankruptcy laws are much less generous than those in the US; catastrophic consumption shocks, however, are insured. For example, such shocks often relate to uninsured healthcare expenses, which are insured by public health systems such as the NHS. An interesting research question is to examine the relative merits of insuring the shocks themselves in this way rather than having to resort to bankruptcy, but this is beyond the scope of this paper.

[25] The percentage of those with high education is 54%.

Hours worked change little except for those in bankruptcy where we see a decline. The result is a fall in welfare for this group of about 1.7%. For the lower education group, shutting down Chapter 13 also reduces bankruptcy by a small amount and has a large impact on the interest rate, because all those who now switch to Chapter 7 impose larger losses on creditors. The net effect is a small increase in welfare of about 0.5%, implying an aggregate impact of -0.73% in consumption equivalent for the whole economy.

These exercises demonstrate that the way bankruptcy law is organized has important distributional consequences masked by the aggregate effect. Moreover, these distributional effects are not a straightforward implication of the differences in the income processes because preferences also differ significantly.

Table 9: Abolishing Bankruptcy by Chapter

	High Education			Low Education		
	Baseline	No Ch. 7	No Ch. 13	Baseline	No Ch. 7	No Ch. 13
Bankruptcy (‰)	10.078	0.529	9.648	14.987	3.752	13.166
Bankruptcy 7 (‰)	6.926	-	9.648	7.144	-	13.166
Bankruptcy 13 (‰)	3.151	0.529	-	8.446	3.752	-
Interest (%)	12.63	6.97	16.28	25.31	27.15	36.27
Ownership	0.712	0.694	0.711	0.573	0.547	0.571
Default	1.208	0.693	1.197	1.661	1.254	1.654
Hours	2186	2189	2187	2053	2022	2052
Hours Renters	2242	2239	2245	2125	2064	2130
Hours Owners	2184	2173	2184	2033	2004	2030
Hours Renters (in ch. 13)	1666	1863	-	1687	1809	-
Hours Owners (in ch. 13)	2194	-	-	1993	-	-
Cons. Equivalent (%)	-	10.22	-1.74	-	-12.128	0.463

6.2 The Impact of the BAPCPA reform

The Bankruptcy Abuse Prevention and Consumer Protection Act (BAPCPA) was signed into law in April 2005 and took effect after October 17 of the same year. The bill was designed to make it more difficult to file for bankruptcy, and in particular, to file under Chapter 7. For instance, under the reform, to be eligible for filing under Chapter 7, individual earnings have to be lower than the state median. The cost of bankruptcy filing has also gone up significantly after the reform. According to a report by the US Government Accountability Office (2008), average total of filing and attorney costs of Chapter 7 increased from $900 to $1500 after the reform, and those for Chapter 13 from $3700 to $5700. This reform has been evaluated extensively in the literature as we have reviewed in the introduction. We revisit it here from the perspective

of our model, which allows for labor supply adjustments and distinguishes between education groups.

Table 10: Impact of BAPCPA Reform

Impact of BAPCPA Reform				
	High Education		Low Education	
	Baseline	BAPCPA	Baseline	BAPCPA
Bankruptcy (‰)	10.078	9.383	15.591	15.429
Bankruptcy 7 (‰)	6.926	6.521	7.144	8.493
Bankruptcy 13 (‰)	3.151	2.862	8.446	6.936
Interest (%)	12.63	12.04	25.31	28.16
Ownership	0.712	0.711	0.573	0.573
Default (%)	1.208	1.206	1.661	1.653
Hours	2186	2185	2053	2054
Hours Renters	2242	2241	2124	2127
Hours Owners	2184	2185	2033	2034
Hours Renters (in ch. 13)	1666	1689	1687	1703
Hours Owners (in ch. 13)	2194	2086	1993	2017
Consumption Equivalent WTP (%)	–	-0.046	–	-0.603

We analyze the effects of the BAPCPA reform by looking at two steady states of the model economy, before and after the reform. Throughout, we keep the stochastic shocks describing the economic environment constant. The policy equilibrium in the model is characterized by the implementation of the means test to access Chapter 7, the implementation of homestead exemption cap, and the increase of monetary filing costs. The results are shown in Table 10 by education group.

Starting with the high education group, we see that the reform has the expected effect of reducing both Chapter 7 and Chapter 13 cases, due to means tests requirement for Chapter 7 filing and higher filing costs for both Chapters. As a result, average unsecured interest falls. Aggregate ownership and default are barely affected by the reform. Aggregate hours worked do not change much either. However, renters in Chapter 13 work more while owners in Chapter 13 work less. Overall, higher educated individuals are almost indifferent to BAPCPA, with a negative willingness to pay of about 0.05%.

For the lower education group, bankruptcy rates are similar to the baseline, but there is some substitution towards Chapter 7 bankruptcy. This results in an increase in interest rates for unsecured debt from 25.3% to 28.2%. In terms of labor supply, those filing under Chapter 13 work slightly more. On balance, the BAPCPA reform implies a 0.6% reduction in consumption equivalent welfare for the low education group. The nature

of income and spending shock processes implies a more frequent need for bankruptcy protection for this group and BACPCA made them substantially worse off.

In terms of aggregate headline numbers, our estimation indicates a smaller welfare loss associated with BAPCPA than that in Mitman (2016). The comparison is not straightforward, because Mitman's calculations includes the transition period. Moreover, there are important differences in the two models, including the fact ours is a lifecycle model with labor supply and the presence of catastrophic consumption shocks.

7 Conclusions

In this paper we evaluate central aspects of bankruptcy legislation and consider how these effects differ across education groups with different exposure to risk and different preferences. We do so by specifying and estimating a lifecycle model of consumption, housing demand and labor supply in an environment where individuals may file for bankruptcy or default on their mortgage. Uncertainty in the model is driven by house price shocks, catastrophic consumption shocks (such as health expenditures) and wage/productivity shocks, while bankruptcy is governed by the basic institutional framework in the U.S. as implied by Chapter 7 and Chapter 13. Importantly, the supply of unsecured and secured credit is endogenous, leading to interest rates that depend on the probability of an individual filing for bankruptcy protection or defaulting on their mortgage. Allowing for such endogenous interest rates is central to understanding the role of bankruptcy legislation because there is a very stark tradeoff between the effects of insurance protection and moral hazard.

There are a number of key insights from our paper. First, labor supply adjusts before bankruptcy to mitigate the effects of negative shocks and to avoid filing, implying that a number of bankruptcies are avoided by such preventive action. Labor supply declines at the moment of filing, because of the large negative productivity shocks that induce it. It recovers only gradually. Though the overall population labor supply is not sensitive to changes in bankruptcy legislation, it is sensitive to changes in risk and associated wealth. Second, the availability of Chapter 7 has starkly different implications for low education and high education groups, increasing substantially the welfare of the former and decreasing it for the latter, despite the presence of Chapter 13. The aggregate effect on welfare is however, zero. For the high education group the moral hazard aspect of Chapter 7 is the dominant factor, while for the lower education group the insurance component is central. Third, the availability of Chapter 13 also has opposing effects for the two education groups, improving the welfare of the higher group but decreasing slightly the one for the lower (given the

presence of Chapter 7). However, the impacts are much smaller. A key implication of this result is that in evaluating bankruptcy legislation the distributional component across demographic groups is important to consider. We emphasize that this is not just due to differences in the income process and level but also due to important differences in preferences for housing and work.

Finally, we reevaluate BAPCPA and find it has very small effects on bankruptcy and only on the high education group. Overall the welfare effects were negative and mostly due to the lower education group, which is consistent with the value of Chapter 7 for this group. Future research should also consider how family labor supply interacts with bankruptcy legislation and with filing and what role the added worker effect has in mitigating extreme shocks. While this is an important issue, it is left for future work.

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Appendices

A The Complete Description of the Value Functions

A.1 The Choice of Renters

In what follows we describe the problem including the means test to cover the BACPCA period. Let W represent the maximal expected lifetime utility for a renter of age t if not in a bankruptcy state and let $\tilde{W}_j$ denote the utility for a renter in bankruptcy state $j = 7, 13$. Let s denote the end of period savings (i.e. $s = a'$) and $\text{med}(y)$ the state median income. We then have:

$$W(a,w,t) = \begin{cases} \max\left(W^{\text{rent}}, W^{\text{buy}}, W^{\text{file.7}}, W^{\text{file.13}}\right) & \text{if } a < 0, yl < \text{med}(y), \\ \max\left(W^{\text{rent}}, W^{\text{buy}}, W^{\text{file.13}}\right) & \text{if } a < 0, yl \geq \text{med}(y), \\ \max\left(W^{\text{rent}}, W^{\text{buy}}\right) & \text{if } a \geq 0. \end{cases} \tag{A.1}$$

The restriction on the discrete choice set of the renter in (A.1) makes explicit the fact that one can file for bankruptcy only if there are effectively unsecured debts to discharge. In addition we implement the BAPCPA means test by preventing individuals with labor income above a threshold $\text{med}(y)$ to file for Chapter 7. We define the conditional value functions next.

Value of Renting

The value of renting is given by

$$\begin{aligned} W^{\text{rent}}(R) &= \max_{a' \in \mathbb{R}, l \in L} u(c,l,\underline{h}) + \beta E_{w'|w}\left[W(R')\right] && \text{(A.2)} \\ &\text{subject to} \\ c + q(a'|w)a' &= yl + a > 0 && \text{(A.3)} \\ \pi^7(a'|w) &= E_{w'|w}\left[\mathbf{1}\left[W^{\text{file.7}}(R') > W^{-\text{file.7}}(R')\right]\right] && \text{(A.4)} \\ \pi^{13}(a'|w) &= E_{w'|w}\left[\mathbf{1}\left[W^{\text{file.13}}(R') > W^{-\text{file.13}}(R')\right]\right] && \text{(A.5)} \\ & q_a(a'|w) \text{ as in (7)}, && \text{(A.6)} \end{aligned}$$

where R is the current state space and R' the state space as it evolves. Equation (A.3) is a standard budget constraint that requires expenditures (consumption c and saving/borrowing a') to be equal to cash-on-hand

(labor income plus assets minus rent, which is normalized to zero). Equations (A.4) and (A.5) show how the probability of bankruptcy for each case (π^7 and π^{13} for Chapter 7 and 13 respectively) is calculated by the lender in order to define the price of debt q in equation (A.3). We use the convention that labeling a value function with $-j$ means all other discrete choice values *except* j.

Renter Bankruptcy Chapter 7

The value of filing for bankruptcy under Chapter 7 as a renter is similar to the value of staying a renter with the exception that current assets are set to $a = 0$ in the budget constraint since all assets are used against the debt. Moreover, the various penalties are applied (psychic cost of bankruptcy $\lambda_{7,e} \in (0,1]$ and no borrowing; $\lambda_{7,e} = 1$ implies no punishment at all, $\lambda_{7,e} = 0$ would imply zero consumption as punishment. The future value in the bankruptcy state 7 is denoted by $\tilde{W}_7$. Upon filing for Chapter j, a fee of f_j is collected, and no savings are possible.

$$\begin{aligned} W^{\text{file.7}}(R) &= \max_{l \in L} u(c\lambda_{7,e}, l, \underline{h}) + \beta E_{w'|w}\left[\tilde{W}_7(R')\right] \\ &\text{subject to} \\ c &= yl - f_7. \end{aligned} \tag{A.7}$$

The individual suffers the utility (stigma) cost $\lambda_{7,e}$ and cannot borrow until she exits this state. This happens with probability δ in each period. Thus the expected duration of the punishment state is $\frac{1}{\delta}$. The value $\tilde{W}_7$ in the bankruptcy state is

$$\begin{aligned} \tilde{W}_7(a,w,t) = \max_{a' \in \mathbb{R}_+, l \in L} & \; u(c\lambda_{7,e}, l, \underline{h}) + \beta E_{w'|w}\left[\delta W(R') + (1-\delta)\tilde{W}_7(R')\right] \\ \text{subject to} & \\ c + \frac{1}{1+r}a' &= yl + a. \end{aligned}$$

Renter Bankruptcy Chapter 13

Individuals may not be eligible for Chapter 7, or indeed may choose Chapter 13. This problem is very similar to the previous one except that a repayment $\bar{y}$ needs to be made. Hence moving into the bankruptcy state we have

$$\begin{aligned} W^{\text{file.13}}(a,w,t) &= \max_{l \in L} u(c\lambda_{13,e}, l, \underline{h}) + \beta E_{w'|w}\left[\tilde{W}_{13}(\bar{y}(a,w), 0, w, t+1)\right] \\ &\text{subject to} \\ c &= yl - f_{13} > 0, \end{aligned} \tag{A.8}$$

where $\bar{y}(a,w)$ is defined in (A.9).

We denote by $\bar{y}$ the amount to be repaid in each period of Chapter 13, and by $\bar{Y}$ total expected income over the next T_{bk} years. Federal law imposes a maximum debt to income ratio $\hat{y} = 0.15$ that the repayment $\bar{y}$ must respect, hence we define

$$\begin{aligned} \bar{y} &= \iota(a, \bar{Y}, \hat{y}) \frac{\bar{Y}}{T_{bk}} \\ \iota(a, \bar{Y}, \hat{y}) &= \begin{cases} \frac{-a}{\bar{Y}} & \text{if } \frac{-a}{\bar{Y}} < \hat{y} \\ \hat{y} & \text{else.} \end{cases} \end{aligned} \tag{A.9}$$

Then the corresponding punishment state following filing for Chapter 13 is given by

$$\tilde{W}_{13}(\bar{y}, a, w, t) = \max_{a' \in \mathbb{R}_+, l \in L} u(c\lambda_{13,e}, l, \underline{h}) + \beta E_{w'|w}\left[\delta W(R') + (1-\delta)\tilde{W}_{13}(R')\right]$$

subject to

$$c + \frac{1}{1+r}a' = yl - \bar{y} + a > 0.$$

A.2 The Problem of the Owner

The discrete choice problem of an owner not in a bankruptcy state is quite complex because of the large number of subcases, depending on the asset position, the house value and the level of income. It is given by

$$V(S) = \begin{cases} \max\left(V^{\text{stay}}, V^{\text{sell}}\right) & \text{if } a \geq 0, hp_t - m_t \geq 0, \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{def}}\right) & \text{if } a \geq 0, hp_t - m_t < 0, \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{file.7}}, V^{\text{file.13}}\right) & \text{if } a < 0, hp_t - m_t \geq 0, yl < \text{med}(y), \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{file.13}}\right) & \text{if } a < 0, hp_t - m_t < 0, yl \geq \text{med}(y), \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{def}}, V^{\text{file.7}}, V^{\text{file.13}}, V^{\text{file.def}}\right) & \text{if } a < 0, hp_t - m_t < 0, yl < \text{med}(y), \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{def}}, V^{\text{file.13}}, V^{\text{file.def}}\right) & \text{if } a < 0, hp_t - m_t < 0, yl \geq \text{med}(y), \end{cases} \tag{A.10}$$

where $a \geq 0$ denotes someone with positive financial assets and $hp_t - m_t$ is the net equity in the house. Again, not all discrete choices are available everywhere on the state space, as can be seen from the restrictions for each case. For example, the admissible chapter of bankruptcy depends on labor income lying below the threshold $\text{med}(y)$, as before. The default choice is an option only if home equity is negative. In other words we assume that a person who has difficulty repaying a mortgage (say because of a negative income shock) but has positive equity in the house will always choose to sell. Owners with home equity in excess of the exemption level face eviction should they file for bankruptcy under Chapter 7. The level of homestead exemption determines whether an owner filing under Chapter 7 stays on in the house or is evicted. We define the sub-problems in sequence below. Let $S = (a, w, p, n, h, e, t)$ denote the current state space.

Value of Staying as Owner

The value of staying in the current home is

$$V^{\text{stay}}(S) = \max_{a' \in \mathbb{R}, l \in L} u(c, l, h) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[V\left(S'\right)\right] \tag{A.11}$$

subject to

$$c + \frac{q(a'|S)}{1+r} = yl + a - \kappa(p_{i0}h, r_m, T_m).$$

This problem is similar to the buyer's problem defined in the main text of the paper except that there is no down-payment in the budget constraint.

Value of Selling the Home

The value of selling depends on the renter's continuation value:

$$\begin{aligned} V^{\text{sell}}(S) &= \max_{s\in\mathbb{R}, l\in L} u(c,l,\underline{h}) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[W(R')\right] \\ &\text{subject to} \\ c + \frac{q(a'|S)}{1+r} &= yl + a + ((1-\phi)ph - m), \end{aligned} \tag{A.12}$$

where $(1-\phi)ph - m$ is the capital that can be recovered following the sale: ϕ is the proportion of capital lost by the process of selling due to administrative and marketing costs.

Value of Default

The default value, in turn, is similar to the value of selling with the exception that for a defaulter unsecured borrowing is impossible, and a one-time utility penalty is incurred. Regarding recourse legislation, we include a factor $\psi \in [0,1]$ here that relates to the fraction of negative equity ($(1-\phi)(ph-m)$) that is rolled over in post default life. For example $\psi = 1$ would mean that the entire remaining mortgage debt is rolled over into post default life. Notice that the future value is that of a renter, but the asset state takes into account any remaining mortgage debt d brought forward.

$$\begin{aligned} V^{\text{def}}(S) &= \max_{a'>0, l\in L} u(c,l,\underline{h}) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[W(d + a' - \underline{a}, w', p', t+1)\right] \\ &\text{subject to} \\ c + \frac{1}{1+r}a' &= yl + a, \\ d &= \psi((1-\phi)ph - m). \end{aligned} \tag{A.13}$$

Owner Bankruptcy Chapter 7

The value of an owner who files for Chapter 7 while staying in the home is given by

$$\begin{aligned} V^{\text{file.7}}(S) &= \max_{a'>0, l\in L} u(c\lambda_{7,e}, l, h) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[\tilde{V}_7\left(S'\right)\right] \\ &\text{subject to} \\ c + \frac{1}{1+r}a' &= yl - \kappa(p_{i0}h, r_m, T_m) - f_7. \end{aligned} \tag{A.14}$$

This value is defined only if current assets are negative, $a < 0$. Crucially, the household may stay in the house only if net home equity lies below the homestead exemption level, i.e. iff $(1-\phi)(ph-m) < \xi$.

Value of Filing and Default The value for the owner when filing for bankruptcy and defaulting on the mortgage at the same time is as follows:

$$\begin{aligned} V^{\text{file,def}}(S) &= \max_{a'>0, l\in L} u(c\lambda_{7,e}, l, \underline{h}) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[\tilde{W}_7(R')\right] \\ &\text{subject to} \\ c + \frac{1}{1+r}a' &= yl - f_7, \end{aligned} \tag{A.15}$$

assuming that any remaining mortgage debt is discharged in Chapter 7 bankruptcy.

Owner Bankruptcy Chapter 13

The main difference between Chapter 13 and Chapter 7 bankruptcy is that the owner may keep the house (and all other assets) no matter how much equity there is after signing up to a Chapter 13 repayment plan. Consequently we don't have to compute a value of eviction and we also rule out the possibility of filing for Chapter 13 and defaulting on the mortgage at the same time.[26]

$$\begin{aligned} V^{\text{file.13}}(S) &= \max_{a'>0, l\in L} u\left(c\lambda_{13,e}, l, h\right) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[\tilde{V}_{13}\left(\bar{y}(a,w), 0, w', p', n', h, e, t+1\right)\right] \quad \text{(A.16)} \\ &\text{subject to} \\ c + \frac{1}{1+r}a' &= yl - \kappa(p_{i0}h, r_m, T_m) - f_{13} > 0 \end{aligned}$$

Owner Bankruptcy Punishment States

An owner in punishment state for either chapter has the discrete choice set "stay," "sell" and "default". His savings s cannot be negative (he cannot borrow). As in the case of the renter, exit from the state is governed by the Bernoulli random variable $X \sim \text{Bernoulli}(\delta)$. Thus the value for this owner is

$$\tilde{V}_j(S) = \max\left(\tilde{V}_j^{\text{stay}}, \tilde{V}_j^{\text{sell}}, \tilde{V}_j^{\text{def}}\right), j = 7, 13,$$

where the value for *stay* is given by

$$\begin{aligned} \tilde{V}_j^{\text{stay}}(S) &= \max_{a'>0, l\in L} u\left(c\lambda_{j,e}, l, h\right) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[(1-\delta)\tilde{V}_j\left(S'\right) + \delta V(S')\right] \quad \text{(A.17)} \\ &\text{subject to} \\ c + \frac{1}{1+r}a' &= a + yl - \mathbf{1}\left[j = 13\right]\bar{y} - \kappa(p_{i0}h, r_m, T_m), \\ j &= 7, 13. \end{aligned}$$

The value for *sell* is given by

$$\begin{aligned} \tilde{V}_j^{\text{sell}}(S) &= \max_{a'>0, l\in L} u\left(c\lambda_{j,e}, l, \underline{h}\right) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[(1-\delta)\tilde{W}_j(R') + \delta W(R')\right] \\ &\text{subject to} \\ c + \frac{1}{1+r}a' &= yl - \mathbf{1}\left[j = 13\right]\bar{y} - \kappa(p_{i0}h, r_m, T_m) + a + (1-\phi)ph - m, \\ j &= 7, 13. \end{aligned}$$

[26] Filing for Chapter 13 and defaulting at the same time is a particularly unrealistic choice, since the consumer assumes the increased burden of Chapter 13 (wage tax) without getting to enjoy the benefits (staying in the house).

Finally the value for *default* in the punishment state is given by

$$\begin{aligned} \tilde{V}_j^{\text{def}}(S) &= \max_{a'>0, l\in L} u\left(c\lambda_{j,e}, l, \underline{h}\right) + \beta \mathbb{E}_{w'|w,p'|p,\underline{a}}\left[(1-\delta)\tilde{W}_j(R') + \delta W(R')\right] \qquad \text{(A.18)} \\ &\text{subject to} \\ c + \frac{1}{1+r}a' &= yl - \mathbf{1}\left[j = 13\right]\bar{y} - \kappa(p_{i0}h, r_m, T_m) + a. \end{aligned}$$

The amount of assets that the person carries over into the next period depends both on the extent of recourse in the specific state and on the amount of mortgage debt. In any case a cannot be negative since the person has already filed for bankruptcy and cannot borrow. However it can be positive if the person started saving after filing. In a recourse state the existing financial assets will be used to pay off the mortgage (under chapter 7). We assume that any remaining mortgage debt is then forgiven and $a = 0$.

B Wage Process

We employ the same procedure as in De Nardi et al. (2020) to estimate wage support points by age as well as age-specific transition matrices $\Pi_w(t)$. The method in De Nardi et al. (2020) allows for a generalization of the traditional income process used in macroeconomics. For further details and thorough comparison to the traditional approach, please refer to De Nardi et al. (2020). We replicate their results using the outline in section 4 of their paper, but splitting the data into two education groups. We use PSID data from 1969–1997, because thereafter we have biennial observations only on wage. We subset the data to household heads between age 25 and 60, whom we observe in at least two consecutive periods, and we drop observations with annual earnings below \$900. We use 2003 as the base year for consumer price index (CPI) adjustment.[27] Finally, we keep only observations with a valid education entry, and real hourly wage in $[4, 999]$. We classify all observations with less than 13 years of education as "low" education, and the remainder as "high."

We regress log real earnings on a year dummy and a fourth order polynomial in age (term $f^e(t)$ in equation 4), by education group. From the residual of the regressions, we recover the support of the wage shock w_{it} at each age t for 5 bins, and for each education group, as well as their respective transition across time. The binning classifies the residuals at each age into 5 regions delimited by the quantiles of the corresponding residual distribution. We illustrate the outcome in figure B.1.

[27] We use the headline CPI obtained from the Bureau of Labor Statistics.

Figure B.1: Wage Support and Age-Specific Transition Matrices for Wage Shock w

Note: We cut the empirical distribution of wage residuals into 5 quantiles, and take the midpoints to be the points of support for the corresponding bin. The transition matrix at each age (right panel of plot) is estimated by counting the proportion of bin i in period t which ends up in bin j in period $t+1$. The right panels illustrate the probability associated with each transition from state i to state j.

We illustrate the evolution of the cross sectional average and standard deviation of simulated wages by age and by education group in Figure B.2.

Figure B.2: Mean and Standard Deviation of Hourly Wages by Age and by Education Group from the Simulated Model

Note: The shaded area is standard deviation of wages at each age.

C More Model Evidence

In this appendix, we present life cycle profiles in asset holding, homeownership rate, mortgage borrowing, and hours worked for the baseline analyses as well as several counterfactual policy analyses when we remove bankruptcy chapter-wise in figures C.1 for high and C.2 for low educated individuals. We include the profiles for experiment *abolishment of chapter 7 light* (labeled `no7_light`), where we restrict the means test to one half of state median income. Given we found very small welfare effects, we do not report those results in table 9, however the results are readily available. What stands out in those is the drastic change in aggregate behavior induced by the complete abolishment of chapter 7, deterring a lot of initial unsecured borrowing, and related to that, homeownership.

Figure C.1: Lifecycle Profiles in Different Module Configurations with and without Bankruptcy Choices for the High Education Group

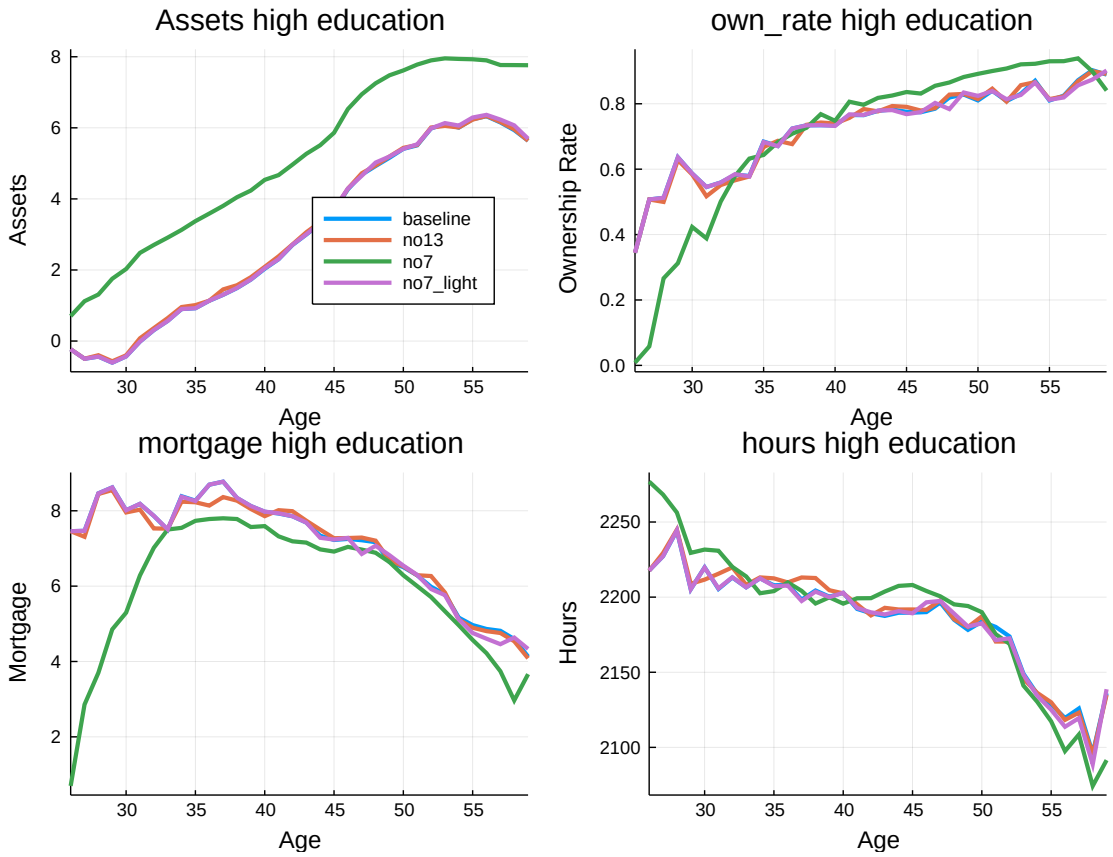
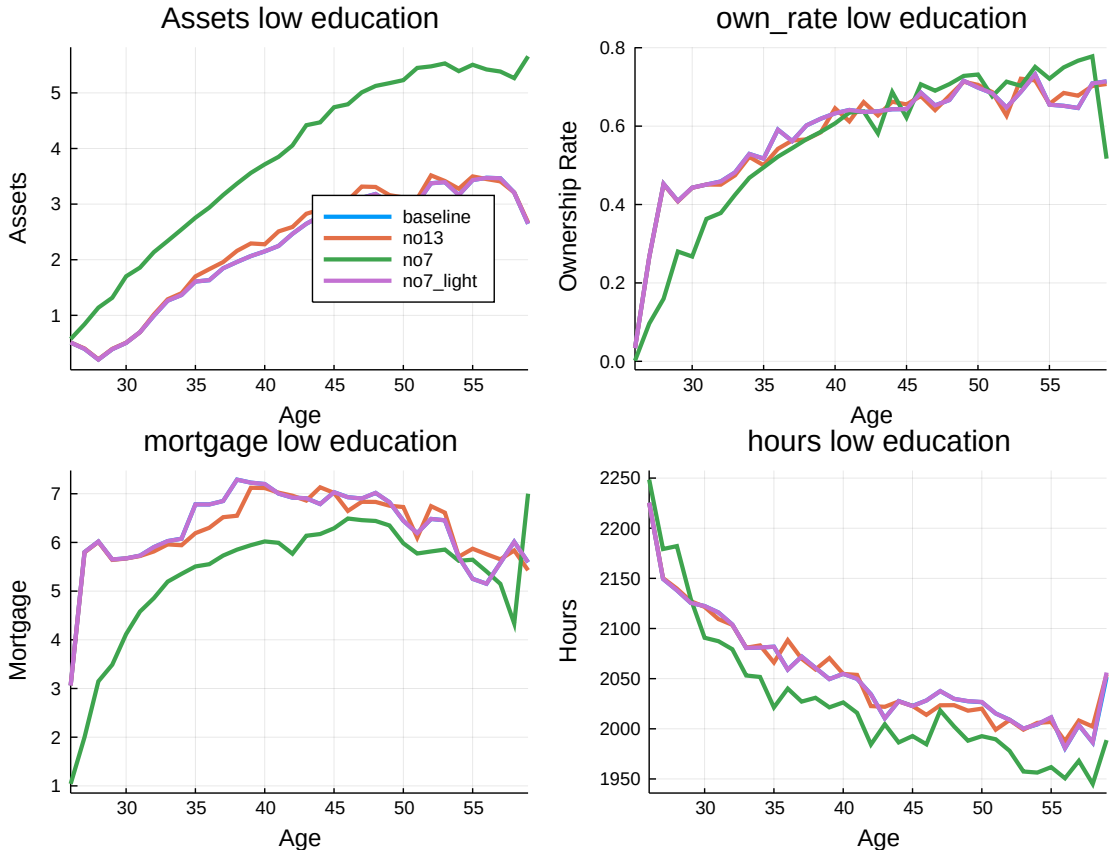


Figure C.2: Lifecycle Profiles in Different Module Configurations with and without Bankruptcy Choices for the Low Education Group



D Tables

In this appendix, we prresent two additional tables that provide information on our computation and state legislation.

Table D.1: Numerical Parameters

Number of grid points chapter 13 repayment	4
Number of grid points assets	31
Number of grid points wage	5
Number of grid points p	5
Number of grid points mortgage	15
Number of grid points house size	2
Number of periods	35
Levels of Labor supply	5
Scale factor on asset grid	1.3
Number of discrete choices renter (excluding buying)	3
Number of discrete choices owner in BK state	1
Number of discrete choices owner	6
Number of discrete choices owner in BK state	3
Initial unit price of house	1
Size of smallest house	0.0
Size of a small house	300
Size of a large house	600
number of simulated individuals	15000
Mean of LogNormal initial asset distribution	-2.1
Std. Dev. of LogNormal initial asset distribution	0.9

Table D.2: Grouping of US States by Legal Environment Concerning Bankruptcy and Mortgage Default

State	Deficiency	Homestead Exemp. ($)	Median Inc. ($)	ξ Exemp./Med. Inc.	group
NC	No	18500	45607.13	0.41	1
WA	No	40000	59951.18	0.67	1
AK	No	54000	63456.71	0.85	2
CA	No	50000	58509.89	0.85	2
MT	No	100000	43752.43	2.29	2
ND	No	80000	51275.34	1.56	2
AZ	No	150000	49907.10	3.01	3
MN	No	200000	59445.86	3.36	3
AL	Yes	5000	43445.55	0.12	4
GA	Yes	10000	49418.75	0.20	4
IL	Yes	7500	54433.88	0.14	4
IN	Yes	7500	48301.03	0.16	4
KY	Yes	5000	42728.06	0.12	4
MD	Yes	0	68697.79	0.00	4
OH	Yes	5000	49214.44	0.10	4
TN	Yes	5000	43074.65	0.12	4
VA	Yes	5000	62967.78	0.08	4
WY	Yes	10000	53708.11	0.19	4
AR	Yes	17425	41227.34	0.42	5
CO	Yes	45000	61377.39	0.73	5
DE	Yes	50000	56565.67	0.88	5
HI	Yes	17425	64089.82	0.27	5
LA	Yes	25000	42654.21	0.59	5
ME	Yes	35000	50249.51	0.70	5
MI	Yes	17425	51084.04	0.34	5
MO	Yes	15000	48774.10	0.31	5
NE	Yes	12500	53861.02	0.23	5
NJ	Yes	17425	68284.69	0.26	5
NM	Yes	30000	45115.96	0.66	5
OR	Yes	25000	52448.20	0.48	5
PA	Yes	17425	51987.45	0.34	5
SC	Yes	17425	44104.29	0.40	5
SD	Yes	30000	49528.12	0.61	5
UT	Yes	20000	60398.63	0.33	5
WI	Yes	40000	53704.30	0.74	5
WV	Yes	25000	42656.15	0.59	5
CT	Yes	75000	67675.40	1.11	6
ID	Yes	104471	50053.53	2.09	6
MA	Yes	100000	63015.52	1.59	6
MS	Yes	75000	38908.97	1.93	6
NH	Yes	100000	68438.14	1.46	6
NV	Yes	550000	54782.10	10.04	6
NY	Yes	50000	52655.17	0.95	6
RI	Yes	200000	55399.59	3.61	6
VT	Yes	75000	55026.47	1.36	6
FL	Yes	∞	47917.01		7
IA	No	∞	52378.80		7
KS	Yes	∞	48913.09		7
OK	Yes	∞	46108.99		7
TX	Yes	∞	48876.19		7

Note: Columns 2 and 3 are taken from table 7 of the online appendix of Mitman (2016). Median income in 2011 dollars. States are grouped by interquartile range of ξ and whether or not they allow Deficiencies.

D.1 Supplementary Results: Changing the Level of Recourse

Mortgage lenders have different amounts of recourse to deficient mortgage contracts in different states. Our baseline assumes a probability of 10% that a deficiency judgment would be handed down to a borrower who defaults on the mortgage with negative equity. This parameter is informed by court records which were analyzed in Table A.1 of Li and Oswald (2017), . In case a deficiency judgment is carried out (with probability 0.1), the borrower has to settle the remaining debt in the future, possibly leading them to file for bankruptcy.

The impact of varying recourse is displayed in Table D.3. Starting with the high education group, increasing recourse leads to declines in default as we would expect given the higher cost associated with default. It also leads to increases in bankruptcy because deficient mortgages turn into unsecured debt more often, increasing incentives to expunge the debt through bankruptcy. This has a direct impact on the average interest rate for unsecured debt, which is significantly lower in the no recourse scenario. However, aggregate ownership and hours worked are unaffected. We see a similar impact on the less educated group. Welfare declines steadily with increases in recourse, reflecting the reduction in insurance. This is particularly marked for the low education group, where an increase in recourse from 10% to 20% leads to a loss of welfare equivalent to a reduction in consumption of 3.5%. The complete abolition of recourse (by setting $\psi = 0$) would be equivalent to a 0.9% increase in consumption for this group. The higher educated group has a slightly positive willingness to pay for the no-recourse scenario (0.2%), and a slightly negative one for the high recourse one (-0.39 %).

Table D.3: Changing the Level of Recourse

	High Education			Low Education		
	$\psi = 0.0$	$\psi = 0.1$ *baseline*	$\psi = 0.2$	$\psi = 0.0$	$\psi = 0.1$ *baseline*	$\psi = 0.2$
Bankruptcy (‰)	9.897	10.078	10.455	15.223	15.591	15.831
Bankruptcy 7 (‰)	6.849	6.926	7.21	6.965	7.144	7.278
Bankruptcy 13 (‰)	3.048	3.151	3.246	8.259	8.446	8.552
Interest (%)	11.97	12.63	13.28	24.5	25.31	25.15
Ownership	0.712	0.712	0.711	0.574	0.573	0.573
Default (%)	1.24	1.208	1.158	1.708	1.661	1.592
Hours	2186	2186	2185	2053	2053	2053
Hours Renters	2242	2242	2242	2125	2125	2124
Hours Owners	2184	2184	2184	2033	2033	2033
Hours Renters (in ch. 13)	1670	1666	1666	1688	1687	1686
Hours Owners (in ch. 13)	2190	2194	2190	1993	1993	1993
Consumption Equivalent WTP (%)	0.196	–	-0.338	0.915	–	-3.502

Note: The revel of recourse for mortgage lenders is governed by the parameter ψ, which controls the probability with which a mortgage in default will lead to a deficiency judgment. The Baseline value is $\psi = 0.1$.