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Kurt Mitman

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Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: (44 20) 7183 8801
www.cepr.org

MACROECONOMIC EFFECTS OF BANKRUPTCY AND FORECLOSURE POLICIES[†]

Abstract

I study the implications of two major debt-relief policies in the US: the Bankruptcy Abuse and Consumer Protection Act (BAPCPA) and the Home Affordable Refinance Program (HARP). To do so, I develop a model of housing and default that includes relevant dimensions of credit-market policy and captures rich heterogeneity in household balance sheets. The model also explains the observed cross-state variation in consumer default rates. I find that BAPCPA significantly reduced bankruptcy rates, but increased foreclosure rates when house prices fell. HARP reduced foreclosures by one percentage point and provided substantial welfare gains to households with high loan-to-value mortgages.

JEL Classification: E21, G11, K35 and R21
Keywords: bankruptcy, default risk, foreclosure, household debt and housing

Kurt Mitman kurt.mitman@iies.su.se
IIES, Stockholm University, and CEPR

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The past decade has seen two major changes to nationwide policy aimed at debt relief on unsecured and secured debt. These are the 2005 reform of personal bankruptcy (BAPCPA[1]), and a 2009 mortgage-relief measure aimed at reducing foreclosures (HARP[2]). Both policies involve debt repayment, and a priori, we expect them interact in altering incentives to use and repay unsecured and secured debts. The goal of this paper is to assess quantitatively the effects of these two policies, allowing for their potential interaction. Despite being separate legal processes, bankruptcy and foreclosure can be complements or substitutes: bankruptcy may prevent foreclosure by discharging a household's unsecured debt, thereby freeing up income for making mortgage payments. On the other hand, foreclosure could lead to bankruptcy if banks can sue households who default on their mortgages to recoup losses.

Given the scope of the policy changes, however, strictly empirical approaches, such as those exploiting interstate variation in policy are of limited value. What we need is a model capable of conducting macroeconomic counterfactuals to assess these two reforms. The welfare implications of BAPCPA and HARP are potentially large: since households lack perfect insurance against idiosyncratic risk, the option to default on debt in bad states of the world can yield large welfare gains by improving households' consumption smoothing (see, e.g. Kartik Athreya (2002)).

The contribution of this paper is to develop the first model rich enough to capture empirically-relevant heterogeneities of household balance sheets, of household experiences in labor markets, and of credit-market policy. Such a model is needed to study default on both forms of debt via both liquidation and debt restructuring, and to provide a first analysis of the two policy reforms. As the model suggests significant spillovers, modeling secured and unsecured debt simultaneously is critical for evaluating the consequences of the reforms.

The framework I develop has elements in common with the bankruptcy model of Satyajit Chatterjee, Dean Corbae, Makoto Nakajima & Jose-Victor Ríos-Rull (2007) and the foreclosure models of Dean Corbae & Erwan Quintin (2015) and Karsten Jeske, Dirk Krueger

[1]Bankruptcy Abuse Prevention and Consumer Protection Act of 2005.
[2]The Home Affordable Refinance Program.

& Kurt Mitman (2013). Households can finance purchases of houses with long-term mortgages, and can save in bonds or borrow in unsecured debt. They face idiosyncratic income and housing risk and can default separately on unsecured credit and their mortgages at the cost of forfeiting their housing collateral. Households who file for bankruptcy can choose between Chapters 7 and 13. Under Chapter 7, households have all their unsecured debt discharged and keep only exempt home equity, whereas under Chapter 13 they keep their home but commit to partial debt repayment out of future income. I theoretically characterize the default decision, and show that it depends on the entire household portfolio, unlike Chatterjee et al. (2007) where net worth is a sufficient statistic.

To discipline the parameters of the model, I exploit the significant cross-state variation in default law: the homestead exemption in bankruptcy and recourse in foreclosure. The homestead exemption specifies how much home equity the household can keep after filing for Chapter 7 bankruptcy. In recourse states, after forfeiting their home, foreclosed households are still liable for the difference between the recovered value of the house and the face value of the mortgage. In no-recourse states, on the other hand households can walk away from their mortgages with no additional liability. Figures 1(a) and 1(b), plot the average state bankruptcy (from 1995-2004) and foreclosure (from 1994-1999) rates as a function of the homestead exemption. The figures illustrate the significant variation in default rates and laws across states. In addition, Figure 1(a) illustrates a *negative correlation* between the generosity of the bankruptcy law and the bankruptcy rate. This relationship is striking: one might expect that more generous bankruptcy laws would induce more households to file for bankruptcy[3]. In a seminal study, Scott Fay, Erik Hurst & Michelle J. White (2002) find that a household's probability of filing for bankruptcy is increasing in the financial benefit

[3]The homestead exemption also impacts which chapter of the bankruptcy code households choose to file under. Under Chapter 7, if the household has home equity above the homestead exemption, the property would have to be liquidated and the non-exempt equity is transferred to creditors, whereas in Chapter 13 the household can keep all of its equity, but commits to repay some of its debt. In 9 in the Online Appendix I plot the fraction of households that file under Chapter 13 as a share of total non-business filings. In states with lower exemptions the share of Chapter 13 is higher, likely driven by households that are more likely to have non-exempt assets.

from doing so. However, their micro analysis is silent on whether portfolios of debt held by households vary systematically with different homestead exemption policies[4].

My model can reconcile the micro and macro facts related to bankruptcy. It is theoretically consistent with the micro evidence and quantitatively consistent with state-level default rates, showing that the homestead exemption and recourse can account for 40 percent of the overall variation in bankruptcy rates and share of Chapter 13 filings. The mechanism is as follows: more generous exemptions lessen the penalty from Chapter 7 bankruptcy and therefore raise the probability of homeowners going bankrupt for a fixed portfolio. This raises the equilibrium interest rate on unsecured borrowing. The higher interest rate, coupled with access to secured borrowing, induces households to substitute secured credit for unsecured by taking on more highly leveraged mortgages. Therefore, states with higher exemptions see household portfolios more heavily weighted toward secured debt, resulting in lower bankruptcy rates, but higher foreclosure rates. I validate the mechanism by showing that the differences in leverage and unsecured interest rates between high and low homestead-exemption states in the data (using the Residential Finance Survey and the Consumer Expenditure Survey) are consistent with the model implications. Satisfied that the model is an appropriate laboratory to study consumer default law, I then proceed to evaluate BAPCPA and HARP.

The BAPCPA reform restricted the ability of households earning above median income in their state from filing for Chapter 7 bankruptcy, increased the cost of filing, and limited asset exemptions. Analyzing the transition path induced by the reform, I find that bankruptcy rates initially drop, and then slowly converge to about 70% of the pre-reform level. The total unsecured debt outstanding and the fraction of households with negative net worth both increase significantly along the transition. Despite the fact that BAPCPA only changed bankruptcy law, I find that it has a modest long-run effect on foreclosure rates, raising them from 52 to 54 basis points. However, if house prices fall along the transition by a similar magnitude, as was observed from 2007 to 2009 in the U.S., I find that BAPCPA increased

[4] One notable exception is recent work by Michelle M Miller (2011), who documents lower unsecured debt holdings in states with higher exemptions.

foreclosure rates by about 60 basis points. However, over the entire 2008–2013 time period it cut bankruptcy rates by a cumulative 2.7 percentage points, from 8.7% to 6%. The decline in bankruptcy and increase in foreclosure indicates that BAPCPA made bankruptcy and foreclosure less substitutable for high income households. Further, the reform can rationalize the relatively low levels of bankruptcy filings despite a severe contraction in real activity and house prices.

Despite the restrictions imposed and the increase in costs associated with filing for bankruptcy I find that the average household is willing to pay 0.12 percent of lifetime consumption to implement the reform. There is disagreement among households, however, regarding the desirability of the reform. Households who file for Chapter 7 bankruptcy would be willing to pay 0.4 percent of lifetime consumption to avoid the reform — rationalizing the large spike in Chapter 7 filings in the period leading up to the implementation of the reform in 2005. In total, more than 11% of households are made worse off from the passage of BAPCPA.

The disagreement between households is driven by the increase in fixed filing costs. That feature of the reform is salient for low-income households. Since filing costs are paid out of current income, the increase results in a one for one drop in contemporaneous consumption. For high-income households, however, BAPCPA moves unsecured debt closer to an insurance contract. By removing the option to discharge debt under Chapter 7, households effectively commit to repaying debt (at least partially) if their income remains high, but retain the discharge option when income falls. Because income is persistent, *ceteris paribus*, this commitment causes interest rates on unsecured debt to fall for high-income households. These households, however, have a low propensity to borrow even though the reform created a "borrow to save" motive. Since home equity is partially exempt, households can simultaneously increase unsecured debt and home equity to effectively buy insurance. If income falls, the household can discharge the debt and keep the home equity, transferring resources across states of the world and improving the ability to smooth consumption.

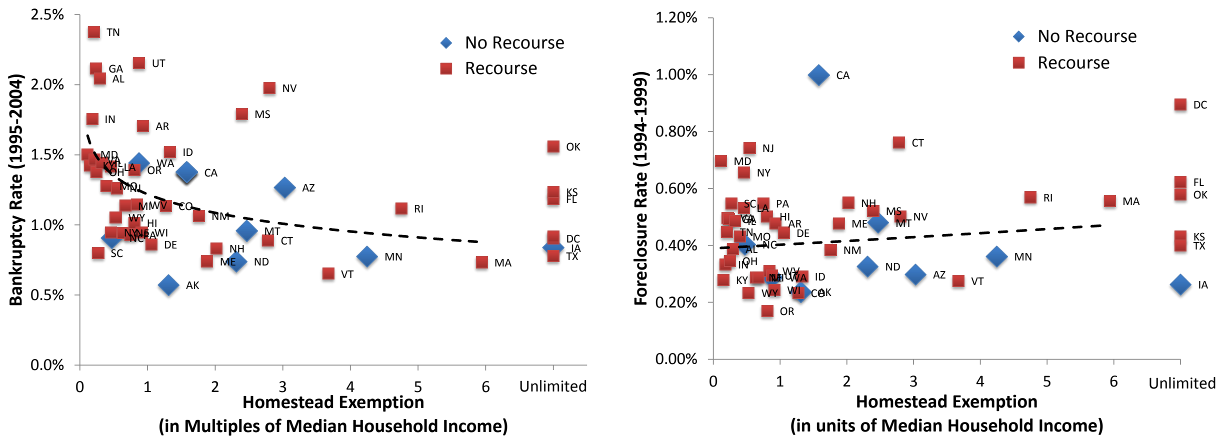
HARP was instituted in 2009 to enable borrowers with greater than 80% loan-to-value (LTV) ratios to refinance their mortgages so as to take advantage of lower interest rates[5]. I model the policy as an interest-rate subsidy on refinanced mortgages with LTV between 80% and 125% (the maximum LTV for refinancing is relaxed relative to 100% in the baseline model) consistent with HARP[6]. I find that the cumulative effect of introducing HARP was to reduce foreclosure rates by almost one percentage point over 2009–2013 from 11.5% to 10.5%, and to reduce bankruptcy rates by 40 basis points from 4.6% to 4.2%.

HARP enabled households to reduce the cost of their mortgage debt after the drop in house prices. Homeowners with mortgages over 80% LTV would be willing to pay on average 0.4 percent of lifetime consumption to implement the reform. The welfare effects of the reform are large despite the modest reduction in foreclosures. This is so because households who would not have defaulted absent the reform could exploit the lower borrowing costs to increase consumption. By increasing the option value of not defaulting, the reform did reduce foreclosure rates, however; for the bulk of homeowners with underwater mortgages, a higher option value was not sufficient to prevent default. These findings are consistent with recent empirical work by Sumit Agarwal, Gene Amromin, Souphala Chomsisengphet, Tomasz Piskorski, Amit Seru & Vincent Yao (2015), who find significant effects of HARP refinancing on consumption but only modest effects on foreclosure.

The rest of the paper is organized as follows. In Section 1, I turn to a more complete discussion of the literature. I describe the model economy in Section 2. In Section 3, I provide theoretical characterizations of household decisions and endogenous prices. The calibration procedure and the relevant data targets are presented in Section 4. Characteristics of the calibrated economy are discussed in Section 5. I discuss the results of policy experiments in Section 6 and conclude in Section 7.

[5]Borrowers also were exempt from paying private mortgage insurance, which is typically a requirement for mortgages with LTV greater than 80%.

[6]In December 2011 the LTV limit was abolished altogether.



(a) State bankruptcy rates

(b) State foreclosure rates

Figure 1: Bankruptcy and Foreclosure Rates Across States.

Figure 2: Bankruptcy and Foreclosure Rates Across States. *Notes:* The homestead exemptions is from state law and median household income is from the Census, both in 2000. Average state bankruptcy rates 1995-2004 are computed using bankruptcy filings from the American Bankruptcy Institute and the number of households in each state from the Census. Average state foreclosure rates 1994-1999 are computed from the Mortgage Banker Association's quarterly National Delinquency Survey from 1994-1999. The dashed lines are smoothed versions of the data.

1 Connections to Existing Literature

This paper is related to multiple areas of the literature on incomplete markets and household default[7]. Chatterjee et al. (2007) and Igor Livshits, James MacGee & Michèle Tertilt (2007) study economies with savings and competitively priced unsecured debt, with prices depending on loan size and household characteristics.[8] In their models, these authors abstract from a household portfolio of exempt assets and liabilities and only consider the net household position since their focus is only on bankruptcy and unsecured credit. In my framework, I include an exempt housing asset and show that the net position is not sufficient to determine the default decision.

[7] My paper focuses on non-business bankruptcy filings. A separate literature (see e.g. Ahmet Akyol & Kartik Athreya (2011) and Cesaire Meh & Yaz Terajima (2008)) has investigated the effects of exemptions and bankruptcy on entrepreneurship

[8] Athreya (2002) provides an early analysis of an incomplete markets model integrating a bankruptcy option. However, he assumes that all loans are pooled, so that loan pricing does not depend on household characteristics or loan sizes.

Including assets and liabilities allows the model to be consistent with the significant fraction of bankrupt households who have positive home equity. Further, the endogenous penalty of having non-exempt assets seized generates average credit spreads on unsecured credit that are consistent with what is observed in the data, which the existing literature has had trouble matching. Marina Pavan (2008) and Wenli Li & Pierre-Daniel Sarte (2006) incorporate durables into equilibrium default models to study the effects of homestead exemptions, but abstract from secured debt. Thomas Hintermaier & Winfried Koeniger (2009) analyze optimal debt portfolios in a life-cycle model of durable and non-durable consumption, but without the possibility of mortgage default.

Kartik Athreya (2006) investigates the role of bankruptcy exemptions in a model with secured and unsecured credit. In his setting all households are homeowners and their homes only serve the purpose of providing collateral for risk-free mortgage borrowing. He similarly finds that higher exemptions lead to higher interest rates on unsecured credit (via the same mechanism discussed above), however, he finds bankruptcy rates are increasing in the homestead exemption. Introducing default risk in mortgage borrowing and endogenous home ownership changes the trade-offs involved in selecting an optimal portfolio and may explain some of the differences in the results.

Recent papers by Jeske, Krueger & Mitman (2013), Corbae & Quintin (2015), Satyajit Chatterjee & Burcu Eyigungor (2015) and Carlos Garriga & Don Schlagenhauf (2009) build equilibrium models of housing, endogenous leverage choice, and foreclosure. Those papers abstract from unsecured debt and bankruptcy, and are primarily focused on understanding the effects of government housing market policy or the 2007 housing bust.[9] I see this paper as complementing those papers by providing insight on how BAPCPA may have contributed to the subsequent rise in foreclosures. To my knowledge, this is the first study to investigate the joint causes and consequences of foreclosure and bankruptcy in a structural, dynamic,

[9]There is also an important, empirically focused literature that investigates the causes and consequences of the recent housing bust, see e.g. Foote et al. (2009) or Atif Mian, Amir Sufi & Francesco Trebbi (2011).

equilibrium model.[10]

Another strand of the literature has empirically investigated the effects of homestead exemptions and recourse. These papers provide an empirical benchmark to evaluate the predictions of the model. Reint Gropp, John Karl Scholz & Michelle J. White (1997) find that in states with higher homestead exemptions households with lower wealth are more likely to be denied auto loans. Miller (2011) finds that households with more home equity are more likely to file for bankruptcy in states with high exemptions. Karen M. Pence (2006) finds smaller mortgages are originated in states with borrower friendly foreclosure laws. Complementing that work, Andra C. Ghent & Marianna Kudlyak (2011) estimate that recourse laws significantly reduce the probability of foreclosure for households who purchased homes worth more than $200,000.

2 Model

I model each state in the US as a small open endowment economy, populated with a measure one continuum of households, a measure one continuum of banks and a measure one continuum of real estate construction companies. Time is modeled discretely and all agents are infinitely lived.

2.1 Households

Households derive period utility $U(c, s)$ from nondurable consumption $c \geq 0$ and housing services $s \geq 0$. Households are expected utility maximizers and discount the future with parameter β. Each period, households receive an idiosyncratic endowment of the consumption good y. The endowment is assumed to follow a stochastic process consisting of a persistent and a transitory component:

$$\log(y) = z + \varepsilon_y \tag{1}$$

[10] This work also complements a growing empirical literature that focuses on the interaction between foreclosure and bankruptcy (e.g., Sarah Carroll & Wenli Li (2008), Wenli Li & Michelle J. White (2009)).

where $z' = \rho_z z + \sqrt{(1-\rho_z^2)}\nu_z$, and ε_y and ν_z are independent normally distributed random variables with variances $\sigma^2_{\varepsilon_y}$ and $\sigma^2_{\nu_z}$.

Housing Households can purchase houses h' from the finite set $\mathcal{H}$ at a price $p_h = 1$ per unit of housing. Each unit of the housing good generates a unit flow of housing services, which can be consumed in the same period of purchase. Houses are subject to *idiosyncratic* price shocks consisting of a persistent and a transitory component:

$$\log(p_h) = \omega + \varepsilon_h \tag{2}$$

where $\omega' = \rho_h \omega + \sqrt{(1-\rho_h^2)}\nu_h$, ε_h and ν_h are independent normally distributed random variables with variances $\sigma^2_{\varepsilon_h}$ and $\sigma^2_{\nu_h}$. The price shocks affect the value of the home, but not the services that it generates. Households can purchase one home and consume the services generated by it. Housing is subject to a per period maintenence cost, μ_h. Home owners also face an i.i.d. moving shock (that occurs with probability θ), which requires the household to sell its home. Renters rent from a competitive rental market with price p_r. The market for rental homes is restricted to the smallest house size, $\underline{h} = \min \mathcal{H}$[11].

Financial Assets Households can finance housing purchases with mortgages m'. The mortgage is secured by the house, and the price $q_m(\cdot)$ can be a function of all observable household characteristics and asset choices. Mortgages are of infinite duration[12], and future payments are discounted at interest rate r_m. Households pay the interest due on the principal each period but can make optional principal payments (and thus accumulate home equity). If households wish to increase the principal owed, however, they must refinance. This flexi-

[11] This assumption is to capture that the rental market this thinner than the owner-occupied one and is partly a device to help generate home-ownership without having to assume a "pride of ownership" or additional utility gain from owner occupied housing and has been employed in the literature (e.g., Corbae & Quintin (2015)).

[12] Because of the presence of the moving shock, the effective maturity is $1/\theta$, similar to the debt contract considered by (Chatterjee & Eyigungor 2015) but with a slower path of equity accumulation. In the calibration I will target median household leverage to match the equity accumulation observed in the data.

ble mortgage structure allows me to capture elements of mortgages and home equity loans while keeping the household problem tractable. A mortgage therefore is a contract to receive $m' \times q_m(m', \cdot)$ units of the consumption good in the current period and to repay (at least) $r_m \times m'$ in the subsequent period.

Households can save or borrow by purchasing one-period bonds with face value b' (with negative values interpreted as unsecured loans). The "price" of a bond with face value b' can be a function of all observable household characteristics as well as asset choices and is denoted $q_b(\cdot)$. The timing is such that the household pays $b' \times q_b(b', \cdot)$ in the current period to receive b' in the subsequent period[13].

2.2 Legal Environment

2.2.1 Foreclosure

Households have the option to default on mortgages after the realization of the house price, income and moving shocks. When a household defaults, the house is liquidated subject to an inefficient foreclosure technology, $\gamma \leq 1$, such that the proceeds from the foreclosure sale are $\gamma p_h h$. If the proceeds of the foreclosure sale are less than the face value of the mortgage[14], the difference is converted into unsecured debt via a stochastic deficiency judgment technology. Deficiency judgments $\mathcal{J} = 1$ occur with probability $\psi(h) \in [0, 1]$[15]. The probability of a deficiency judgment depends on the size of the house purchased[16]. After a foreclosure the bond position of a household becomes $b_F = b + \mathcal{J}(\gamma p_h h - m(1 + r_m))$. A no-recourse state

[13] For unsecured borrowing, the household receives $-b' \times q_b(b', \cdot)$ and has to repay $-b'$ in the subsequent period.

[14] If the foreclosure sale proceeds exceed the face value of the mortgage, the excess is returned to the household. This is consistent with foreclosure law. If the value of the collateral exceeds the outstanding debt, the bank must return the excess after liquidating the collateral and covering any associated foreclosure costs. However, absent frictions in the housing, in equilibrium no household will default with positive equity.

[15] The assumption of stochastic deficiency judgments is an abstraction to capture the decision of the bank to sue a household motivated by the fact that banks do not pursue deficiency judgments for all households who go into foreclosure even if it is legally allowed.

[16] This assumption is motivated by Ghent & Kudlyak (2011) who find that the effects of recourse depend on the original price of the home at purchase.

is a state where $\psi = 0$[17]. Households who default on their mortgages have the foreclosure annotated on their credit history, which excludes them from new mortgage and unsecured borrowing and imposes a proportional consumption penalty λ[18]. For tractability, I assume the foreclosure flag is removed stochastically with probability α_F (as opposed to remaining for a deterministic period of time).

2.2.2 Bankruptcy

The bankruptcy decision is made after the decision to default on the mortgage (and any deficiency judgment realization). The timing convention is chosen to preclude the possibility of the household having an empty budget set after both default decisions. The state homestead exemption is denoted by χ. If a household files Chapter 7 bankruptcy, in the current period the following happens:

1. Unsecured debt is set to 0 and the household cannot accumulate bonds
2. The household's credit history gets the Chapter 7 flag
3. If the household is a homeowner with only exempt equity, it keeps the home and if it has a mortgage makes an interest payment
4. If the household is a homeowner with non-exempt equity, the house is sold and any mortgage is paid off. It keeps the exempt portion of the equity, but cannot use it for contemporaneous consumption

The restrictions on savings and home equity come from the process of liquidation and exemptions[19]. Importantly, a household that keeps its home can keep its current mortgage,

[17] In general, only mortgages used for the purchase of a home are guaranteed to be no-recourse. In some states mortgages used for refinance can become recourse. In addition, home equity loans and home equity lines of credit are also generally recourse in all states. For tractability I assume that all mortgages in no-recourse states are no-recourse, so I may understate the difference between the two types of states.

[18] This represents, among other things, the increased difficulty of getting a cell phone or a lease, for households with a foreclosure or bankruptcy on a credit record.

[19] Households can sell their homes in bankruptcy and keep the exempt equity only if they use or intend to use that equity to purchase another home. In some states, e.g. Florida and Texas, exempt equity proceeds from the sale of a home must be placed into a homestead account until the new homestead is purchased.

but cannot refinance. The Chapter 7 flag is removed stochastically probability α_7.

If a household files Chapter 13 bankruptcy in the current period the following happens:

1. Unsecured debt is set to 0
2. The household's credit history gets the Chapter 13 flag
3. The household pays $\phi \times y$ to the creditor even period that Chapter 13 flag remains
4. The household keeps its home if it has one

Here, the household can keep all of its assets, but commits to partial repayment. The fraction of income is determined as $\phi = \min\{{}^{-b'}/_{\bar{y}}, \bar{\phi}\}$, where $\bar{y}$ is the expected discounted income over the repayment period and $\bar{\phi}$ is the maximum penalty[20]. Notice that if the expected payments are less than the outstanding debt $({}^{-b'}/_{\bar{y}} > \bar{\phi})$ then part of the debt is forgiven. Households are only allowed to file for Chapter 13 if creditors receive at least as much payment as they would under Chapter 7. The income penalty expires and Chapter 13 flag are removed stochastically with probability α_{13}.

2.3 Household Decision Problem

Households can be in one of four credit history states, $\mathcal{C} = \{G, F, 7, 13\}$[21]. The state of a homeowner at the beginning of the period is summarized by the household portfolio, credit history, and shocks: $X = (b, h, m, p_h, \omega, y, z, \theta)$. The timing within the period is as follows: shocks realize, the decisions to default on mortgages, file for bankruptcy and sell ones home are made, credit histories update, and then the new portfolio is chosen. Let $\eta = p_h h - (1 + r_m)m$ denote the amount of home equity that a homeowner has. The timeline of events within the period for a homeowner with good credit and a mortgage is shown in figure 2.3.

[20] In reality, households commit to pay *all* discretionary income over the relevant period. I implement the garnishment scheme as a reduced form way to capture that.

[21] G represents a good credit history and $F, 7$, and 13 represent flags after foreclosure, Chapter 7 and Chapter 13 bankruptcy, respectively.

The full dynamic programming problem of the household is described in the Online Appendix. To understand the choices and asset structure faced by households it is instructive to consider the discrete choices faced by a homeowner with good credit and a mortgage and the value functions of a homeowner that keeps its home.

A homeowner who begins the period with a good credit history, and was not hit by a moving shock ($\theta = 0$) has lifetime utility given by:

$$V_G^{own}(b, h, m, p_h, \omega, y, z, \theta = 0) = \tag{3}$$
$$\max \left\{ \begin{array}{ll} \text{No def., keep house:} & W_G^{own}(b + y, h, m, \omega, z) \\ \text{No def., sell house, buy:} & W_G^{buy}(\eta + b + y, z) \\ \text{No def., sell house, rent:} & W_G^{rent}(\eta + b + y, z) \\ \text{Chapt. 7, no mort. def.:} & (\mathbf{1}_{\eta \leq \chi} W_7^{keep}(h, m, y, \omega, z) + \\ & \quad (1 - \mathbf{1}_{\eta \leq \chi}) W_7^{liquidate}(y, \chi, z)) \\ \text{Chapt. 13, no mort. def.:} & W_{13}^{own}((1 - \phi)y, h, m, \omega, z, \phi) \\ \text{Mort. def.:} & \mathbb{E}_{\mathcal{J}} \left[(1 - \mathcal{J}) W_F^{rent}(b_F, z) + \right. \\ & \quad \left. \mathcal{J} \max \left\{ W_F^{rent}(b_F, z), W_7^{liquidate}(y, 0, z) \right\} \right] \\ \text{Mort. def and Chapt. 7:} & W_7^{liquidate}(y, 0, z) \\ \text{Mort. def and Chapt. 13:} & W_{13}^{rent}((1 - \phi)y, \phi, z) \end{array} \right\}$$

where W_G^{own} is the value of not defaulting on either debt, nor selling one's home, W_G^{buy} and W_G^{rent} are the value of not defaulting, selling one's home, and buying a new home or becoming a renter, respectively[22], $\mathbf{1}_{\eta \leq \chi}$ is an indicator if the household has only exempt home equity, W_7^{keep} and $W_7^{liquidate}$ are the values of filing for Chapter 7 bankruptcy without and with having to liquidate, respectively, W_{13}^{own} is the value of filing Chapter 13 bankruptcy, W_F^{rent} is the value of defaulting on the mortgage ($\mathbb{E}_{\mathcal{J}}$ is the expectation over a deficiency judgment

[22]Note that the timing assumption is such that these households can immediately buy a new home and live in it during the period.

if the household goes in to foreclosure), and W_7^{rent} is the value of being foreclosed upon and filing for Chapter 7 bankruptcy[23]. The discrete decision is similar for a household hit by the moving shock, however it no longer has the option to keep the house. That value function can be found in the Online Appendix.

A homeowner that keeps its home and does not default on (any) debt solves the following program:

$$W_G^{own}(a,h,m,\omega,z) = \max_{c,p_h h \geq m' \geq 0, b'} \left\{ U(c,h) + \beta \mathbb{E}_{p_h',\omega',y',z',\theta'|\omega,z} V_G^{own}(b',h,m',p_h',\omega',y',z',\theta') \right\}$$

$$\text{subj. to} \quad c + m(1+r_m) - m'Q_m + b'q_b(b',h,m',\omega,z,G) - \mu_h p_h h \leq a \tag{4}$$

$$\text{where:} \quad Q_m = \begin{cases} q_m(b',h,m',\omega,z,G) & \text{if } m' > m \\ 1 & \text{if } m' \leq m. \end{cases}$$

When the homeowner makes a mortgage payment, Q_m takes the value of one, whereas if the household wants a larger principal balance it must refinance its mortgage, which is represented by $Q_m = q_m$ (the price which takes into account the default risk of taking the new mortgage). By assumption, households can only originate mortgages with principal balances less than the current value of the home. This does not preclude households from having negative equity on existing mortgages, they simply cannot originate new mortgages with negative equity (this is the relevant constraint which will be relaxed when considering HARP).

The full household problems consists of 18 coupled Bellman equations, the solutions to which imply binary decision rules for foreclosure and both chapters of bankruptcy, $f_{\mathcal{C}}^*(X')$, $B7_{\mathcal{J}}^*(X')$ and $B13_{\mathcal{J}}^*(X')$respectively, (where a value of 1 implies default) where $\mathcal{J}$ is the indicator representing whether the household received a deficiency judgment. In addition,

[23] The assumption here is that Chapter 7 bankruptcy is a worse credit event than foreclosure, and thus the credit state evolves to the more serious default.

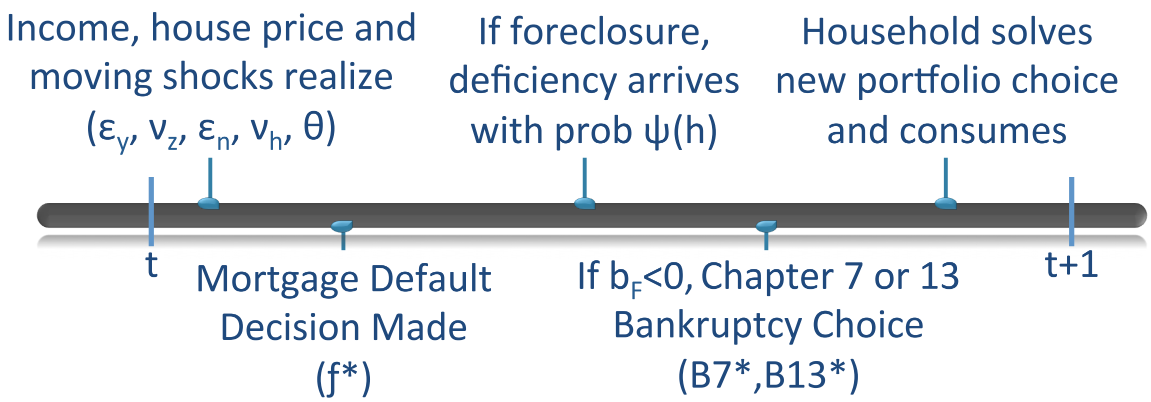


Figure 3: Timeline of events within the period for a household that starts the period as a homeowner with a mortgage.

the solutions also imply policy rules for housing, mortgage and bond choice.

2.4 Financial Intermediaries

Banks can borrow at the risk-free interest rate, denoted r_b. To capture administrative and screening costs, I impose a proportional resource costs r_h and r_u for issuing each unit of a mortgage or unsecured debt respectively. Agents simultaneously apply for mortgages and unsecured loans and banks can observe the portfolio choices b', h', m', persistent states z, ω (if a homeowner) and the credit history. The banking sector is competitive, and banks are assumed to make zero expected profit loan-by-loan (as in Chatterjee et al. (2007) for unsecured debt and Jeske, Krueger & Mitman (2013) for mortgages). The zero-profit assumption allows me to analyze the mortgage and bond problems separately.

2.4.1 Mortgage Problem

The return to issuing a mortgage depends on the repayment and default behavior of the household. When a home is sold or mortgage refinanced, the existing mortgage is paid off in full. If the household defaults on the mortgage, the bank recovers the depreciated value of the house processed through the foreclosure technology, $\gamma h' p_h'$, wins a deficiency judgment,

$(1+r_m)m' - \gamma p_h' h'$, with probability ψ. In case of mortgage default and bankruptcy, the bank recovers bonds held by the household.[24]. The typical bank will only issue mortgage contracts with a non-positive expected net-return:

$$q_m(b', h', m', z, \omega, G)m' \geq \frac{1}{1+r_b+r_m} \times \mathbb{E}_{p_h', \omega', y', z', \theta' | z, \omega} \tag{5}$$

$$\left\{ \begin{array}{c} (S_G^*(X') + R^*(X'))(1+r_m)m' + \\ P_G^*(X')\left((1+r_m)m' - m'' + m'' q_m(b'', h', m'', z', \omega', G)\right) + \\ (1 - f_G^*(X'))B7^*(X') \left[\begin{array}{c} (1 - \mathbf{1}_{\eta \leq \chi}(1-\theta'))(1+r_m)m' + \\ (1-\theta')\mathbf{1}_{\eta \leq \chi}\left(r_m m' + m' q_m(0, h', m', z', \omega', 7)\right) \end{array} \right] + \\ (1 - f_G^*(X'))B13^*(X') \left[\begin{array}{c} \theta'(1+r_m)m' + \\ (1-\theta')\left((1+r_m)m' - m'' + m'' q_m(b'', h', m'', \phi, z', \omega', 13)\right) \end{array} \right] + \\ f_G^*(X') \left[\begin{array}{c} \psi(h')\left((1-B^*)(1+r_m)m' + B^*(\gamma p_h' h' + \max(b', 0))\right) + \\ (1-\psi(h'))(\gamma p_h' h') \end{array} \right] \end{array} \right\}$$

where the first line corresponds to a household selling its home (S^*) or refinancing its mortgage (R^*). The second line corresponds to a household that keeps its home (P_G^*) and chooses new principal balance m'' ($\leq m'$). The value to the financial intermediary going forward is as if a mortgage of size m'' was originated to the household[25], taking into account the evolution of borrowers' exogenous states as well as endogenous portfolio choice. The third line is for a household that only files for Chapter 7. In case of a moving shock or non-exempt home equity, the mortgage is repaid. Otherwise it makes an interest payment and the continuation value takes into account the Chapter 7 flag. The fourth line corresponds to a household that only files for Chapter 13 bankruptcy. In case of the moving shock, the mortgage is repaid, otherwise the household makes a payment. The continuation value takes into account that the household has a Chapter 13 credit flag and income penalty, ϕ. The last

[24]The seizure of bonds is assumed to be efficient to represent the fact that secured debt is treated as senior debt in bankruptcy, and thus is paid before fees and administrative costs.

[25]This formulation is similar to that for long-term debt analyzed by Chatterjee & Eyigungor (2015)

line reflects households who default on their mortgages. The bank seizes the home subject to the foreclosure technology. If the bank obtains a deficiency judgment and the household does not file for bankruptcy ($B^* = B7^* + B13^*$), it receives payment in full. Otherwise, the bank receives the house (processed through the foreclosure technology) and bonds.

Even though households with bad credit histories can't originate new mortgages, the bank needs to keep track of the shadow price of issuing such mortgages for bankrupt households in order to properly value the mortgages it originates to households with good credit. The shadow prices for households with Chapter 7 and Chapter 13 bad credit histories are reported in the Online Appendix.

2.4.2 Unsecured Credit Problem

When households are saving in bonds, $b' \geq 0$, q_b represents the price of buying a bond that pays b' units of consumption good tomorrow. There is no default risk on savings and thus for a homeowner:

$$q_b\left(b', h', m', \omega, z, \mathcal{C}\right) \leq \frac{1}{1+r_b} \tag{6}$$

and for a renter

$$q_b\left(b', z, \mathcal{C}\right) \leq \frac{1}{1+r_b} \tag{7}$$

which from the zero profit condition immediately implies that the price only depends on the risk-free rate, $q_b = \frac{1}{1+r_b}$ when $b' \geq 0$ for both homeowners and renters.

When households have a bad credit history, they cannot take on unsecured debt, so $q_b = 0$ when the credit history is $F, 7$, or 13. For a renter with a good credit history, the price of a bond with negative face value b' depends on the household's probability of filing for bankruptcy. The bank receives nothing if the household files for Chapter 7 bankruptcy, and will receive partial repayment if the household files for Chapter 13, otherwise it receives the face value of the debt. The condition for the bank issuing unsecured debt of size b' to a renter is therefore:

$$- b'q_b\,(b', z) \geq \frac{1}{1 + r_b + r_u} \times \mathbb{E}_{y',z'|z}\Big\{ - b'(1 - B7^*(X') - B13^*(X')) + B13^*(X')\phi\bar{y}\Big\} \quad (8)$$

For a homeowner, the problem of the bank also depends on the home equity of a household and its non-exempt assets, since they can be seized if a household files for Chapter 7 and places restrictions on whether the household can file for Chapter 13. If a household declares bankruptcy and has home equity in excess of the homestead exemption χ the bank can recover a fraction of it. Let ξ' denote the non-exempt portion of a household's home equity, namely $\xi' = \max\{p_h'h' - (1 + r_m)m' - \chi, 0\}$. Through the bankruptcy technology, the bank can recover $\max\{-b', \zeta\xi'\}$ from a household that declares bankruptcy, where $\zeta \leq 1$ represents the bankruptcy recovery technology. If the household files for Chapter 13, the bank recovers $\phi\bar{y}$. Households can only file for Chapter 13 bankruptcy if $\phi\bar{y} \geq \zeta\xi'$. The condition for the bank issuing unsecured debt of size b' to a household with characteristics X' is:

$$\begin{aligned} -b'q_b\,(b', h', m', p_h', \omega, z) \geq \frac{1}{1 + r_b + r_u} \times \qquad\qquad (9) \\ \mathbb{E}_{\mathcal{J},p_h',\omega',y',z',\theta'|z,\omega}\Big\{ \big[-b'(1 - B7^*_{\mathcal{J}}(X') - B13^*_{\mathcal{J}}(X')) + B7^*_{\mathcal{J}}(X')\zeta\xi' + B13^*_{\mathcal{J}}(X')\phi\bar{y}\big] \Big\} \end{aligned}$$

where the B^* indexed by $\mathcal{J}$ represents the bankruptcy choice conditional on any foreclosure and deficiency judgment realization.

2.5 Credit Market Equilibrium

The pair (ψ, χ) summarizes the legal environment for the state. Each state is treated as a small open economy for the purpose of the bond and mortgage market taking the risk-free rate r_b as given. The rental price p_r and the idiosyncratic house-price process, p_h, are also taken as exogenous. The equilibrium is a fixed point in pricing schedules for unsecured credit and mortgages, such that given prices, households maximize and given optimal default behavior of households, intermediaries make zero profit in expectation. The formal definition of equilibrium is given in the Online Appendix.

3 Theoretical Results

The purpose of this section is to provide theoretical results that characterize household default decisions that will show the model is consistent with micro evidence in Fay, Hurst & White (2002) and help guide the interpretation of the quantitative results. In addition, the theory will prove useful in the computation of the equilibrium. I characterize the bankruptcy and foreclosure decisions. Further, I analyze how housing, foreclosure, and the homestead exemption affect the household bankruptcy decision.

3.1 Existence and Characterization of the Household Problem

In order to prove the existence of a solution to the household problem, I assume that utility is bounded above and that the utility of consuming zero is small enough that a household will always prefer to go bankrupt rather than having zero consumption in a given period.[26] Further, consistent with the penalties associated with bankruptcy, a household with a bad credit history *ceterus paribus* has lower lifetime utility than one with a good credit history.

Proposition 1 Existence of a Solution to the Household Problem

(1) The household value functions $V^{\mathcal{H}}$ exist and are unique; (2) The value functions are bounded and increasing in a; (3) A bad credit score reduces utility, i.e. $V^G \geq V^{F,7,13}$

The proof of the existence of a solution to the household problem follows from standard contraction mapping arguments (boundedness from below comes from the option to default). The details of all proofs can be found in the Online Appendix.

[26] In my quantitative analysis I will assume a constant relative risk aversion utility function with CRRA parameter greater than 1 which satisfies this condition.

Now that I have shown a solution to the household problem exists, I proceed to characterize the Chapter 7 bankruptcy decision[27]. Since that decision is made after the foreclosure decision, similar to Chatterjee et al. (2007), I can characterize the Chapter 7 bankruptcy decision as a *bankruptcy set*, $\overline{\mathcal{B}}_7^*$. For renters and homeowners that are foreclosed upon, the bankruptcy set depends on the unsecured debt position (b for renters and b_F for foreclosed upon households) and persistent income state. For homeowners who are hit by the moving shock and do not default on their mortgages, the bankruptcy set depends only on the home equity, $\eta = p_h h - (1 + r_m)m$, the non-exempt home equity, $\xi = \max\{0, \eta - \chi\}$, the unsecured debt, b, and the persistent income state z. For homeowners not hit by the moving shock who do not default on their mortgages, the bankruptcy set depends on unsecured debt, the mortgage balance, the size of the home, the persistent income shock and persistent house price shock, ω.

Proposition 2 Chapter 7 Bankruptcy Characterization

1. (a) *For renters, for any value of unsecured debt, b, the Chapter 7 bankruptcy set is either a closed interval, i.e. $\overline{\mathcal{B}}^*_{7,R}(b, z) = [\underline{y}^B, \bar{y}^B]$, or empty, i.e. $\overline{\mathcal{B}}^*_{7,R}(b, z) = \emptyset$.*

   (b) *For homeowners who default on their mortgages, for any value of unsecured debt, b_F, the Chapter 7 bankruptcy set is either a closed interval, i.e. $\overline{\mathcal{B}}^*_{7,F}(b_F, z) = [\underline{y}^B, \bar{y}^B]$, or empty, i.e. $\overline{\mathcal{B}}^*_{7,F}(b_F, z) = \emptyset$.*

   (c) *For homeowners who do not default on their mortgages and are hit by the moving shock, $\theta = 1$, for any value of unsecured debt, b, home equity η, non-exempt home equity, ξ, and persistent income state, the Chapter 7 bankruptcy set is either a closed interval, i.e. $\overline{\mathcal{B}}^*_{7,\theta=1}(b, \eta, \xi, z) = [\underline{y}^B, \bar{y}^B]$, or empty, i.e. $\overline{\mathcal{B}}^*_{7,\theta=1}(b, \eta, \xi, z) = \emptyset$.*

   (d) *For homeowners who do not default on their mortgages and are not hit by the moving shock $\theta = 0$, for any value of unsecured debt, b, house size h, mortgage*

[27] A characterization of Chapter choice is provided in the Online Appendix.

debt m, persistent house price state ω and persistent income state z, the Chapter 7 bankruptcy set is either a closed interval, i.e. $\overline{\mathcal{B}}^*_{7,\theta=0}(b,h,m,\omega,z) = [\underline{y}^B, \bar{y}^B]$, or empty, i.e. $\overline{\mathcal{B}}^*_{7,\theta=0}(b,h,m,\omega,z) = \emptyset$.

2. *The bankruptcy set expands with indebtedness b, i.e. $\overline{\mathcal{B}}^*_7(\hat{b},\cdot) \subseteq \overline{\mathcal{B}}^*_7(b,\cdot)$ for $b < \hat{b}$.*

The intuition for this result is that households with very low endowment realizations prefer to take on debt to increase contemporaneous consumption above the period endowment (consumption in Chapter 7 bankruptcy). Whereas households with high endowments prefer to maintain access to credit, and thus repay, but may consume less than if they had declared Chapter 7 bankruptcy (since they have to repay debt).

Next, I provide a partial characterization of how the portfolio of the household affects the Chapter 7 bankruptcy decision. Unlike Chatterjee et al. (2007), but consistent with the findings of Fay, Hurst & White (2002), the Chapter 7 bankruptcy decision depends on more than the net asset position of the household. Homeowners hit by the moving shock with more non-exempt home equity are less likely to file Chapter 7 bankruptcy. Intuitively, as the household holds more non-exempt home equity the cost of filing Chapter 7 increases (more housing wealth would be lost), but the benefit of filing Chapter 7 is constant. Thus, the set of endowment realizations for which the household files Chapter 7 shrinks. Having a substantial amount of non-exempt home equity effectively increases the punishment of bankruptcy - either because assets are seized in Chapter 7 or debts must be partially repaid in Chapter 13. This mechanism is important for understanding the equilibrium price effects generated in the quantitative analysis. Further, for a given net asset position a greater share in home equity increases the chance of filing for bankruptcy (either in Chapter 7 or 13). Keeping the net asset position fixed but changing its composition does not affect the value of repaying,[28] but more home equity increases the value of going bankrupt under Chapter 7 and possibly also Chapter 13. These results are formalized in Proposition 3:

[28]Since after repayment the relevant state variable for the household is the consolidated asset position.

Proposition 3 Home Equity, Exemptions and Bankruptcy

For homeowners hit by the moving shock who do not default on their mortgage:

(a) *The Chapter 7 bankruptcy set contracts in non-exempt home equity* ξ*, i.e.* $\overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi_1,z) \subseteq \overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi_2,z)$*, for* $\xi_2 < \xi_1$*.*

(b) *Holding net assets constant (i.e. fixing* $\eta + b$*) the probability of filing for bankruptcy is increasing in home equity, that is either the Chapter 7 bankruptcy set is expanding,* $\overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z) \subseteq \overline{\mathcal{B}}^*_{7,\theta=1}(b-x,\eta+x,\xi,z)$ *for* $x > 0$ *or for the union of the Chapter 7 bankruptcy set and the set of* y *realizations for which the household files for Chapter 13 bankruptcy is expanding,* $\overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z) \subseteq \overline{\mathcal{B}}^*_{7,\theta=1}(b-x,\eta+x,\xi,z) \cup \overline{\mathcal{B}}^*_{13,\theta=1}(b-x,\eta+x,\xi,z)$ *for* $x > 0$*. Or equivalently, the probability of bankruptcy is increasing in the difference of home equity and debt* $\eta - b$*.*

(c) *When home equity exceeds the homestead exemption, the Chapter 7 bankruptcy set is decreasing in home equity, i.e.* $\overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta+x,\xi+x,z) \subseteq \overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z)$ *for* $x > 0$*.*

(d) *The bankruptcy set is empty if net assets exceed the homestead exemption, i.e. if* $\eta + b > \chi$*, then* $\overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z) = \emptyset$*.*

Having partially characterized the bankruptcy decision, working backwards I now analyze the foreclosure decision. In the model having negative equity is a necessary, but not sufficient, condition for a household to default on its mortgage.

Proposition 4 *Homeowners with mortgages will never default when they have positive home equity, i.e.* $f^*_{\mathcal{C}}(X) = 0$ *for all* $b, h, m, \omega, z,$ *and* y *when* $p_h h \geq (1 + r_m)m$*.*

4 Calibration and Model Fit

The goal of the calibration is to assure that the model can account for aggregate facts related to both secured and unsecured borrowing, foreclosure, and bankruptcy. Each state is treated as a small open economy. They vary only in the homestead exemption χ, whether there is recourse ($\psi > 0$), and the level of median income,[29] keeping technology and preference parameters constant across states.

To balance richness in variation with computational feasibility, I restrict the calibration to seven configurations of the homestead exemption and recourse law[30]. I allocate each state in the US to one of the seven bins - three homestead exemption bins for no-recourse states and four homestead exemption bins for recourse states. For each bin I calculate the average homestead exemption and median income, weighting by state populations. The relative weight of the seven economies in calculating aggregate statistics is determined by the relative proportion of households from those states. For ease of exposition, I refer to the seven binned economies by the name of a representative state from the bin: Washington, California, Minnesota, Maryland, Michigan, Massachusetts and Florida .[31]

The values for the homestead exemption χ are constructed from state laws and state-level median household income estimates from the Current Population Survey published by the U.S. Census Bureau. The values used for the homestead exemption and income are taken from the year 2000 (see Online Appendix for details). For each state, median income is normalized to 1, so χ is in units of state median income. For example, median household income in Pennsylvania was \$40,106, with an exemption of \$30,000 for couples, yielding a $\chi^{PA} \approx 0.75$.

Where possible, parameters are calibrated independently based on direct empirical evidence. There are four remaining parameters without direct empirical evidence: (1) risk-aversion σ, (2) discount factor β, (3) consumption penalty λ and (4) minimum house size $\underline{h}$; which are calibrated jointly to match six data targets: (1) median leverage, (2) probability of bankruptcy conditional on foreclosure, (3) bankruptcy rate, (4) foreclosure rate, (5) share of unsecured debt, and (6) homeownership rate. The parameters are estimated by minimiz-

[29]The income process is the same across states modulo its median level.

[30]The model is computed using standard value function iteration techniques, exploiting the theoretical results where possible.

[31]The state policy parameters are summarized in Table 8 in the Online Appendix.

ing the distance between model and data moments using a diagonal weighting matrix with weights equal to the inverse of the data moment[32]. Table 1 summarizes the jointly calibrated parameters and targets.

4.1 Preferences and Technology

Preferences: I assume constant relative risk aversion preferences and a Cobb-Douglas aggregator over non-durable consumption and housing services:

$$U(c,h) = \frac{\left(c^{\pi}h^{1-\pi}\right)^{(1-\sigma)} - 1}{1-\sigma}$$

This allows me to independently calibrate π to match the share of housing in total consumption. According to NIPA data, the housing share of total consumption has been relatively stable at 14.1% over the last forty years, thus I set $\pi = 0.8590$.

The CRRA parameter σ is set to 2.126 to jointly match median leverage and the probability of bankruptcy conditional on foreclosure observed in the data[33]. I use the 2004 Survey of Consumer Finances to compute the median leverage of prime age households (head age between 25 and 50). Leverage is computed as all debt secured by the primary residence divided by the value of the primary residence[34]. Median leverage is found to be 63%. Li & White (2009) analyze a sample of prime and sub-prime mortgages and find that roughly 28% of households who have foreclosure proceedings initiated against them also file for bankruptcy within six months.

I calibrate the discount factor β to 0.942 to match the aggregate bankruptcy rate (Chapter 7 and 13) from 1995-2004 and the foreclosure rate. The American Bankruptcy Institute publish aggregate annual bankruptcy filings, and I construct rates using data on the number

[32]This procedure minimizes the percent deviations from the data means.

[33]Note that the discussion relating parameters to data targets is heuristic in the sense that all parameters determine all endogenous variables jointly in the model. In the discussion I relate parameters with the moments that they affect the most quantitatively. Further, I target more moments than parameters.

[34]I restrict to all mortgage debt secured by the primary residence since that is the closest analogue to the model (it includes first and second mortgages, home equity loans and home equity lines of credit).

of households from the Census. Sugato Chakravarty & Eun-Young Rhee (1999) report that 16.4% of respondents in the Panel Survey of Income Dynamics who filed for bankruptcy listed excessive health-care bills as the cause. Since I abstract from such expenditure shocks in the model, I target $100\% - 16.4\% = 83.6\%$ of the observed bankruptcy rate in the data[35]. Consistent with data from the Mortgage Banker's Association on foreclosure rates from 1990-2003, I target an aggregate foreclosure rate of 0.55 percent[36].

Endowment Process: Following Storesletten et al. (2004), I set persistence of the shock z, $\rho = 0.98$ and the variance to the innovations to $\sigma_\eta^2 = 0.09$. Estimates for the variance of log annual income range from 0.04 to 0.16 . I thus set $\sigma_\varepsilon^2 = 0.06$, generating a variance of log annual income of 0.15. Using the method of Rouwenhorst, I approximate the persistent component with a three-state Markov chain.

Foreclosure Technology: The foreclosure loss parameter, γ, is set to match the additional loss incurred in a foreclosure (e.g., it captures effects such as decreased maintenance by the occupants). The average loss was estimated by Pennington-Cross (2006) to be 22%. He estimates the loss by comparing revenue from foreclosed home sales to a market price constructed via the Office of Federal Housing Enterprise Oversight (OFHEO) repeat sales index. I therefore set $\gamma = 0.78$ for all states in the model.

Legal Technology: In order to map the bankruptcy recovery rate from the U.S. to the model, I must determine if 1) there is any loss in the forced sale of the home in bankruptcy; and 2) what fraction of assets recovered are actually distributed to creditors. First, note that if the house has been foreclosed the secured creditors seize it and there is nothing for unsecured creditors to collect (see Proposition 4). Campbell et al. (2011) estimate the

[35] David U. Himmelstein, Deborah Thorne, Elizabeth Warren & Steffie Woolhandler (2009) attribute a much higher fraction of bankruptcies (62.1%) to health shocks because they include health related job loss and income changes. Job loss and income changes are captured in the calibration of the income process, thus it seems appropriate to attribute a lower share of bankruptcies to medical shocks.

[36] See Jeske, Krueger & Mitman (2013) for a discussion on constructing this number.

discount due to bankruptcy in Massachusetts, and find it to be less than 5 percent. Thus, if a homeowner has positive equity in the home and declares bankruptcy, I assume that there is no loss in the sale of the house. The proceeds of the sale are first used to repay secured creditors. Next, the costs of administering the bankruptcy (including court costs, fees and administrative expenses) are paid. Finally, unsecured creditors are repaid from anything that remains. The U.S. Department of Justice[37] reports of roughly \$10.5 billion collected in asset cases from 1994-2000, only 52 percent was dispersed creditors. Thus, I set the recovery parameter $\zeta = 0.52$. The remaining 48 percent is assumed to cover the unmodeled costs of administering bankruptcy.

In addition to state-specific laws regarding bankruptcy, the legal environment is described by $\alpha_F, \alpha_7, \alpha_{13}$ and λ, the parameters governing how long a household has a bad credit record and the consumption penalty, respectively. Fair Issac reports[38] that households' FICO scores can recover in as little as two years after a foreclosure. As such, I set $\alpha_F = 0.5$, so that on average households regain access to credit after two years. After filing for Chapter 7 bankruptcy, households are excluded from filing again for Chapter 7 for six years. I set $\alpha_7 = 0.2$ so that on average households regain access to credit after five years (on which they could file for Chapter 7 bankruptcy in the following year). Households that file for Chapter 13 bankruptcy enter into repayment plans that last for 3-5 years. I set $\alpha_{13} = 0.2$ to match the period of time that a household takes to complete the repayment plan[39].

The parameter λ is set to 0.989 to match the unsecured share of household debt. As with

[37]"Preliminary Report on Chapter 7 Asset Cases 1994 to 2000."

[38]http://www.myfico.com/crediteducation/questions/Foreclosure-FICO-Score-Affect.aspx

[39]Setting the period of exclusion from credit markets under Chapters 7 and 13 to be coincident with the prohibition on refiling and payment plan, respectively was chosen to two reasons. First, computationally it avoids having to add a state variable to separately keep track of when households regain access to credit. Second, if households are precluded from filing for bankruptcy they should receive *lower* interest rates than households with good credit histories, which is counterfactual (the model would have to be augmented with an informal default choice to address this issue). The Fair Credit Reporting Act stipulates that foreclosure and Chapter 7 bankruptcy filings cannot remain on a household's record for more than 7 and 10 years, respectively and Chapter 13 filings remain for 7 years after completion of the payment plan, so last for 10-13 years after the date of filing. My period of exclusion is significantly less than the statutory restrictions on credit histories, and more in line with evidence by Song Han & Geng Li (2011) that households regain access to credit while the bankruptcy notation still appears on their credit report.

median leverage, I focus on households with heads aged 25 to 50 because of strong life-cycle effects in housing and mortgage choice[40]. To construct the household share of unsecured debt, I first compute the total mortgage debt secured by the primary residence for prime age households in the 2004 Survey of Consumer Finances, which I find to be 1.74 (in terms of median household income). I then construct a measure of unsecured debt in the SCF by taking total debt, subtracting all mortgage debt, auto loans and student loans (since they are not dischargable in bankruptcy). I then take the ratio of unsecured debt to the sum of unsecured debt and debt secured by the primary residence and find it to be 4.9%. I aggregate unsecured debt and total debt across the seven economies (weighted by households and income) and compute the unsecured share.

Good data on deficiency judgments during 1995-2004 is not available. However, the drop in house prices after 2006 has provided some additional information into how deficiency judgments are pursued. According to the Office of the Inspector General of the Federal Housing Finance Agency, in 2011 there were approximately 340,000 foreclosure sales for mortgages owned or insured by Fannie Mae and Freddie Mac. Deficiencies were only pursued on 35,000 of those properties, which implies a probability of slightly above 10%. The methodology used for deciding whether to pursue a judgment depended on the state law, a borrower's credit history and characteristics of the property and loan. (Ghent & Kudlyak 2011) found on a sample of almost 3 million loans that recourse was only a deterrent on default for properties appraised above $200,000 at origination. As such, I set the probability of a deficiency judgment at 10% for houses that are worth less 3.5 times median income and 15% for houses worth more than 3.5 times median income.

The House Price Process: I calibrate the depreciation process to match house price moments from the data. I also target the variance and persistence of house prices. Using data on repeat home sales, the OFHEO estimates both aggregate and purely idiosyncratic

[40]Households in an infinite horizon model more closely correspond to prime age households in the data.

components of house price risk.[41] The average annual idiosyncratic house price volatility reported by the OFHEO across states is 8%. Chaitra H Nagaraja, Lawrence D Brown & Linda H Zhao (2011) estimate the annual persistence in idiosyncratic shocks to house prices of 0.97[42]. I set the standard deviation of the iid shock to 0.5%. The persistence shock is discretized using the Rouwenhorst method into a five point Markov chain.

Housing Technology I calibrate the minimum house size, $\underline{h}$ to 1.552 to simultaneously match the average value of owner-occupied homes relative to median income and the home ownership rate. I compute the average value of the primary residence using the 2004 SCF and divide by median income to arrive at a value of 3.48. The housing maintenance rate, μ_h is set at 2% to capture an average annual depreciation rate of 1.48% from NIPA and property taxes. The moving shock is calibrated to match median tenure for homeowners. Using data from the Suvery of Income and Program Participation, Peter Mateyka & Matthew Marlay (2011) find that median tenure of homeowners aged 25-34 was 3.2 years and aged 35-44 was 5.6 years. As such I set $\mathbb{E}[\theta] = 0.2$ to generate a median tenure of five years. The moving shock can be thought to also encapsulate life-cycle events that would could a household to move, including divorce or child-birth[43]. I set the rental rate, p_r equal to the maintenance cost of housing. The table of independently calibrated parameters can be found in Table 7 in the Online Appendix.

4.2 Model Fit

Aggregated statistics are listed in Table 2. The model performs well accounting for non-targeted moments in the data. Importantly, it matches the characteristics of households

[41] It models log house prices as a diffusion process consisting of a market price index and a house specific random walk. The technical details can be found in Charles A. Calhoun (1996).

[42] The OFHEO data estimates the variance based on the assumption of a random walk. But given the presence of the moving shock, over the expected duration of housing tenure the difference in variance between the two processes is small. I increase the variance slightly by adding the iid shock to the house price

[43] In Livshits, MacGee & Tertilt (2007), they calibrate small expenditure shocks to be consistent with divorce and unplanned children and show that these are important drivers of bankruptcy.

Table 1: Internally Calibrated Parameters

Parameter	Value	Target	Data	Model
Preferences				
Risk aversion, σ	2.126	Median Leverage	63%	62%
		Probability of bankruptcy conditional on foreclosure	28%	26%
Discount factor, β	0.942	Bankruptcy rate	1.06%	1.05%
		Foreclosure rate	0.55%	0.52%
Technology				
Consumption penalty, λ	0.989	Unsecured debt/primary residence debt	4.9%	4.9%
Minimum house size, $\underline{h}$	1.552	Primary residence/income	3.48	3.45
		Home ownership rate	68%	72%

that file for bankruptcy, validating its use for policy analysis. The Department of Justice reports that in approximately four percent of Chapter 7 bankruptcies assets are disbursed to creditors, in the model two percent of bankruptcies are "asset cases." Thus, virtually all households that file for Chapter 7 bankruptcy have home equity below the exemption level. Miller (2011), analyzing a sample of bankruptcy petitions from 2007, finds that households with more home equity are more likely to file for bankruptcy (her data set includes files from both chapters) in states with high exemptions. The model also generates higher average home equity of filers in high exemption states. She also reports that the average home equity of households filing for bankruptcy is $9,833[44] compared to $9,972[45] in the model.

The model under predicts the share of households that file for Chapter 13 bankruptcy at approximately 9% compared to 29% in the data. Given the fact that home equity is the only exempt asset in the model, it is not surprising (and perhaps reassuring) that the share of Chapter 13 bankruptcies is smaller than in the data. Households may have other non-exempt assets which would motivate them to file under Chapter 13 even if all of their home equity would be exempt. Since I have only targeted a fraction of the overall bankruptcy rate, I do not see this as a problem in evaluating the cross-state or policy implications of the model.

[44] For comparison in the 2001 and 2004 SCF the average home equity of households that reported filing for bankruptcy in the previous year were $9,421 and $27,271.

[45] The average home equity of Chapter 7 filers in the model is $5,492

Table 2: Aggregate Results

	Model	Data	Source
Debt	-1.80	-1.86	SCF 2004
Bonds, B_+	0.41	0.18	Savings/Bonds, SCF 2004
Unsecured debt, B_-	-0.09	-0.12	Unsecured Debt, SCF 2004
Mortgages M	1.71	1.75	Primary residence debt, SCF 2004
Fraction of households with net worth ≤ 0	4.1%	6.7%	SCF 2004
Chapter 7 Asset Cases	2%	4%	DOJ Report 2001
Home equity of bankrupt households	\$9,972	\$9,833	Miller (2011)
Fraction of households with Unsecured Debt	21%	33%	SCF 2004
Fraction of homeowners w/o mortgage	16%	10%	SCF 2004
Mortgage Default Premium	33%	33%	MORTG, DGS10 from FRED

The model is also able to successfully replicate the default premium on mortgages. The mean mortgage interest rate in the model is 1.43%, corresponding to a default premium of 33% (net of the 10 basis point cost of issuing mortgage debt). By comparison, the implied default premium for a 30-year-fixed rate mortgage (MORTG from St. Louis FRED) over the 10-year Treasury constant maturity rate (DGS10) during 1995-2004 was 33%.

5 Results

5.1 The Household Default Decision

To understand how default policies affect default rates and household balance sheets it is instructive to understand when households choose to default. In Figure 4 I consider a household in the Virginia economy (a recourse state with a \$10,000 homestead exemption), who had purchased a \$65,000 house, had a 95% leverage mortgage and took on \$18,000 of unsecured debt. I plot the bankruptcy and foreclosure decisions as a function of the realized home equity (after the price shock) and income realization for a household hit by the moving shock. The dot-dashed line is the level of the exemption (so all home equity above that line is non-exempt) and the dashed line equals zero home equity.

The graph illustrates the complementarity and substitutability of the two types of default. In the upper left, when the household has significant non-exempt home equity and very low income, it chooses to file for Chapter 13 bankruptcy. It keeps its home equity, and because it has low income, in expectation most of its debt will be forgiven. Moving down, when the household has less non-exempt equity, or only exempt equity it files for Chapter 7 bankruptcy. If it has significant negative equity and low income it defaults on its mortgage and files for Chapter 7 bankruptcy. As its income increases it's willing to tolerate more negative equity before defaulting on its mortgage. And as its income increases further still, it defaults on its mortgage, but would only file for bankruptcy it if received a deficiency judgment. At the highest levels of income the household doesn't default on either its mortgage or unsecured debt even if it has significant negative equity.

While figure 4 provides one example of a household, to better understand which shocks drive the decisions of households to default, in table 5.1 I decompose the fraction of defaulting households that experience a persistent income shock (z), persistent house price shock (ω), moving shock (θ) or deficiency judgment shock in the period of default[46]. Almost one third of households that file for bankruptcy experience a persistent shock to their house value in the period of default. The decline in the value of the home makes it more difficult for households to borrow in either mortgage or unsecured debt, so a household that already has substantial unsecured debt may file for bankruptcy to avoid mortgage default. Only about 2.5% of bankruptcies are the result of households experiencing deficiency judgments.

Turning to mortgage default, roughly 57% percent of foreclosures are driven by the moving shock and almost one fifth receive a persistent shock to the house price in the period of foreclosure. Having negative equity therefore is a necessary condition for mortgage default, but not a sufficient one. Less than 20% of households with negative equity default on their mortgages[47]. The moving shock is important for generating foreclosure, but more than 85%

[46]The numbers need not sum to one since a household may have experienced more than one shock in the period of default, or experienced none of the shocks (households are still subject to transitory income and house price shocks).

[47]It is important to recall that the standard deviation of the transitory house price shock is only 0.5%, so

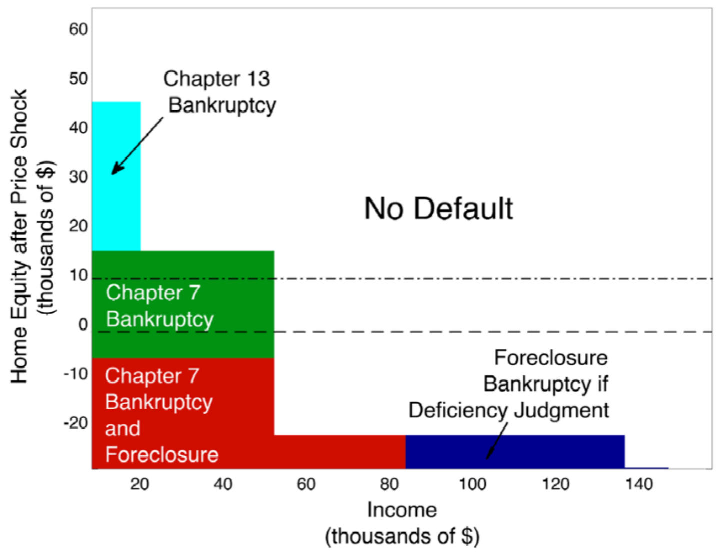


Figure 4: Household discrete choices with a house size equal to five times the median income and an 80% leveraged mortgage.

of homeowners with mortgages that experience the moving shock do not default. The moving shock can be thought to encapsulate life-cycle events (e.g. divorce, unexpected children) that may necessitate a household to move. The model thus captures salient empirical observations related to mortgage default, namely that households in general are willing to tolerate negative equity without defaulting and that a drop in house prices alone is not sufficient to explain foreclosures, but household with negative equity must also experience an adverse life event - the "double-trigger" hypothesis discussed in Christopher Foote, Kristopher Gerardi, Lorenz Goette & Paul Willen (2009).

After examining the household default decision, I proceed to analyze how that decision feeds back into equilibrium interest rates on unsecured and mortgage credit and how those different prices affect the portfolios households select into.

5.2 Effects of the Homestead Exemption

In the theoretical results, I proved that households with less non-exempt home equity are more likely to go bankrupt. Since the prices of unsecured credit reflect the implied default

that it is not a significant driver of house price declines.

Table 3: Drivers of Default

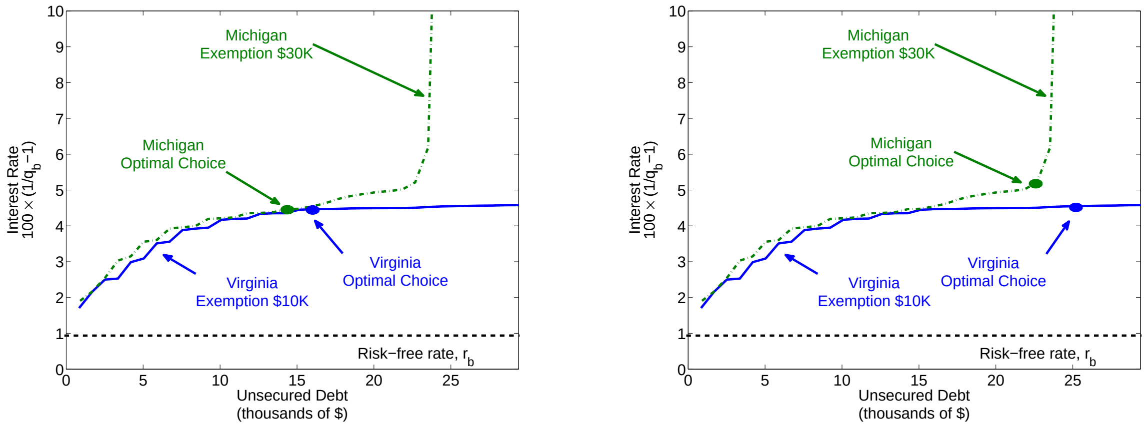
	Fraction of Defaulters Hit by Shock in Period of Default			
	Income	House Price	Moving	Deficiency Judgment
Bankrupt Homeowner	5.4%	31.6%	14.8%	2.5%
Bankrupt Renter	1.4%			
Foreclosure	0.8%	19.0%	56.9%	

Notes: The income and house price shocks refer to the persistent components of income (z) and house prices (ω). The numbers need not sum to one, as households could be hit by multiple shocks, or may have experienced none of those shocks.

probabilities, a household with less non-exempt home equity should face a higher cost of borrowing in unsecured credit than one with more non-exempt home equity.

To illustrate this effect, I choose two households, one in Virginia and one in Michigan (both recourse states) that are both homeowners that own the same size house, same house price, have the same mortgage and cash at hand and the same persistent income state. The households have a house worth \$160K and a 72% leverage mortgage and a persistent income realization that equates to an average income of \$42K.

Figure 5(a), plots the unsecured interest rate for hypothetical amounts of unsecured borrowing for the Virginia and Michigan households when they choose to keep their mortgage principal the same. In this scenario both households have about \$28K cash at hand (which means that they had about \$14K in unsecured debt, since their income on average is \$42K). Notice that the interest rate is higher for all debt choices in the Michigan economy. In equilibrium, the households both end up receiving the same interest rate, but the Virginia household is able to borrow more - \$16K versus \$14K. Both households have \$45K in home equity. At the value of unsecured credit chosen, the Michigan household is close to the financial break-even point for filing for Chapter 7, it would lose \$15K in non-exempt equity, but would have \$14K in unsecured debt discharged. The Virginia household, on the other hand, would stand to lose \$35K in non-exempt equity to have \$16K discharged, for a net loss of \$19K. Thus, at every point in the graph the punishment for filing for Chapter 7 is higher



(a) Unsecured Interest Rates

(b) Unsecured Interest Rates

Figure 5: Interest rates on unsecured debt for households of identical house, mortgage, and cash at hand in Virginia and Michigan. The dots in both figures represent the optimal policy choices. *Notes:* Both households have a house worth $160K, a 72% LTV mortgages and persistent income realization corresponding to $42K. In the left column the households have $28K cash-at-hand and in the right $16K

for the Virginia household (though, the punishment would be identical under Chapter 13).

Figure 5(b), plots the optimal choices for households in the two states that have the same income, houses and mortgages as described in the previous paragraph, but now have only $16K cash at hand (equivalent to roughly $26K in unsecured debt). The household in the Virginia economy now takes on more debt at a lower interest rate than the Michigan household[48].

These differences in allocations are consistent with evidence in Miller (2011). She analyzes the portfolios of households in the Panel Survey of Income Dynamics (PSID) and finds that households have less debt when exemptions are high and that that effect is larger when households hold non-exempt equity. Her analysis is directly comparable to the example households discussed above - both households have non-exempt equity, and in the state with the higher exemption (Michigan) the household took on less unsecured debt. The magnitudes are also consistent with Miller (2011), who finds a difference of about $4K.

[48]The Virginia household takes on $25K in unsecured debt at a 4.6% interest rate, compared to $22K at 5.2% for the Michigan household.

The mechanism by which the model generates the differences in allocations is through equilibrium price effects on unsecured credit. To test this prediction of the model, I construct a measure of the cost of unsecured borrowing using the Consumer Expenditure Survey (CEX) from 1994-2003. For households that reported having unsecured debt, I compute the effective real interest rate by dividing the expenditure on interest and finance charges by the amount of unsecured debt and deflating by the Consumer Price Index[49] (CPI) for prime aged households[50]. While a crude measure, to my knowledge the CEX is the only publicly available data source that provides information on unsecured debt, interest and finance charges, and state of residence[51].

There are 11,055 observations in my sample, so I simulate 100 samples of the same size from the model. Because the CEX is not designed to be representative at the state level, I divide states into high and low exemption states and then compare the mean interest rates[52] in Table 4. The real interest rates in the CEX are remarkably close to those in the model[53]. In addition, I compute interest rates by weighting by the amount of unsecured debt the household holds. In both the model and the CEX, the debt-weighted average interest rate is significantly lower than the household-weighted one. There is no significant difference between the debt-weighted interest rates in high and low exemption states. The debt-weighted average is relevant because it provides a direct comparison to charge-off rates on credit cards, providing validation of the CEX measure of interest rate and the magnitude of default in the model. The average charge off rate on credit cards from 1995-2004 was

[49]The average inflation rate during this time period was 2.5%.

[50]I only include households that earned at least $5,000 in income. This procedure generates some extreme outliers, so I trim observations with an implied interest rate over 1000% (N=42). For consistency, I perform the same sample exclusion on model generated data.

[51]Alternatively, one could use the SCF to determine interest rates. One limitation, however, is that the question only asks for the interest rate on the card with the highest balance, which may be a systematically downward biased measure of the interest rate paid, if households allocate the largest balances to the cards with the lowest interest rates. Further, it does not capture the total costs associated with borrowing, such as fees finance charges.

[52]Means and standard errors are computed across simulations for the model generated data.

[53]In the Online Appendix, as a robustness exercise, I control for household observables as well to ensure the differences in interest rates across states aren't being driven by differences in households across those states. When controlling for household income and home equity I still find that living in a high exemption state increases the average interest rate on debt.

Table 4: Unsecured Interest Rates

	Person weighted		Debt weighted	
	Data (CEX)	Model	Data (CEX)	Model
Low Exemption	19.0%	18.9%	6.1%	6.0%
	(0.7%)	(1.1%)	(0.2%)	(0.4%)
High Exemption	21.8%	22.7%	6.1%	5.9%
	(1.6%)	(1.3%)	(0.5%)	(0.5%)

Notes: Data constructed by diving interest and finance charges by total debt and computing the mean across households. The model means are the averages of 100 simulations of a sample of size $N = 11,055$. Standard errors are reported across simulations

5.03%[54]. With a risk-free rate of 1%, the analogous charge off rates are 5% (=6%-1%). In sum, the data on interest rates confirm that the model captures the relevant mechanism.

A second implication of the mechanism in the model is that higher prices for unsecured debt in high exemption states induce households to more heavily weight their balance sheets towards mortgage debt. To test this implication, I construct household mortgage leverage from the 2000 Residential Finance Survey (RFS). Leverage is computed by summing across the balance on all mortgages outstanding[55] and diving by the current value of the home for all prime-aged households with a positive mortgage balance. Since the RFS only includes state identifying information for twelve states (note that those twelve states include 65 percent of all households in the US[56]) I partition the states between high and low exemption states. The mean leverage of households with a mortgage and standard errors are reported in Table 5. I simulate households from the model of the same sample size ($N = 4,315$) 100 times and report the mean leverage and standard deviation across simulated means also in Table 5. The model does remarkably well in matching the leverage in high and low exemption states, further validating the mechanism by which the homestead exemption operates in the model.

[54] Charge off rates are provided by the Federal Reserve at http://www.federalreserve.gov/releases/chargeoff/chgallsa.htm

[55] This includes first and second mortgages, home equity loans and balances on home equity lines of credit.

[56] The twelve states are: California, Florida, Illinois, Massachusetts, Michigan, New Jersey, New York, Ohio, Pennsylvania, Texas, Virginia, Washington.

Table 5: Mortgage Leverage

	Data (RFS)	Model
Low Exemption	67.03%	64.97%
	(0.82%)	(0.39%)
High Exemption	74.50%	74.70%
	(5.23%)	(0.51%)

Notes: Data constructed by dividing mortgage balances by current house value and computing the mean across households. The model means are the averages of 100 simulations of a sample of size $N = 4,315$. Standard errors are reported across simulations

5.3 Effects of Recourse

Recourse has surprisingly little effect on foreclosure and average mortgage interest rates. Recourse and no recourse states with the same homestead exemption have nearly identical foreclosure rates. For low levels of leverage, default risk is close to zero, so the potential additional cost of recourse cannot move default rates very much in absolute terms. Households choose highly leveraged mortgages tend to have lower income and assets. As shown in 4, conditional on receiving an adverse shock those households are likely to default on their mortgages *and* file for bankruptcy, limiting the efficacy of recourse.

Households that are directly affected by recourse are those with high incomes and substantial savings in bonds. Those households are less likely to default on their mortgages because they have the resources to repay an underwater mortgage and want to avoid a deficiency judgment.[57] However, households that have high incomes and have substantial savings in bonds take on mortgages with low leverages and thus have low probabilities of ending up foreclosure to begin with.

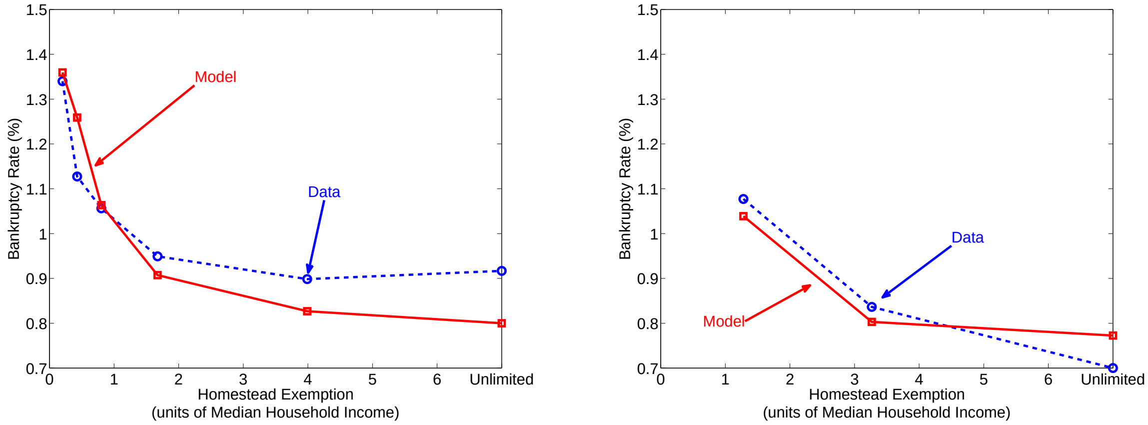
[57] This is consistent with the interpretation of the effects of recourse found in Ghent & Kudlyak (2011).

5.4 Accounting for State Differences in Bankruptcy Rates

A natural question to ask is how much of the cross-state variation in bankruptcy rates can be explained by the differences in the homestead exemption and recourse[58]. One important caveat is that states vary in demographic and legal characteristics that are abstracted from in the model, but which may be relevant to state default rates. For example, two important dimensions along which states vary are whether the foreclosure process is judicial or non-judicial and the volatility of house prices as discussed in John Y. Campbell, Stefano Giglio & Parag Pathak (2011). The nature of income risk and generosity of social safety nets could also play an important role. The model should, therefore, not be expected to explain all of the variation in bankruptcy rates across states. In order to partially control for that additional variation, Figure 6(a), plots model and data bankruptcy rates for states binned by exemption level and recourse policy (I solve the model for all 50 states and the District of Columbia). The model captures the negative relationship between the homestead exemption and bankruptcy rates and the positive relationship between recourse laws and bankruptcy rates.

Figure 6(a) only presents conditional means. For a more careful accounting, I compute the R^2 between the model generated bankruptcy rates and the bankruptcy rate in the data. I find an R^2 of 0.42, so that variation in the homestead exemption and recourse explains just over 40% of the variation in bankruptcy rates across states. Despite the fact that the model predicts a lower level of Chapter 13 bankruptcies relative to the data, the model does a good job in explaining the cross-state *variation* in the share of Chapter 13 bankruptcies and is able to capture the negative relationship between the homestead exemption and the Chapter 13 share. Moving from the low exemption economy to an unlimited exemption decreases the

[58]It is important to note that, in the model, the variation in policies is given exogenously. Richard M. Hynes, Anup Malani & Eric A. Posner (2004) provide a detailed historical account of the origins of property exemptions in bankruptcy. They find that historical exemption levels have more predictive power in explaining current exemption levels than contemporaneous economic and political factors, and that historical exemptions were mainly driven by economic forces of the 19th and early 20th century. Thus, to the extent that current economic conditions are independent of the economy a century ago, I view treating state exemption levels as exogenous as defensible.



(a) Recourse states.

(b) Non-recourse states.

Figure 6: Accounting for the cross-state variation in bankruptcy rates.

Chapter 13 share by 10 percentage points in both the data and model. The R^2 between the model generated share of Chapter 13 bankruptcies and the data is also 0.42, so that variation in default policy explains roughly 40% of the variation in the share of Chapter 13 bankruptcies.

The discussion of the homestead exemption and recourse in the preceding sections sheds light on why household balance sheets are different across states, but does not directly answer why these differences lead to different default rates. In all states, there are very low net worth households that are renters and borrow in unsecured credit. The debt portfolios and default rates of these households are, to first order, unaffected by the exemption (since they're renters and have no home equity). The equilibrium price effects of the homestead exemption do, however, affect the fraction of households with housing that choose to take on unsecured debt. Households with non-exempt home equity have access to relatively cheap unsecured borrowing. As the homestead exemption rises, the fraction of households that have non-exempt home equity falls. As a result, some households stop borrowing unsecured and only take on mortgage debt. Thus, the fraction of households who borrow unsecured, and therefore *are at risk of going bankrupt* is smaller in high exemption states. This leads to lower bankruptcy rates.[59] The extensive margin choice by home owners of whether to take on unsecured debt drives the majority of the variation in bankruptcy rates. Further, differences in the extensive margin explain why states with higher interest rates also have lower default rates (even though interest rates reflect default probabilities). In states with high exemptions, *conditional on borrowing unsecured* households have a higher propensity to default, but since fewer households are borrowing, the state bankruptcy rate is lower. Foreclosure rates are higher in high exemption states because mortgage leverage is higher and the probability of foreclosure is increasing with leverage. These effects can be seen in the state level aggregates in Tables 9 and 10 in the Online Appendix, along with a counterfactual exercise that illustrates that a model without foreclose does not reproduced the observed patterns in the data.

In addition, the model predicts that recourse states will have slightly higher bankruptcy rates than no-recourse states. The result is intuitive, since in recourse states foreclosing households face additional liability, which may trigger bankruptcy following foreclosure. In addition, in recourse states households are more likely to go bankrupt conditional on foreclosure compared to no-recourse states. That number directly reflects the effect of the parameter ψ, the probability of a deficiency judgment. These results are consistent with recent research by Li & White (2009) (see their Table 5) that suggests that households are more likely to file for bankruptcy after foreclosure in recourse states than no-recourse states.

Having shown that the model is an appropriate laboratory for studying bankruptcy and foreclosure in the U.S., I proceed with policy analysis.

6 BPACPA and HARP

I now use the calibrated model to conduct two policy experiments. In the first policy experiment, I consider the effects of the 2005 Bankruptcy Abuse Prevention and Consumer

[59] In recourse states even households that hold no unsecured debt but hold mortgages are at risk of bankruptcy because of the deficiency judgments in foreclosure. However, quantitatively, these households account for less than 1% of bankrupt households in recourse states.

Protection Act (BAPCPA), the first major reform to bankruptcy in almost 30 years. The reform made it more difficult for households earning more than the median income in their state from filing for Chapter 7 bankruptcy. The analysis enables me to evaluate the hypothesis of Donald P. Morgan, Benjamin C. Iverson & Matthew Botsch (2009) and Wenli Li, Michelle J. White & Ning Zhu (2010) that BAPCPA contributed to the subsequent observed rise in foreclosure rates. The second experiment evaluates the effects of the Home Affordable Refinance Program (HARP), a program passed in 2009 to help homeowners with low or negative home equity refinance their mortgages.

Evaluating the efficacy of HARP (and the full impact of BAPCPA) requires simulating an aggregate shock to house prices to generate a substantial number of households with low or negative equity. To generate the aggregate shock, in one period when computing transitions for households instead of using the transition probabilities implied by the Markov chain for the persistent house price shock, I assume that all households deterministically transit to one state lower in the Markov chain (and households at the lowest state remain there). All households thus experience the same percentage drop in house prices (except those at the bottom of the Markov chain)[60]. The advantages of modeling the shock in this way are: 1) while in the aggregate the drop was a zero probability event, from the perspective of the households, they had all assigned positive probability to such individual transition taking place; 2) the shock to house prices is very persistent, but not permanent, which provides incentive for households to stay and refinance underwater mortgages; and 3) the economy will transition back to the original steady state[61]. In terms of timing, I assume that the shock happens two periods into the transition after the implementation of BAPCPA (which occurred at the end of 2005).

[60] In addition, in the period the shock occurs, I assume that only 5% of households experience a moving shock, as opposed to 20%, to avoid an unrealistic spike in the foreclosure rate

[61] A permanent shock to the level of housing would be equivalent to a positive supply shock of housing, which would lead to a new steady state with a significantly higher (and counterfactual) homeownership rate.

6.1 BAPCPA

In order to "prevent abuse", the BAPCPA reform instituted a means test for filing for Chapter 7 bankruptcy. Households who earned less than the median income in their state are free to still file under Chapter 7, however a "presumption of abuse" exists if the household earns above the median income. Households can then submit evidence that after expenses (e.g. mortgage, living costs, etc) discretionary income is very low and that they are not "abusing" Chapter 7. Since operationally it would be difficult to replicate the means test in the model, to capture the spirit of the means test, I specify that households above median income based on the persistent component of earnings are prevented from filing for Chapter 7 (but still retain the option to file under Chapter 13). I choose this to reflect the fact that households close to the median income are more likely to pass the means test (especially if they have high allowable expenses)[62].

In addition to imposing the means test, the reform also increased the costs of filing for bankruptcy. The direct filing fees increased, lawyer fees on average increased because of the added complexity and liability. These increased costs particularly affected Chapter 7 filers because they are required to pay those costs upfront, whereas Chapter 13 filers can pay those costs as part of their repayment plan. Tal Gross, Matthew J Notowidigdo & Jialan Wang (2014) report that filing and legal fees increased on average $456 dollars for Chapter 7 filers. Further, households were required to attend mandatory credit counseling sessions before filing. The amount of paperwork required for filing also increased significantly. The BAPCPA also limited the homestead exemption to $125,000 in all states except if special circumstances apply.

My introduction of BAPCPA in the model consists of three changes:

1. Households who are above median income based on the persistent component of earnings are precluded from filing for Chapter 7.

[62] Based on the discretization of the income process this applies to the top 25% of earners in the model. All of these households earn at least 25% more than the median income.

Table 6: Aggregate Effects of BAPCPA

	Baseline	BAPCPA
Housing, H	3.45	3.46
Unsecured debt, B_{-}	-0.09	-0.20
Mortgages M	1.71	1.77
Fraction with net worth ≤ 0	4.1%	7.5%
Bankrupty Rate	1.05%	0.75%
Foreclosure Rate	0.52%	0.54%

2. Households who file for Chapter 7 bankruptcy now have to pay a fixed filing cost

3. The homestead exemption is capped at $125,000 in all states[63]

I set the fixed cost of filing for Chapter 7 bankruptcy at 2% of median income to match the increase in filing and legal fees, the cost of credit counseling and the time cost of attending counseling and preparing additional paperwork. The passage of the reform is unexpected, and implemented after the default decisions are made for the period. I then compute the transition from the original steady state to the new steady state equilibrium.

6.1.1 Effects on Allocations

The reform significantly increases the amount of unsecured debt taken on by households, and the number of households with non-positive net worth, as shown in Table 6. Despite the increase in debt, bankruptcy rates fall 0.3 percentage points to 0.75%, whereas foreclosure rates increase modestly from 0.52% to 0.54%. Unsurprisingly, the share of Chapter 13 bankruptcies increases.

The reform significantly reduces the cost of unsecured borrowing for high income households. Even though those households still retain the option to file for Chapter 13 bankruptcy, the partial repayment penalty is a significant deterrent. Further, even if those households were to file for Chapter 13 bankruptcy, since their income is high, they would repay a substantial portion of their debts over the five year period, which keeps the interest rate low.

[63]The BAPCPA limited the homestead exemption to $125,000 in all states unless certain tenure and residency requirements were met.

In the data, we have not seen a doubling of unsecured debt over the past ten years since the passage of BAPCPA. However, revolving consumer credit did increase roughly 20% between 2005 and 2007[64]. After the onset of the Great Recession, however, there was a significant contraction in consumer credit. That event, combined with the persistent effects of the recession may explain why we have not see a significant increase in unsecured debt[65]. In the model, most of the increase in consumer credit is driven by high income households. Another possible explanation for why we have not seen as large an increase in borrowing in the data is because of life-cycle savings concerns. This point was made first in Livshits, MacGee & Tertilt (2007), who noted that older households who are high-earners tend to be also saving for retirement, which would attenuate their desire to borrow despite having lower interest rates.

To first order, the borrowing of low and middle income households is unaffected by the means test. They are, however, affected by the introduction of the fixed cost of filing, which does lower interest rates by increasing the punishment for defaulting. Consider the same household in the Michigan economy as in section 5 (recall that the households owns a house worth $160K, has a 72% leverage mortgage and a persistent income realization that equates to an average income of $42K, and $16K cash at hand). In Figure 6.1.2, I plot the unsecured interest rate schedule that that household faces under the baseline economy and under BAPCPA. The interest rate schedule under BAPCPA is uniformly lower than in the baseline. As a result the household optimally borrows approximately 5% more under BAPCPA, but at a slightly lower interest rate than in the baseline. The household is therefore borrowing more, but is less likely to default. The combination of the means test and increased cost of filing explains the overall drop in filing rates.

[64]Unsecured borrowing had been steadily increasing before 2005 as well, as documented in, e.g. Igor Livshits, James MacGee & Michèle Tertilt (2010).

[65]Interestingly, however, we have seen a significant expansion in student loans over the past ten years. Government issued student loans have always been non-dischargeable, however, loans issues by private entities in the past could be discharged in bankruptcy. BAPCPA essentially made all student loans non-dischargable, which may have had a similar effect of decreasing interest rates and increasing supply.

6.1.2 Effect of Homestead Exemption under BAPCPA

Before the reform, higher homestead exemptions resulted in lower bankruptcy rates and lower fraction of bankrupts filing under Chapter 13. After BAPCPA, the relationship between bankruptcy rates and the homestead exemption still holds[66], however the fraction of households choosing to file under Chapter 13 increases relatively more in states with high exemptions. Further, the increase in unsecured credit is disproportional - unsecured borrowing increases more in states with high exemptions than in states with low exemptions.

The income restriction imposed under BAPCPA significantly mitigates the price effect of higher exemptions for high income households since they are prevented from discharging debt under Chapter 7 even when there is a financial benefit of doing so. They still have the to option to file under Chapter 13, but with high income they would repay a substantial portion of their debt. High income households thus have a motive to "borrow to save" - they can increase their unsecured borrowing and increase home equity to mimic an insurance contract against low income realizations. If the households remain with high income they repay the debt (absent the BAPCPA restriction they would have a strong financial incentive to file under Chapter 7 bankruptcy), whereas if they fall below the median income they can file for Chapter 7 bankruptcy and keep all of their exempt home equity. The level of insurance provided is limited by the level of the exemption, making it more attractive to households in high exemption states than low exemption states. Despite the increase in borrowing among some high income households, the probability of falling below the median is still sufficiently low that it does not result in a significant increase in the bankruptcy rate. The increase in borrowing again is subject to the same caveat as in the previous section, that some of this behavior may be mitigated by life-cycle savings concerns.

[66]The state by state default rates are presented in Table 11 the Online Appendix.

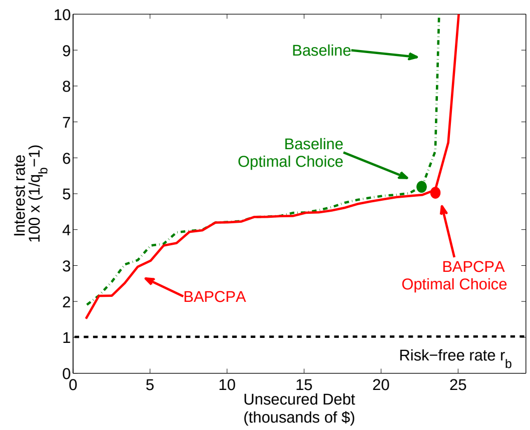


Figure 7: Interest rates on unsecured debt for a household in Michigan before and after the BAPCPA reform. The dots represent the optimal policy choices of the household. *Notes:* Before the reform, the household optimally chooses a $210K house, $155K mortgage and $6K of unsecured debt. The BAPCPA line in (a) represents the price schedule that the household would face if it chose the same size house and mortgage as before the reform. The BAPCPA line in (b) represents the price schedule given the household's optimal choice of housing and mortgage after the reform: $280K house, $190K mortgage and $41K of unsecured debt.

6.1.3 Welfare Consequences of the Reform

Households, on average, are made slightly better off from the passage of the reform. Taking into account the transition, the average consumption equivalent welfare gain across households from adopting the policy is 0.12 percent of lifetime consumption (this is a utilitarian welfare measure). Not all households are made better off by the reform. Households that file for bankruptcy are significantly worse off - on average they would be willing to pay 0.4 percent of lifetime consumption to avoid implementing the reform. In addition, low income households with debt also are worse off, since they are likely to file for bankruptcy and now face the higher fixed cost. Overall, 11.4% of households are made worse off from the passage of the reform. The welfare loss may seem high given that the increase of the fixed cost is relatively small, only 2% of median household income. However, as documented by Livshits, MacGee & Tertilt (2010), the median income of bankrupt households is only about $20,000, so having to pay a fixed cost is a substantial sum, occurring exactly when the households have low consumption. The finding also seems in line with Gross, Notowidigdo & Wang

(2014), who find that low income households sometimes lack sufficient liquidity to file for bankruptcy. While, that liquidity channel is abstracted from here, it does suggest that the filing and legal fees do impose a significant burden on bankrupt households.

As discussed in the calibration section, I abstract from bankruptcies which are the result of medical expenditure shocks. As discussed in Livshits, MacGee & Tertilt (2007), the desirability of reforms to bankruptcy which limit the ability of households to discharge debt (such as BAPCPA) depend on the exposure of households to large but infrequent expenditure shocks. Their findings show that limiting the ability to discharge has negative welfare consequences if households are subject to expense shocks. Thus, given the modest welfare gains in the model, it is possible that introducing expenditure shocks could overturn net positive effect of the reform. The results also suggest that explicitly modeling the fixed costs of bankruptcy can have important implications for evaluating the welfare implications of reforms to bankruptcy.

6.1.4 BAPCPA and the House Price Decline

In order to understand how BAPCPA may have contributed to the increase in foreclosures, I also simulate the aggregate shock to house prices in the baseline economy (as opposed to the one undergoing the transition induced by the passage of BAPCPA). I find that the BAPCPA economy increases the foreclosure rate by a cumulative 0.6 percentage points over 2008-2013, consistent with hypotheses of Morgan, Iverson & Botsch (2009) and Li, White & Zhu (2010). Over the same time period, however, BPACPA reduced bankruptcy rates by a cumulative 2.7 percentage points, from 8.7% to 6%. The counterfactual suggests that the passage of BPACPA explains why bankruptcy rates remained low despite the huge decline in household wealth and increase in leverage.

6.2 HARP

In 2009, after the collapse of house prices from their peak and the onset of the Great Recession, the Congress passed HARP to help households with little or no home equity to refinance to take advantage of lower interest rates to lower their monthly mortgage payments. The program allowed households with less than 20% equity to refinance mortgages at up to 125% LTV without having to pay for private mortgage insurance[67]. The program was limited to homeowners who were current on their mortgages, had not had any late payments in the previous six months and had purchased their homes before 2009. I investigate to what extent the policy reduced foreclosures and increased household welfare.

In the period after the shock the government implements a 3% interest rate subsidy for refinanced mortgages with leverage greater than 80%, for households that have experienced a drop in house prices. The interest rate subsidy is supposed to capture both the effects of the waived private mortgage insurance and the fact that nominal interest rates declined substantially after 2008. The program is essentially a level shift in the interest rate for mortgages with LTV between 80-100%, and a relaxation of LTV limits up to 125% (as opposed to 100% in the baseline economy).

The interest rate subsidy has a significant effect in reducing foreclosure rates after the aggregate shock. In the first period of implementation, the interest rate subsidy reduces the foreclosure rate by 0.4 percentage points, from 3.3% of mortgages to 2.8%. The effect of the program dies out after about 5 years, resulting in a cumulative decrease in the foreclosure rate over the five year period of 1 percentage point, from 11.5% to 10.5% under the policy. The reform increases the option value of remaining in ones home by reducing the cost of servicing the mortgage. The reduction of foreclosures on impact by 50 basis points indicates that the option value channel reduced would be defaulters by only about 15%. The bulk of households defaulting had sufficient negative equity that despite the lower borrowing costs it was more

[67]Typically mortgages originated with LTV greater than 80% are required to buy private mortgage insurance. The original program specified a 105% LTV limit, but in less than a year was changed to 125%. In December 2011 the LTV limit was abolished entirely

attractive to default. Further, increasing the option value reduces default, but because the program doesn't reduce the leverage of households, they are still at high risk of defaulting in the future if they experience adverse shocks. This explains why the reduction in foreclosures was modest relative to the total cumulative foreclosure experience after the decline in house prices and highlights that it has limited effectiveness as a foreclosure reduction tool.

In addition to reducing foreclosure, the program also benefited households that would not have defaulted even in the absence of the program. Those households were also able to enjoy refinancing at the subsidized rate and thus increase their consumption after experiencing a large negative wealth shock (because of the fall in house prices). These outcomes are consistent with recent empirical findings by Agarwal et al. (2015), who show significant effects of HARP refinances on consumption and small effects on foreclosure.

In terms of welfare, I find that homeowners with LTV greater than 80% (those targeted under the policy) would be willing to pay 0.4% of lifetime consumption to implement the subsidy. While the nature of the policy in the context of the model is stylized, it does suggest that a program like HARP was welfare improving and resulted in a non-trivial reduction in the foreclosure rate after the aggregate drop in house prices. One important caveat to the analysis is that the implementation of the policy was unexpected by households. If households understand that in the future similar programs will be instituted after aggregate drops in house prices, this may induce them to take on more risk and higher LTV mortgages, which may offset some of the welfare gains measured here.

7 Conclusions

In this paper, I have evaluated the effects of two recent major reforms to credit markets, the Bankruptcy Abuse Protection and Consumer Protection Act of 2005 and the Home Affordable Refinance Program. To do so required developing a novel economic framework rich enough to capture the heterogeneity of household balance sheets and the uninsurable risks that households face. I used cross-state variation in default law to validate the mechanism in the model and shed light on how that variation affects household portfolio choice and cross-state default rates. I found that the BAPCPA reform significantly reduces the prevalence of bankruptcy, but contributed to the significant rise in foreclosures in the Great Recession. The reform provides modest welfare gains, but there is disagreement among households as to the desirability of the reform. The HARP program enabled high LTV households to refinance their mortgages. The program provided significant welfare gains to high LTV households, with the bulk of the gains accrued to households who would not have defaulted even in the absence of its implementation. In addition, the program was found to have reduced aggregate foreclosures by almost one percentage point.

Given the findings on HARP, an exciting avenue for future research would be to evaluate the Home Affordable Modification Program (HAMP), which was intended to complement HARP in dealing with the large decline in house prices from 2007-2009. The HAMP program was widely regarded as unsuccessful. To help guide the development of future macroprudential policy requires understanding why past policy interventions were unsuccessful. The framework developed is uniquely suited to do so, and to evaluate other proposed reforms, such as allowing bankruptcy judges to modify the principal balances on mortgages (commonly referred to as "cramdowns"). I defer these analyses to future work.

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ONLINE APPENDIX NOT FOR PUBLICATION

8 Supplementary Tables

Table 8: Legal Environments Considered

States	Homestead Exemption	Recourse	Median HH Income	Weight
Washington, N. Carolina	0.64	No	42334	0.053
California, Alaska, N. Dakota	1.58	No	47211	0.112
Minnesota, Arizona, Montana	3.33	No	42154	0.050
Maryland, Ohio, Georgia, Illinois, Tennessee, Indiana, Virginia Kentucky, S. Carolia, Alabama	0.23	Yes	42146	0.248
Michigan, Missouri, Louisiana, New York, Wyoming, New Jersey, Nebraska, Michigan, Pennsylvania, Hawaii, Oregon, West Virginia, Utah, Wisconsin, Arkansas, Delaware, Colorado, Idaho	0.677	Yes	42650	0.305
Massachusetts, New Mexico, Maine, New Hampshire, Mississippi, Nevada, Connecticut, Vermont, Rhode Island	3.65	Yes	44872	0.075
Florida, Texas, Kansas Oklahoma, S. Dakota, D.C.	∞	Yes	38944	0.158

Table 9: State Results - Recourse

	Maryland $\chi^s = 0.23$	Michigan $\chi^s = 0.68$	Massachusetts $\chi^s = 3.7$	Florida $\chi^s = \infty$
Debt	-1.85	-1.74	-1.80	-1.81
Bonds, B_+	0.34	0.43	0.53	0.46
Unsecured debt, B_-	-0.16	-0.10	-0.04	-0.01
Mortgages M	1.69	1.65	1.76	1.8
Bankruptcy rate	1.34%	1.05%	0.87%	0.80%
Foreclosure rate	0.3%	0.4%	0.8%	0.8%
In debt	4.4%	3.7%	4.2%	4.3%
Fraction of households with Unsecured Debt	40%	23%	26%	27%

Table 7: Externally Calibrated Parameters

Parameter	Value	Target
Income Process		
Persistence, ρ_z	0.98	
Std. of persistent shocks, σ_{ν_z}	0.3	Income process (Storesletten et al, 2004)
Std. of transitory shocks σ_{ε_y}	0.245	
House Price Process Persistence, ρ_h,	0.97	Nagaraja et al, 2009
Std. of persistent shocks, σ_{ν_h}	0.08	OFHEO HPI
Std. of transitory shocks, σ_{ε_h}	0.005	OFHEO HPI
Legal Technology		
Foreclosure technology, γ	0.78	Foreclosure Sale Loss
Bankruptcy technology, ζ	0.52	Distributions to Creditors
Clean credit history, α_7	0.2	File for Chapter 7 every 6 years
Clean credit history, α_{13}	0.2	Chapter 13 5-year repayment
Clean credit history, α_F	0.5	Fair Issac
Probability of deficiency judgment, ψ	0.10/0.15	See text
Housing Technology		
Housing maintenance	2%	Depreciation+taxes
Moving shock	0.2	Median tenure
Interest Rates		
Risk-free rate, r_b	0.01	Risk-free rate
Cost of issuing mortgages, r_m	10 BP	Mortgage administration cost
Cost of issuing unsecured debt, r_b	50 BP	Unsecured administration cost
Preferences		
Cobb-Douglas parameter, θ	0.8590	Housing share of consumption 14.1%

Table 10: State Results - No Recourse

	Washington $\chi^s = 0.64$	California $\chi^s = 1.57$	Minnesota $\chi^s = 3.32$
Housing, H	3.40	3.49	3.44
Debt	-1.72	-1.88	-1.80
Bonds, B_+	0.39	0.45	0.49
Unsecured debt, B_-	-0.12	-0.07	-0.02
Mortgages M	1.61	1.81	1.78
Bankruptcy rate	1.12%	0.95%	0.80%
Foreclosure rate	0.4%	0.8%	0.8%
In debt	3.6%	4.3%	4.2%
Fraction of households with Unsecured Debt	21%	24%	27%

Table 11: State Level Implications of BAPCPA

State	Bankruptcy Rates		Chapter 13 Share	
	Baseline	BAPCPA	Baseline	BAPCPA
Maryland	1.34%	0.83%	9%	17%
Michigan	1.05%	0.77%	10%	16%
Massachusetts	0.87%	0.68%	3%	18%
Florida	0.80%	0.72%	0%	14%
Washington	1.12%	0.73%	10%	18%
California	0.94%	0.61%	2%	10%
Minnesota	0.80%	0.65%	1%	16%

Table 12: Borrower Characteristics and Interest Rates

$$intrate_i = \beta_0 + \beta_1 \log(y_i) + \beta_2 \log(\eta_i) + \beta_3 \mathbf{1}_{HighExemption} + \epsilon_i$$

Variable	**Coefficient**	**(Std. Err.)**
log(Income)	-3.81***	(0.999)
log(Home equity)	-0.30**	(0.134)
High Exemption Dummy	2.75*	(1.639)
N	11,055	
R^2	0.003	

*** indicates significance at 1% level

** indicates significance at 5% level

* indicates significance at 10% level

9 Supplementary Figures

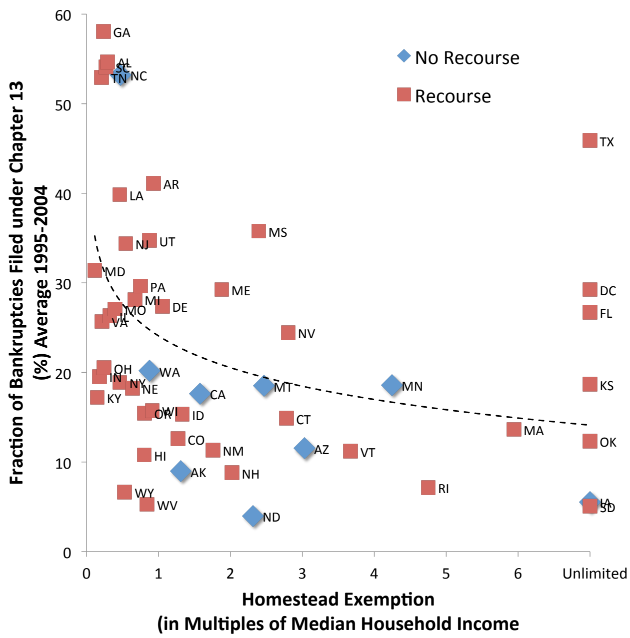
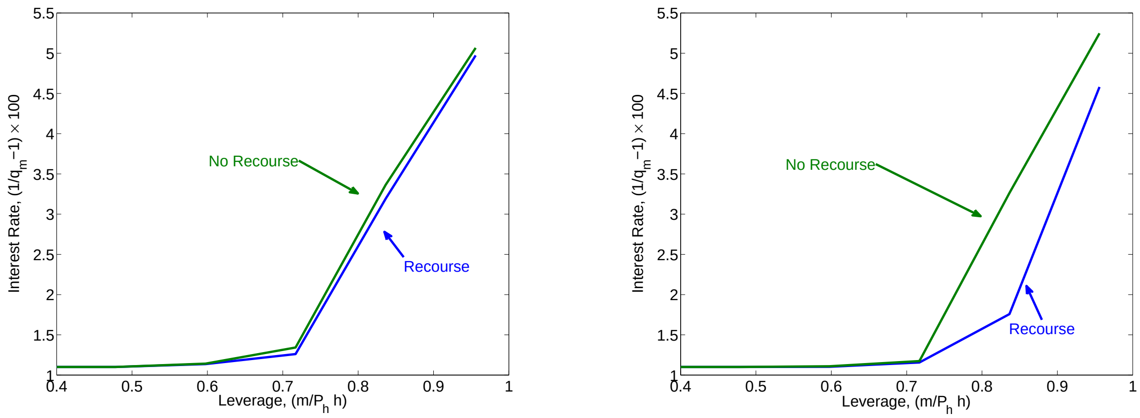


Figure 8: Bankruptcy and Foreclosure Rates Across States. *Notes:* The homestead exemptions in terms of median income is calculated by state law for the homestead exemption in the year 2000 and median household income from the Census in 2000. Average state bankruptcy rates 1995-2004 are computed using bankruptcy filings from the American Bankruptcy Institute and the number of households in each state from the Census. Average state foreclosure rates 1994-1999 are computed from the Mortgage Banker Association's quarterly National Delinquency Survey from 1994-1999. The dashed lines are smoothed versions of the data.



(a) Mortgage Interest Rates

(b) Unsecured Interest Rates

Figure 9: Mortgage interest rates are plotted as a function of leverage, $\frac{m}{p_h h}$, for identical households in recourse and no-recourse states. *Notes*: In the left panel the household has median income, a house worth 3.5 times median income and no savings or unsecured debt. In the right panel the household has 2.5 times median income, a house worth 6 times median income and no unsecured debt or savings.

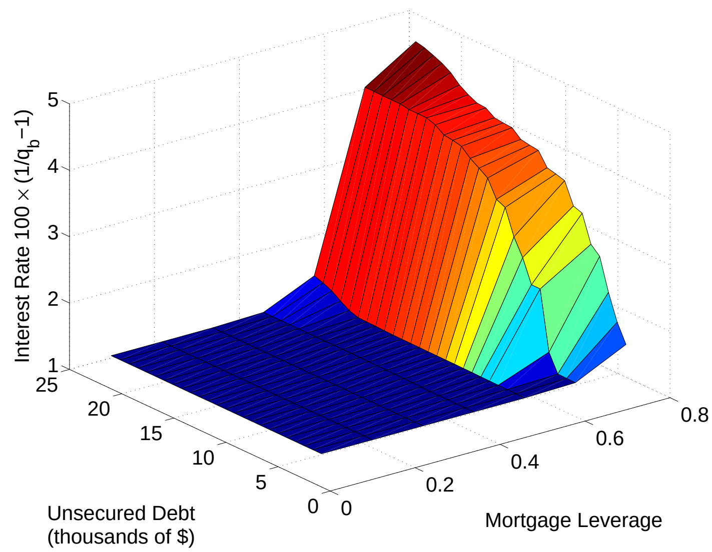


Figure 10: Model unsecured interest rates

Notes: The unsecured interest rate is plotted as a function of leverage, $\kappa = \frac{m}{p_h h}$, and unsecured debt b, for a household that owns a house worth roughly 3.5 times median income, that has median income, is in a recourse state with an exemption of \$30,000

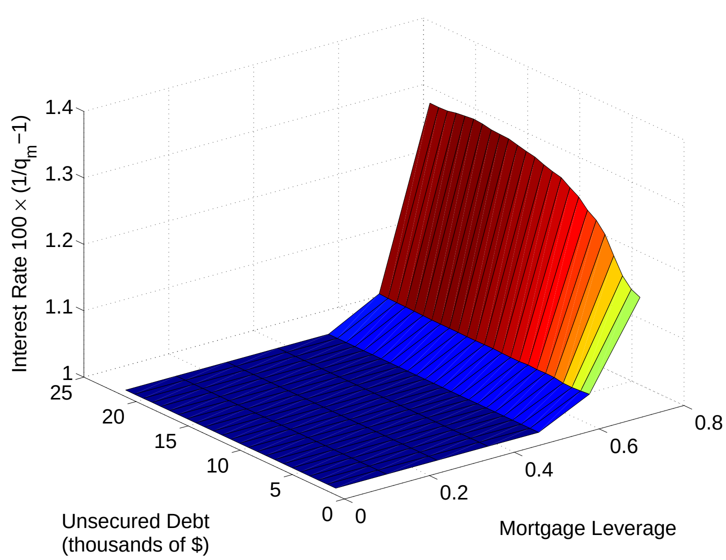


Figure 11: Model mortgage interest rates

Notes: The mortgage interest rate is plotted as a function of leverage, $\kappa = \frac{m}{p_h h}$, and unsecured debt b, for a household that owns a house worth roughly 3.5 times median income, that has median income, is in a recourse state with an exemption of \$30,000

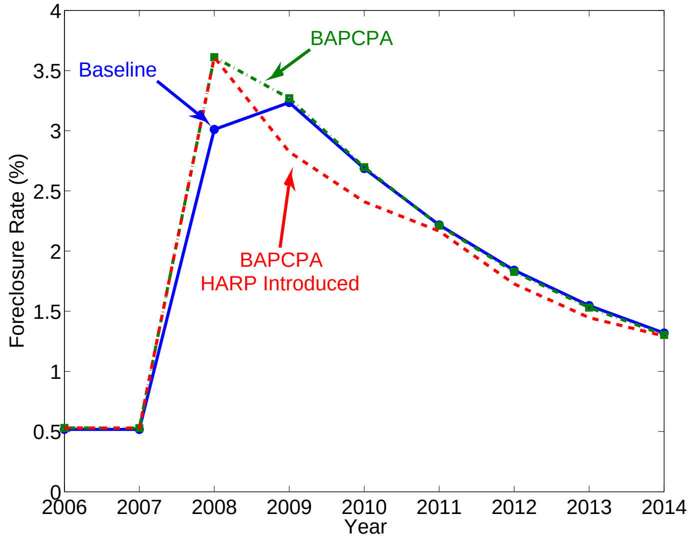


Figure 12: Effects of BAPCPA and HARP on foreclosures following an aggregate price drop

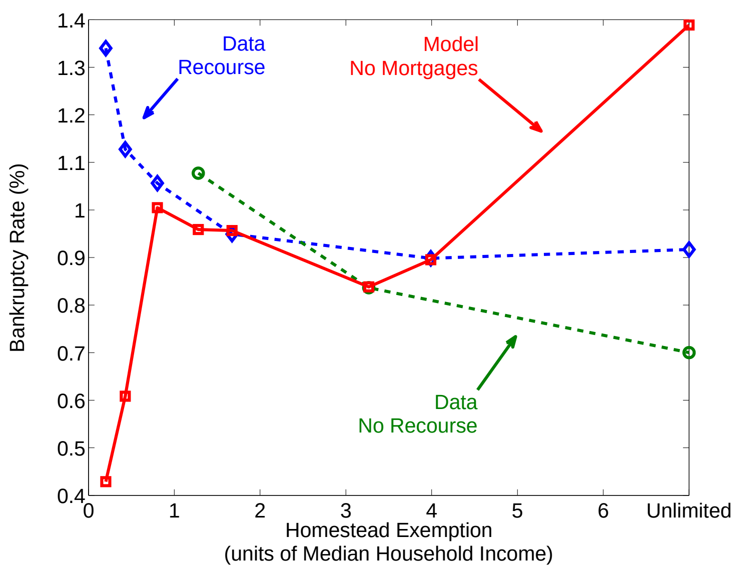


Figure 13: Data vs counterfactual model without mortgages and foreclosure.

10 Counterfactual Model without Mortgages

To illustrate the importance of studying foreclosure and bankruptcy together in order to capture the cross-state variation in bankruptcy rate, I conduct the following thought experiment: would a modified model without mortgages and foreclosure capture the cross-state variation? To answer this question, I re-solve the model for all 50 states without mortgages. I plot the conditional means in Figures 6(a) and 6(b). This version of the model does not reproduce the observed negative relationship between bankruptcy rates and the homestead exemption. In fact, it generates a positive relationship between the homestead exemption and the bankruptcy rate. This result is reminiscent of the findings of Athreya (2006), who modeled exemptions without the possibility of default on secured debt. Further, exlcuding states with an unlimited exemption, it also generates a positive relationship between the homestead exemption and the Chapter 13 bankruptcy rate. Households are using credit card debt partially to finance the purchases of homes. The bankruptcy rate is lower in low exemption states because households stand to lose significant home equity if they file for Chapter 7 bankruptcy. The increase in the bankruptcy rate when the exemption increases is almost entirely driven by an increase in Chapter 13 bankruptcy. Filing for Chapter 13 allows them to partially repay what was owed over five years. The Chapter 13 filing rate is low in low exemption states because of the legal restriction that creditors must receive at least as much payment under Chapter 13 as they would have if non-exempt assets were liquidated in Chapter 7. Thus, households with significant non-exempt home equity (concentrated in low-exemption states) are precluded from filing for Chapter 13 when income is low. This counterfactual analysis highlights the importance of modeling bankruptcy and foreclosure together.

11 Full Specification of the Household Problem

For completeness, I include here the full specification of the household problem (including value functions already discussed in the main text).

$$V_G^{own}(b,h,m,p_h,\omega,y,z,\theta=0) = \tag{10}$$
$$\max\left\{\begin{array}{ll}
\text{No def., keep house:} & W_G^{own}(b+y,h,m,\omega,z) \\
\text{No def., sell house, buy:} & W_G^{buy}(\eta+b+y,z) \\
\text{No def., sell house, rent:} & W_G^{rent}(\eta+b+y,z) \\
\text{Chapt. 7, no mort. def.:} & (\mathbf{1}_{\eta\leq\chi}W_7^{keep}(h,m,y,\omega,z)+ \\
 & \quad (1-\mathbf{1}_{\eta\leq\chi})W_7^{liquidate}(y,\chi,z)) \\
\text{Chapt. 13, no mort. def.:} & W_{13}^{own}((1-\phi)y,h,m,\omega,z,\phi) \\
\text{Mort. def.:} & \mathbb{E}_{\mathcal{J}}\left[(1-\mathcal{J})W_F^{rent}(b_F+y,z)+\right. \\
 & \quad \left.\mathcal{J}\max\left\{W_F^{rent}(b_F+y,z),W_7^{liquidate}(y,0,z)\right\}\right] \\
\text{Mort. def and Chapt. 7:} & W_7^{liquidate}(y,0,z) \\
\text{Mort. def and Chapt. 13:} & W_{13}^{rent}((1-\phi)y,\phi,z)
\end{array}\right\}$$

$$V_G^{own}(b,h,m,p_h,\omega,y,z,\theta=1) = \tag{11}$$
$$\max\left\{\begin{array}{ll}
\text{No def., sell house, buy:} & W_G^{buy}(\eta+b+y,z) \\
\text{No def., sell house, rent:} & W_G^{rent}(\eta+b+y,z) \\
\text{Chapt. 7, no mort. def.:} & W_7^{liquidate}(y,\min(\eta,\chi),z)) \\
\text{Chapt. 13, no mort. def.:} & W_{13}^{rent}((1-\phi)y+\eta,z,\phi) \\
\text{Mort. def.:} & \mathbb{E}_{\mathcal{J}}\left[(1-\mathcal{J})W_F^{rent}(b_F+y,z)+\right. \\
 & \quad \left.\mathcal{J}\max\left\{W_F^{rent}(b_F+y,z),W_7^{liquidate}(y,0,z)\right\}\right] \\
\text{Mort. def and Chapt. 7:} & W_7^{liquidate}(y,0,z) \\
\text{Mort. def and Chapt. 13:} & W_{13}^{rent}((1-\phi)y,\phi,z)
\end{array}\right\}$$

where W_G^{own} is the value of not defaulting on either debt, nor selling one's home, W_G^{buy} and W_G^{rent} are the value of not defaulting, selling one's home, and buying a new home or becoming a renter, respectively[68], $\mathbf{1}_{\eta\leq\chi}$ is an indicator if the household has only exempt home equity, W_7^{keep} and $W_7^{liquidate}$ are the values of filing for Chapter 7 bankruptcy without and with having to liquidate, respectively, W_{13}^{own} is the value of filing Chapter 13 bankruptcy, W_F^{rent} is the value of defaulting on the mortgage ($\mathbb{E}_{\mathcal{J}}$ is the expectation over a deficiency judgment if the household goes in to foreclosure), and W_7^{rent} is the value of being foreclosed upon and filing for Chapter 7 bankruptcy[69]. The discrete decision is similar for a household hit by the moving shock, however it no longer has the option to keep the house. In addition,

[68]Note that the timing assumption is such that these households can immediately buy a new home and live in it during the period.

[69]The assumption here is that Chapter 7 bankruptcy is a worse credit event than foreclosure, and thus the credit state evolves to the more serious default.

when hit by the moving shock if the household files for Chapter 7 and 13 bankruptcies, the house is liquidated. That value function can be found in the Online Appendix.

A homeowner that keeps its home and does not default on (any) debt solves the following program:

$$\begin{aligned}
W_G^{own}(a,h,m,\omega,z) = & \max_{c,p_h h \geq m' \geq 0, b'} \left\{ U(c,h) + \beta \mathbb{E}_{p_h',\omega',y',z',\theta'|\omega,z} V_G^{own}(b',h,m',p_h',\omega',y',z',\theta') \right\} \\
& \text{subj. to} \quad c + m(1+r_m) - m'Q_m + b'q_b(b',h,m',\omega,z,G) - \mu_h p_h h \leq a \qquad (12) \\
& \text{where:} \quad Q_m = \begin{cases} q_m(b',h,m',\omega,z,G) & \text{if } m' > m \\ 1 & \text{if } m' \leq m. \end{cases}
\end{aligned}$$

When the homeowner makes the interest (and possible principal) payment Q_m takes the value of one, whereas if the household wants a larger principal balance it must refinance its mortgage, which is represented by $Q_m = q_m$, the price which takes into account the default risk of taking the new mortgage. By assumption, households can only originate mortages with principal balances less than the current value of the home[70].

A household with good credit that decides to buy a home, chooses non-durable consumption, the size of house, mortgage and bonds, and solves the following program:

$$\begin{aligned}
W_G^{buy}(a,z) = & \max_{c,h' \in \mathcal{H}, h' \geq m' \geq 0, b'} \left\{ U(c,h') + \beta \mathbb{E}_{p_h',\omega',y',z',\theta'|\omega,z} V_G^{own}(b',h',m',p_h',\omega',y',z',\theta') \right\} \\
& \text{subj. to} \quad c + p_h h' - m'q_m(b',h',m',\omega,z,G) + b'q_b(b',h,m',\omega,z,G) - \mu_h p_h h' \leq a \qquad (13) \\
& \text{where: } p_h = 1, \omega = 0
\end{aligned}$$

Since all house price risk is idiosyncratic when households buy a new home the price is set to 1, the unconditional mean of the process.

A household with good credit that decides to be a renter only chooses between non-durable consumptions and bond holdings, and solves the following program:

$$\begin{aligned}
W_G^{rent}(a,z) = & \max_{c,b'} \left\{ U(c,\underline{h}) + \beta \mathbb{E}_{y',z'|z} V_G^{rent}(b',y',z') \right\} \qquad (14) \\
& \text{subj. to} \quad c + p_r \underline{h} + b'q_b(b',z,G) \leq a
\end{aligned}$$

A household that filed for Chapter 7 bankruptcy in the current period and kept its home makes an interest payment (if it has a mortgage) and consumes the rest of its income:

$$\begin{aligned}
W_7^{keep}(h,m,y,\omega,z) = & U(c,h) + \beta \mathbb{E}_{p_h',\omega',y',z',\theta'|\omega,z} V_7^{own}(0,h,m,p_h',\omega',y',z',\theta') \qquad (15) \\
& \text{subj. to} \quad c = y - r_m m - \mu_h p_h h
\end{aligned}$$

[70]This does not preclude households from having negative equity on existing mortgages, they simply cannot originate new mortgages with negative equity

whereas a household that filed for Chapter 7 bankruptcy and had to liquidate its home (either because of having non-exempt home equity, being hit by a moving shock, or being foreclosed upon) and consumes its endowment net of rental costs:

$$W_7^{liquidate}(y, a, z) = U(y - p_r \underline{h}, \underline{h}) + \beta \mathbb{E}_{y', z'|z} V_7^{rent}(a + y', z') \tag{16}$$

A homeowner that files for Chapter 13 bankruptcy and is not hit by the moving shock is allowed to adjust its mortgage (but not refinance) and save, but not borrow unsecured:

$$W_{13}^{own}(a, h, m, \phi, \omega, z) = \max_{c, m \geq m' \geq 0, b' \geq 0} \left\{ U(c, h) + \beta \mathbb{E}_{p_h', \omega', y', z', \theta' | \omega, z} V_{13}^{own}(b', h, m', \phi, p_h', \omega', y', z', \theta') \right\}$$
$$\text{subj. to} \quad c + m(1 + r_m) - m' + b' q_b(b', h, m', \omega, z, 13) - \mu_h p_h h \leq a \tag{17}$$

A homeowner that filed for Chapter 13 bankruptcy and is hit by the moving shock solves the following:

$$W_{13}^{rent}(a, \phi, z) = \max_{c, b' \geq 0} \left\{ U(c, \underline{h}) + \beta \mathbb{E}_{y', z'|z} V_{13}^{rent}(b', \phi, y', z') \right\}$$
$$\text{subj. to} \quad c + p_r \underline{h} + b' q_b(b', h, m', \omega, z, 13) \leq a \tag{18}$$

and a homeowner that defaults on its mortgage but does not file for bankruptcy solves:

$$W_F^{rent}(a, z) = \max_{c, b' \geq 0} \left\{ U(\lambda c, \underline{h}) + \beta \mathbb{E}_{y', z'|z} V_F^{rent}(b', y', z') \right\} \tag{19}$$
$$\text{subj. to} \quad c + p_r \underline{h} + b' q_b(b', z, F) \leq a$$

Now, we turn to the problem of a renter who begins the period with a good credit history, who can choose to buy a home, stay a renter, or file for Chapter 7 or Chapter 13 bankruptcy, and has lifetime utility given by:

$$V_G^{rent}(b, y, z) = \left\{ W_G^{buy}(b + y, z), W_G^{rent}(b + y, z), W_7^{liquidate}(y, 0, z), W_{13}^{rent}(y, 0, z) \right\} \tag{20}$$

Note, the value function $W_7^{liquidate}$ evaluated a 0 home equity is equivalent to a renter who files for bankruptcy.

A homeowner that starts the period with a previous Chapter 7 bankruptcy as its credit history chooses whether to keep or sell its house, or whether to default on its mortgage. After the discrete choice, the household learns whether its credit history stochastically reverts to G or stays 7. If the household sold its house, it can then choose whether to buy a new home, or stay as a renter. Note, that if a household with a bankruptcy files for foreclosure, the credit history stays as 7, the assumption being that the bankruptcy is a worse credit event. Further, a household is only allowed to file for Chapter 7 bankruptcy on a deficiency judgment if not doing so would result in non-positive consumption.

$$V_7^{own}(b,h,m,p_h,\omega,y,z,\theta=0)= \tag{21}$$
$$\max\left\{\begin{array}{ll} \text{No def., keep house:} & \alpha_7 W_G^{own}(b+y,h,m,\omega,z)+ \\ & (1-\alpha_7)W_7^{own}(b+y,h,m,\omega,z) \\ \text{No def., sell house:} & \alpha_7 \max\left\{W_G^{buy}(\eta+b+y,z), W_G^{rent}(\eta+b+y,z)\right\}+ \\ & (1-\alpha_7)\max\left\{W_7^{buy}(\eta+b+y,z), W_7^{rent}(\eta+b+y,z)\right\} \\ \text{Mort. def} & \mathbb{E}_{\mathcal{J}}\left[(1-\mathcal{J})W_7^{rent}(b_F+y,z)+\right. \\ & \quad \left.\mathcal{J}\left(\mathbf{1}_{b_F>0}W_7^{rent}(b_F+y,z)+(1-\mathbf{1}_{b_F>0})W_7^{liquidate}(y,0,z)\right)\right] \end{array}\right\}$$

where the value of not defaulting on the mortgage and keeping the house conditional on not transitioning to good credit is:

$$W_7^{own}(a,h,m,\omega,z)=\max_{c,m\geq m'\geq 0,b'\geq 0}\left\{U(\lambda c,h)+\beta\mathbb{E}_{p_h',\omega',y',z',\theta'|\omega,z}V_G^{own}(b',h,m',p_h',\omega',y',z',\theta')\right\}$$
$$\text{subj. to}\quad c+m(1+r_m)-m'+b'q_b(b',h,m',\omega,z,7)--\mu_h p_h h\leq a \tag{22}$$

and the value of not defaulting on the mortgage, selling the house and buying a new one conditional on not transitioning to good credit is:

$$W_7^{buy}(a,z)=\max_{c,h'\in\mathcal{H},b'\geq 0}\left\{U(\lambda c,h')+\beta\mathbb{E}_{p_h',\omega',y',z',\theta'|\omega,z}V_7^{own}(b',h',0,p_h',\omega',y',z',\theta')\right\}$$
$$\text{subj. to}\quad c+p_h h'+b'q_b(b',h,0,\omega,z,7)-\mu_h p_h h'\leq a \tag{23}$$
$$\text{where: } p_h=1,\omega=0$$

and the value of not defaulting on the mortgage, selling the house and becoming a renter conditional on not transitioning to good credit is:

$$W_7^{rent}(a,z)=\max_{c,b'\geq 0}\left\{U(\lambda c,\underline{h})+\beta\mathbb{E}_{y',z'|z}V_7^{rent}(b',y',z')\right\} \tag{24}$$
$$\text{subj. to}\quad c+p_r\underline{h}+b'q_b(b',z,7)\leq a$$

A homeowner that starts the period with a previous Chapter 7 bankruptcy as its credit history that is hit by the moving shock chooses whether to sell its house or whether to default on its mortgage. After the discrete choice, the household learns whether its credit history stochastically reverts to G or stays 7. If the household sold its house, it can then choose whether to buy a new home, or stay as a renter. Note, that if a household with a bankruptcy files for foreclosure, the credit history stays as 7, the assumption being that the bankruptcy is a worse credit event. Further, a household is only allowed to file for Chapter 7 bankruptcy on a deficiency judgment if not doing so would result in non-positive consumption.

$$
V_7^{own}(b,h,m,p_h,\omega,y,z,\theta=1) = \tag{25}
$$
$$
\max\left\{\begin{array}{ll}
\text{No def., sell house:} & \alpha_7 \max\left\{W_G^{buy}(\eta+b+y,z), W_G^{rent}(\eta+b+y,z)\right\}+ \\
 & (1-\alpha_7)\max\left\{W_7^{buy}(\eta+b+y,z), W_7^{rent}(\eta+b+y,z)\right\} \\
\text{Mort. def} & \mathbb{E}_{\mathcal{J}}\left[(1-\mathcal{J})W_7^{rent}(b_F,z)+\right. \\
 & \quad \left.\mathcal{J}\left(\mathbf{1}_{b_F>0}W_7^{rent}(b_F,z)+(1-\mathbf{1}_{b_F>0})W_7^{liquidate}(y,0,z)\right)\right]
\end{array}\right\}
$$

where $\eta = p_h h - (1+r_m)m$ and b_F is defined as in **??**.

A renter that starts the period with a previous Chapter 7 bankruptcy as its credit history learns whether it receives a good credit history, then decides whether to buy a home or stay as a renter:

$$
V_7^{rent}(b,y,z) = \left\{\begin{array}{l}
\alpha_7 \max\left\{W_G^{buy}(b+y,z)+W_G^{rent}(b+y,z)\right\}+ \\
(1-\alpha_7)\max\left\{W_7^{buy}(b+y,z), W_7^{rent}(b+y,z)\right\}
\end{array}\right\} \tag{26}
$$

A homeowner that starts the period with a previous Chapter 13 bankruptcy as its credit history that is not hit by the moving shock chooses whether to keep or sell its house, or whether to default on its mortgage. After the discrete choice, the household learns whether its credit history stochastically reverts to G or stays 13. If the household sold its house, it can then choose whether to buy a new home, or stay as a renter. Note, that if a household with a bankruptcy files for foreclosure, the credit history stays as 7, the assumption being that the bankruptcy is a worse credit event. Further, a household is only allowed to file for Chapter 7 bankruptcy on a deficiency judgment if not doing so would result in non-positive consumption.

$$
V_{13}^{own}(b,h,m,\phi,p_h,\omega,y,z,\theta=0) = \tag{27}
$$
$$
\max\left\{\begin{array}{ll}
\text{No def., keep house:} & \alpha_{13}W_G^{own}(b+y,h,m,\omega,z)+ \\
 & (1-\alpha_{13})W_{13}^{own}(b+(1-\phi)y,h,m,\phi,\omega,z) \\
\text{No def., sell house:} & \alpha_{13}\max\left\{W_G^{buy}(\eta+b+y,z), W_G^{rent}(\eta+b+y,z)\right\}+ \\
 & (1-\alpha_{13})\max\left\{W_{13}^{buy}(\eta+b+(1-\phi)y,\phi,z), W_{13}^{rent}(\eta+b+(1-\phi)y,\phi,z)\right\} \\
\text{Mort. def} & \mathbb{E}_{\mathcal{J}}\left[(1-\mathcal{J})W_{13}^{rent}(b_F+(1-\phi)y,\phi,z)+\right. \\
 & \quad \left.\mathcal{J}\left(\mathbf{1}_{b_F>0}W_{13}^{rent}(b_F+(1-\phi)y,\phi,z)+(1-\mathbf{1}_{b_F>0})W_7^{liquidate}(y,0,z)\right)\right]
\end{array}\right.
$$

where the value of not defaulting on the mortgage, selling the house and buying a new one conditional on not transitioning to good credit is:

$$
\begin{aligned}
W_{13}^{buy}(a,\phi,z) = &\max_{c,h'\in\mathcal{H},b'\geq 0} \left\{U(\lambda c,h') + \beta\mathbb{E}_{p'_h,\omega',y',z',\theta'|\omega,z}V_{13}^{own}(b',h',0,p'_h,\omega',y',z',\theta')\right\} \\
&\text{subj. to} \quad c + p_h h' + b' q_b(b',h,0,\omega,z,7) - \mu_h p_h h' \leq a \\
&\text{where: } p_h = 1, \omega = 0
\end{aligned} \tag{28}
$$

A homeowner that starts the period with a previous Chapter 13 bankruptcy as its credit history that is hit by the moving shock chooses whether to sell its house, or whether to default on its mortgage:

$$
V_{13}^{own}(b,h,m,\phi,p_h,\omega,y,z,\theta=1) = \tag{29}
$$

$$
\max\left\{\begin{array}{ll}
\text{No def., sell house:} & \alpha_{13}\max\left\{W_G^{buy}(\eta+b+y,z), W_G^{rent}(\eta+b+y,z)\right\} + \\
& (1-\alpha_{13})\max\left\{W_{13}^{buy}(\eta+b+(1-\phi)y,\phi,z), W_{13}^{rent}(\eta+b+(1-\phi)y,\phi,z)\right\} \\
\text{Mort. def} & \mathbb{E}_{\mathcal{J}}\left[(1-\mathcal{J})W_{13}^{rent}(b_F+(1-\phi)y,\phi,z) + \right. \\
& \left.\quad \mathcal{J}\left(\mathbf{1}_{b_F>0}W_{13}^{rent}(b_F+(1-\phi)y,\phi,z) + (1-\mathbf{1}_{b_F>0})W_7^{liquidate}(y,0,z)\right)\right]
\end{array}\right\}
$$

A renter that starts the period with a previous Chapter 13 bankruptcy as its credit history learns whether it receives a good credit history, then decides whether to buy a home or stay as a renter:

$$
V_{13}^{rent}(b,y,\phi,z) = \left\{\begin{array}{l}
\alpha_{13}\max\left\{W_G^{buy}(b+y,z) + W_G^{rent}(b+y,z)\right\} + \\
(1-\alpha_{13})\max\left\{W_{13}^{buy}(b+(1-\phi)y,\phi,z), W_{13}^{rent}(b+(1-\phi)y,\phi,z)\right\}
\end{array}\right\} \tag{30}
$$

A homeowner that starts the period with a previous foreclosure as its credit history that is not hit by the moving shock chooses whether to keep or sell its house. After the discrete choice, the household learns whether its credit history stochastically reverts to G or stays F. If the household sold its house, it can then choose whether to buy a new home, or stay as a renter. Note that a household with the foreclosure credit history cannot have a mortgage.

$$
V_F^{own}(b,h,p_h,\omega,y,z,\theta=0) = \tag{31}
$$

$$
\max\left\{\begin{array}{ll}
\text{Keep house:} & \alpha_F W_G^{own}(b+y,h,0,\omega,z) + \\
& (1-\alpha_F)W_F^{own}(b+(1-\phi)y,h,\omega,z) \\
\text{Sell house:} & \alpha_F\max\left\{W_G^{buy}(\eta+b+y,z), W_G^{rent}(\eta+b+y,z)\right\} + \\
& (1-\alpha_F)\max\left\{W_F^{buy}(\eta+b+y,z), W_F^{rent}(\eta+b+y,z)\right\}
\end{array}\right\}
$$

where

$$
\begin{aligned}
W_F^{own}(a,h,\omega,z) = \max_{c,b'\geq 0} & \left\{ U(\lambda c, h) + \beta \mathbb{E}_{p_h',\omega',y',z',\theta'|\omega,z} V_F^{own}(b',h,p_h',\omega',y',z',\theta') \right\} \\
\text{subj. to} \quad & c + \underline{'} q_b(b',h,m',\omega,z,7) - \mu_h p_h h \leq a
\end{aligned}
\tag{32}
$$

and a household with the foreclosure history that buys a house solves:

$$
\begin{aligned}
W_F^{buy}(a,z) = & \max_{c,h'\in\mathcal{H},b'\geq 0} \left\{ U(\lambda c, h') + \beta \mathbb{E}_{p_h',\omega',y',z',\theta'|\omega,z} V_F^{own}(b',h',0,p_h',\omega',y',z',\theta') \right\} \\
& \text{subj. to} \quad c + p_h h' + b' q_b(b',h,0,\omega,z,F) - \mu_h p_h h' \leq a \\
& \text{where: } p_h = 1, \omega = 0
\end{aligned}
\tag{33}
$$

A renter that starts the period with a previous foreclosure as its credit history learns whether it receives a good credit history, then decides whether to buy a home or stay as a renter:

$$
V_7^{rent}(b,y,z) = \left\{ \begin{array}{l} \alpha_F \max \left\{ W_G^{buy}(b+y,z) + W_G^{rent}(b+y,z) \right\} + \\ (1-\alpha_F) \max \left\{ W_F^{buy}(b+y,z), W_F^{rent}(b+y,z) \right\} \end{array} \right\}
\tag{34}
$$

12 Full Specification of the Intermediary's Problem

Here I restate the problem of an intermediary who chooses whether to originate a mortgage.

$$q_m(b',h',m',z,\omega,G)m' \geq \frac{1}{1+r_b+r_m} \times \mathbb{E}_{p'_h,\omega',y',z',\theta'|z,\omega} \tag{35}$$

$$\left\{ \begin{array}{c} (S^*_G(X')+R^*(X'))(1+r_m)m'+ \\ P^*_G(X')\left((1+r_m)m'-m''+m''q_m(b'',h',m'',z',\omega',G)\right)+ \\ (1-f^*_G(X'))B7^*(X')\left[\begin{array}{c} (1-\mathbf{1}_{\eta\leq\chi}(1-\theta'))(1+r_m)m'+ \\ (1-\theta')\mathbf{1}_{\eta\leq\chi}\left(r_m m'+m'q_m(0,h',m',z',\omega',7)\right) \end{array} \right]+ \\ (1-f^*_G(X'))B13^*(X')\left[\begin{array}{c} \theta'(1+r_m)m'+ \\ (1-\theta')\left((1+r_m)m'-m''+m''q_m(b'',h',m'',\phi,z',\omega',13)\right) \end{array} \right]+ \\ f^*_G(X')\left[\begin{array}{c} \psi(h')\left((1-B^*)(1+r_m)m'+B^*(\gamma p'_h h'+\max(b',0))\right)+ \\ (1-\psi(h'))(\gamma p'_h h') \end{array} \right] \end{array} \right\}$$

Even though households with bad credit histories can't originate new mortgages, the bank needs forecast the expected returns to existing mortgages when households file for bankruptcy. The price of a mortgage for a household that filed chapter 7 bankruptcy is given by:

$$q_m(b',h',m',z,\omega,7)m' = \frac{1}{1+r_b+r_m} \times \mathbb{E}_{p'_h,\omega',y',z',\theta'|z,\omega} \tag{36}$$

$$\left\{ \begin{array}{c} (S^*_7(X'))(1+r_m)m'+ \\ P^*_7(X')\left[\begin{array}{c} \alpha_7((1+r_m)m'-m''_G+m''_G q_m(b''_G,h',m''_G,z',\omega',G))+ \\ (1-\alpha_7)((1+r_m)m'-m''_7+m''_7 q_m(b''_7,h',m''_7,z',\omega',7))) \end{array} \right]+ \\ f^*_7(X')\left[\begin{array}{c} \psi(h')\left(\mathbf{1}_{b'_F+y'>0}(1+r_m)m'+(1-\mathbf{1}_{b'_F+y'>0})(\gamma p'_h h'+\max(b',0)\right)+ \\ +(1-\psi(h'))(\gamma p'_h h') \end{array} \right] \end{array} \right\}$$

And similarly for Chapter 13:

$$q_m(b',h',m',z,\omega,13)m' = \frac{1}{1+r_b+r_m} \times \mathbb{E}_{p'_h,\omega',y',z',\theta'|z,\omega} \tag{37}$$

$$\left\{ \begin{array}{c} (S^*_{13}(X'))(1+r_m)m'+ \\ P^*_{13}(X')\left[\begin{array}{c} \alpha_{13}((1+r_m)m'-m''_G+m''_G q_m(b''_G,h',m''_G,z',\omega',G))+ \\ (1-\alpha_{13})((1+r_m)m'-m''_{13}+m''_{13} q_m(b''_{13},h',m''_{13},z',\omega',13))) \end{array} \right]+ \\ f^*_{13}(X')\left[\begin{array}{c} \psi(h')\left(\mathbf{1}_{b'_F+y'>0}(1+r_m)m'+(1-\mathbf{1}_{b'_F+y'>0})(\gamma p'_h h'+\max(b',0)\right)+ \\ +(1-\psi(h'))(\gamma p'_h h') \end{array} \right] \end{array} \right\}$$

The pricing equations are similar to that of a household with good credit, except households with bad credit histories can't refinance, and can only file for bankruptcy if they receive a deficiency judgment which would result in non-positive consumption (but households retain the option to default on the mortgage). The equations also reflect the fact that the credit history evolves after the decision to default on the mortgage. Thus, this system of three equations determine the price for originating a new mortgage.

13 Equilibrium Definition

Let μ denote the cross sectional distribution of households over the credit history, cash at hand, income and home ownership status, house size, house price, mortgage size and income penalty. I focus on a stationary recursive equilibrium.

Definition Given (ψ, χ) and r_b, a Stationary Recursive Competitive Equilibrium comprises:

- Value functions for the households,
  $\{V^{own} : \mathcal{C} \times \mathbb{R}^4 \times \Omega \times Y \times Z \times \{0,1\} \to \mathbb{R}\}$, $\{V^{rent} : \mathcal{C} \times \mathbb{R} \times Y \times Z \to \mathbb{R}\}$,
  $\{W^{own} : \mathcal{C} \times \mathbb{R}^3 \times \Omega \times Z \to \mathbb{R}\}$, $\{W^{rent} : \mathcal{C} \times \mathbb{R} \times Z \to \mathbb{R}\}$, $\left\{W^{buy} : \mathcal{C} \times \mathbb{R} \times Z \to \mathbb{R}\right\}$,
  $\left\{W_7^{keep} : \mathbb{R}^2 \times \Omega \times Y \times Z \to \mathbb{R}\right\}$, $\left\{W_7^{liquidate} : \mathbb{R} \times Y \times Z \to \mathbb{R}\right\}$
- Default decision rules and policy functions for the households:
  $\{f^* : \mathcal{C} \times \mathbb{R}^4 \times \Omega \times Y \times Z \times \{0,1\} \to \{0,1\}\}$, $\{B^* : \mathbb{R}^4 \times \Omega \times Y \times Z \times \{0,1\}^2 \to \{0,1\}\}$
  $\{S^* : \mathcal{C} \times \mathbb{R}^4 \times \Omega \times Y \times Z \times \{0,1\}^2 \to \{0,1\}\}$, $\{R_G^* : \mathbb{R}^4 \times \Omega \times Y \times Z \times \{0,1\}^2 \to \{0,1\}\}$
  and $\{c, b', m', h'\}$ (whose domains are associated with the W value functions
- Pricing functions $\{q_m : \mathcal{C} \times \mathcal{H} \times \mathbb{R}^3 \times \Omega \times Z \to \mathbb{R}_+\}$ and $\{q_b : \mathcal{H} \times \mathbb{R}^3 \times \Omega \times Z \to \mathbb{R}_+\}$
- An invariant distribution: $\{\mu^*\}$

such that:

1. **Households Maximize:** Given prices and the pricing functions, the value functions solve (3), and c, s, b', h', m' are the associated policy functions, and $B7^*, B13^*, f^*$ are the associated default rules.

2. **Zero Profit Mortgages:** Given f^*, B^*, q_m solves (5) with equality for any contract traded in equilibrium

3. **Zero Profit Unsecured Debt:** Given f^*, f^*,B^*, q_b solves (9) with equality for any contract traded in equilibrium

4. **Zero Profit Bonds:** $q_b = \frac{1}{1+r_b}$ when $b' \geq 0$.

5. **Invariant Distribution:** The distribution μ^* is invariant with respect to the Markov process induced by the exogenous Markov processes ω, z and the policy functions m', h', b', $B7^*$, $B13^*$, f^*, S^*,R^*,P^*

14 Additional Results and Proofs Related to the Household Problem

Assumption 1 *$U(c, s) : \mathbb{R}^2_+ \to \mathbb{R}$ is strictly increasing, concave and differentiable. Further, it is bounded above by $\overline{U}$, and given $p_r > 0$,*

$$U(\underline{y}^z/\lambda - p_r\underline{h}, \underline{h}) - U(0, \underline{h}) > \frac{\beta}{1-\beta}(\bar{U} - u(\underline{y}^z/\lambda - p_r\underline{h}, \underline{h}) \quad \forall\ z$$

Let $M = \{m_1, m_2, \cdots, m_{n_m}\} \subset \mathbb{R}_+$ be the mortgage choice set, $B = \{b_1, b_2, \cdots, b_{n_b}\} \subset \mathbb{R}$ be the bond/unsecured choice set and $B_+ = B \cap \mathbb{R}_+$ be positive bond choices, $\mathcal{H} \subset \mathbb{R}_+$ be the housing choice set, $C \subset \mathbb{R}_+$ be the consumption expenditure choice set. The continuous state variable, cash-at-hand, $a \in A \subset \mathbb{R}_+$. Let Z and Y be the set of possible realizations for the persistent income shock and income, and let Ω and $\mathcal{P}$ by the set of possible realizations for the persistent house price shock and house price. The possible credit histories are $\mathcal{C} = \{G, F, 7, 13\}$. For the household problem, I take the pricing functions $q_b^{rent} : B \times Z \times \to \mathbb{R}_+$, $q_b^{own} : B \times H \times M \times Z \times \Omega \to \mathbb{R}_+$ and $q_m : B \times H \times M \times Z \times \Omega \times \mathcal{H} \to \mathbb{R}_+$ as given. To economize on notation, I will typically not make explicit the dependence of the prices on the choice parameters.

I define the budget correspondences for households based on the above defined value functions:

$$\Gamma_G^{own}(a, h, m, \omega, z) = \\ \{(c, b', m') \in C \times B \times M : c + b'q_b + (1 + r_m)m - m'Q_m + \mu_h p_h h \leq a\} \tag{38}$$

For $i \in \{7, 13\}$

$$\Gamma_i^{own}(a, h, m, \omega, z) = \\ \{(c, b', m') \in C \times B_+ \times M : c + b'q_b + (1 + r_m)m - m' + \mu_h p_h h \leq a; m' \leq m\} \tag{39}$$

$$\Gamma_F^{own}(a, h, \omega, z) = \{(c, b') \in C \times B_+ : c + b'q_b + \mu_h p_h h \leq a\} \tag{40}$$

$$\Gamma_G^{buy}(a, z) = \{(c, b', m', h') \in C \times B \times M \times H : c + b'q_b - m'q_m + p_h(1 + \mu_h)h' \leq a; m' \leq h'\} \tag{41}$$

For $i \in \{F, 7, 13\}$

$$\Gamma_i^{buy}(a, z) = \{(c, b', h') \in C \times B_+ \times H : c + b'q_b + p_h(1 + \mu_h)h' \leq a\} \tag{42}$$

$$\Gamma_G^{rent}(a, z) = \{(c, b') \in C \times B : c + b'q_b + p_r\underline{h} \leq a\} \tag{43}$$

For $i \in \{F, 7, 13\}$

$$\Gamma_i^{rent}(a, z) = \{(c, b') \in C \times B_+ : c + b'q_b + p_r \underline{h} \leq a\} \tag{44}$$

Denote the cardinality of the number of credit states by $N_{\mathcal{C}}$. Let $\mathcal{V}^{own}$ be the set of all continuous (in $b, h, m, \phi, y, z, \omega, p_h, \theta$), vector-valued functions $V^{own} : B \times H \times M \times \Phi \times Y \times Z \times \Omega \times \Theta \times P \to \mathbb{R}^{N_{\mathcal{H}}}$ that are increasing in b, h, y and decreasing in m that satisfy the following:

$$V_{\mathcal{C}}^{own}(b, h, m, \phi, y, z, \omega, p_h, \theta) \in \left[\frac{u(0; \underline{h})}{1-\beta}, \frac{\bar{u}}{1-\beta}\right] \tag{45}$$

$$V_G^{own}(b, h, m, \phi, y, z, \omega, p_h, \theta) \geq V_{F,7,13}^{own}(b, h, m, \phi, y, z, \omega, p_h, \theta) \tag{46}$$

Lemma 1 *$\mathcal{V}^{own}$ is nonempty. With $\|V\| = \max_H\{\sup |V^H|\}$ as the norm, $(\mathcal{V}^{own}, \|\cdot\|)$ is a complete metric space.*

Proof Any constant vector-valued function that satisfies (45) is clearly continuous and satisfies the monotonicity requirements. The set of all continuous vector-valued functions coupled with the same norm $(\mathcal{C}, \|\cdot\|)$ is a complete metric space, thus to prove that $(\mathcal{V}, \|\cdot\|)$ is a complete metric space I need to show that $\mathcal{V}^{own} \subset \mathcal{C}$ is closed under the defined norm. Take an arbitrary sequence of functions from $\mathcal{V}^{own}$, $\{V_n\}$ that is converging to a function V^*. If V^* violates any of the conditions (45)-(46) or the monotonicity properties, then there must exist some N, such that V_N also violates those conditions or properties, but that contradicts the assertion that $V_n \in \mathcal{V}\ \forall n$. Therefore, V^* must satisfy conditions (45)-(46) and the monotonicity properties. To prove the continuity of V^*, one can apply Theorem 3.1 in Stokey, Lucas and Prescott (1989), adapted to a vector-valued function. ∎

Let $\mathcal{V}^{rent}$ be the set of all continuous (in b, ϕ, y, z), vector-valued functions $V^{rent} : B \times \Phi \times Y \times Z \to \mathbb{R}^{N_{\mathcal{H}}}$ that are increasing in b, y that satisfy the following:

$$V_{\mathcal{C}}^{rent}(b, \phi, y, z) \in \left[\frac{u(0; \underline{h})}{1-\beta}, \frac{\bar{u}}{1-\beta}\right] \tag{47}$$

$$V_G^{rent}(b, \phi, y, z) \geq V_{F,7,13}^{rent}(b, \phi, y, z) \tag{48}$$

Lemma 2 *$\mathcal{V}^{rent}$ is nonempty. With $\|V\| = \max_H\{\sup |V^H|\}$ as the norm, $(\mathcal{V}^{rent}, \|\cdot\|)$ is a complete metric space.*

Proof Identical to above. ∎

Let $\mathcal{V} = \mathcal{V}^{own} \cup \mathcal{V}^{rent}$. Therefore $(\mathcal{V}, \|\cdot\|)$ is also complete metric space.

Lemma 3 *$\Gamma_{\mathcal{F}}^B$ is nonempty, monotone, compact-valued and continuous.*

Lemma 4 *Given $V^{own} \in \mathcal{V}$, $W_7^{keep}(h, m, y, \omega, z; V^{own})$ defined by (**??**) exists, is continuous in y, increasing in h, decreasing in m and strictly increasing in y.*

Proof The existence and continuity of $W_7^{keep}(h,m,y,\omega,z;V^{own})$ are because U and V^{own} exist and are continuous. The strict monotonicity in y comes from the strict monotonicity of U. The monotonicity in h and m comes from the monotonicity of V^{own}. ∎

Lemma 5 *Given $V^{rent} \in \mathcal{V}$, $W_7^{liquidate}(y,a,z;V^{rent})$ defined by (??) exists, is continuous in a,y, increasing in a, and strictly increasing in y.*

Proof The existence and continuity of are because U and V^{rent} exist and are continuous. The strict monotonicity in y comes from the strict monotonicity of U. The monotonicity in a comes from the monotonicity of V^{rent}. ∎

Lemma 6 *Given $V^{own} \in \mathcal{V}$, $W_i^{own}(a,h,m,\omega,z;V_i^{own})$ defined by (??,?? and ??) exists, is continuous and increasing in a, and increasing in h.*

Proof The existence and continuity of $W_i^{own}(a,h,m,\omega,z;V_i^{own})$ are a direct consequence of the Theorem of the Maximum, since V_i^{own} is continuous and Γ_i^{own} is compact valued and continuous for $i \in \{F,7,13\}$. The monotonicity in a comes from the the fact that Γ_i^{own} is monotone in a and the monotonicity of V_i^{own}. The monotonicity in h comes from the monotonicity of U and V^{own}. ∎

Lemma 7 *Given $V^{rent} \in \mathcal{V}$, $W_i^{rent}(a,z;V_i^{rent})$ defined by (24, ?? and ??) exists, is continuous and increasing in a.*

Proof The existence and continuity of $W_i^{rent}(a,z;V_i^{rent})$ are a direct consequence of the Theorem of the Maximum, since V_i^{rent} is continuous and Γ_i^{rent} is compact valued and continuous for $i \in \{F,7,13\}$. The monotonicity in a comes from the the fact that Γ_i^{rent} is monotone in a and the monotonicity of V_i^{rent}. ∎

Lemma 8 *Given $V^{own} \in \mathcal{V}$, $W_i^{buy}(a,z;V_i^{rent})$ defined by (23, 28 and 33) exists, is continuous and increasing in a.*

Proof The existence and continuity of $W_i^{buy}(a,z;V_i^{own})$ are a direct consequence of the Theorem of the Maximum, since V_i^{own} is continuous and Γ_i^{buy} is compact valued and continuous for $i \in \{F,7,13\}$. The monotonicity in a comes from the the fact that Γ_i^{buy} is monotone in a and the monotonicity of V_i^{own}. ∎

In order to show the existence of $W_G^{own}(a,h,m,\omega,z;V_G^{own})$, $W_G^{buy}(a,z;V_G^{own})$ and $W_G^{rent}(a,z;V_G^{rent})$ I first need to extend their definitions, because for some values of a the budget correspondence may be empty. First, I will denote by $c_G^{own}(a,h,m,\omega,z,x')$ the consumption of a household with a,h,m,ω,z who makes the portfolio choice x'. Thus, $c_G^{own}(a,h,m,\omega,z,x') \equiv a - b'q_b - \mu_h p_h h + m'Q_m - (1+r_m)m$. Similarly, I define $c_G^{rent}(a,z,x')$ and $c_G^{buy}(a,z,x')$ as the consumption of a household with cash-at-hand a who rents or buys respectively. Note that these consumptions can be negative. Using this notation, I can define lifetime utility from choosing portfolio x' as follows:

$$\Upsilon_G^{own}(a,h,m,\omega,z,x'_{own};V_G^{own}) \equiv u\left(\max\left\{c_G^{own},0\right\}\right) + \beta\mathbb{E}_{p'_h,\omega',y',z',\theta'|\omega,z}V_G^{own}(X'_{own}) \quad (49)$$

$$\Upsilon_G^{rent}(a,x'_{rent};V_G^{rent}) \equiv u\left(\max\left\{c_G^{rent},0\right\}\right) + \beta\mathbb{E}_{y',z'|z}V_G^{rent}(X'_{rent}) \quad (50)$$

$$\Upsilon_G^{buy}(a,x'_{buy};V_G^{own}) \equiv u\left(\max\left\{c_G^{buy},0\right\}\right) + \beta\mathbb{E}_{p'_h,\omega',y',z',\theta'|\omega,z}V_G^{own}(X'_{buy}) \quad (51)$$

where $x'_{own} = (b', m', h)$, $X'_{own} = (x'_{own}, p'_h, \omega', y', z', \theta')$, $x'_{rent} = (b')$, $X'_{rent} = (x'_{rent}, y', z')$, $x'_{buy} = (b', m', h')$ and $X'_{buy} = (x'_{buy}, p'_h, \omega', y', z', \theta')$

Lemma 9 *$\Upsilon^j_G(a, z, x'_j; V)$ is continuous in a and x'_j for $j \in \{rent, buy\}$. Further, for any j, x', Υ^j_G is increasing in a, and strictly increasing if $c^j_G(a, z, x'_j) > 0$.*

Proof Note that $c^j_G(a, z, x'_j)$ are continuous functions of a and x'_j and U is continuous in its first argument. Further, since $V^{own,rent} \in \mathcal{V}$ it is continuous in x'_j and integration preserves continuity. The monotonicity comes because of the strict monotonicity in U and the fact that $c^j_G(a, z, x'_j)$ is increasing in a and strictly increasing in a when $c^j_G(a, z, x'_j) > 0$ ∎

Lemma 10 *$\Upsilon^{own}_G(a, m, h, \omega, z, x'_{own}; V^{own})$ is continuous in a and x'_{own}. Further, for any x'_{own}, Υ^{own}_G is increasing in a, and strictly increasing if $c^{own}_G(a, m, h, \omega, z, x'_{own}) > 0$.*

Proof Identical to above. ∎

Thus, I redefine the extended value functions for $j \in \{rent, buy\}$ as:

$$W^j_G(a, z; V) = \max_{x'_j \in \bar{X}_j(a,z)} \Upsilon^j_G(a, z, x'_j; V^{own,rent}) \tag{52}$$

and for W^{own}_G as:

$$W^{own}_G(a, m, h, \omega, z; V) = \max_{x'_{own} \in \bar{X}_{own}(a,m,h,\omega,z)} \Upsilon^{own}_G(a, m, h, \omega, z, x'_j; V^{own}) \tag{53}$$

where $\bar{X}_{buy}(a, z) = \{(b', h', m') \in B \times H \times M : b'q_b + hp_h - m'q_m \leq a\} \cup \mathbf{0}$, $\bar{X}_{rent}(a, z) = \{(b') \in B : b'q_b \leq a\} \cup \mathbf{0}$ and $\bar{X}_{own}(a, m, h, \omega, z) = \{(b', m) \in B \times M : b'q_b - m'q_m \leq a\} \cup \mathbf{0}$ are taken to be the budget correspondences (without c).

Lemma 11 *$W^j_G(a, z; V)$, $j \in \{rent, buy\}$ and $W^{own}_G(a, m, h, \omega, z; V)$ exist, are continuous in their first argument and increasing in their first argument.*

Proof Immediate from the Theorem of the Maximum and the monotonicity of Υ^j_G. ∎

Lemma 12 *A bad credit history lowers lifetime utility $W_{F,7,13} \leq W_G$*

Proof Since $V^j \in \mathcal{V}$ for $j \in \{rent, own\}$, $\alpha V^j_C + (1-\alpha)V^j_G \leq V^j_G$ for $C \in \{F, 7, 13\}$. From the definition of $c(a, z, x')$, $\max\{c_C(a, z, x'), 0\} \leq \max\{c_G(a, z, x'), 0\}$ for all $C \in \{F, 7, 13\}$. Thus, from the strict monotonicity of U, $\Upsilon^{own}_C \leq \Upsilon^{own}_G$. Hence, since $\bar{X}^C \subset \bar{X}^G$, $W_{F,7,13} \leq W_G$.

I define the operator vector valued operator T based on equations 3, **??**, **??**, 26, 27, 30, 32 and 34.

Lemma 13 *T is a contraction mapping with modulus β.*

Proof In order to prove that T is a contract mapping I appeal to Blackwell's sufficient conditions:

1. Self-map: $TV \subset \mathcal{V}$. In order to show this first note that W_C^j are all continuous in their first argument, the convex combination of two continuous functions is continuous and the maximum of two continuous functions is continuous. The boundedness property (45) is satisfied by the boundedness of W_C^j. That TV is increasing in b', h' and y' comes from the fact that all the W_C^j are increasing in their first argument and that $W_7^{liquidate}$ is strictly increasing in y. By the same argument, TV is decreasing in m'. The monotonicity property (46) is satisfied by virtue of $W_G \geq W_{7,13,F}$ since the payoff in $V_{7,13,F}$ can always be achieved in V_G.

2. Monotonicity: $\hat{V} \geq V \rightarrow T\hat{V} \geq TV$. For each $C \in \mathcal{C}$, $W_C^j(\cdot; V)$ is increasing in V. Therefore, because the convex combination of two increasing functions is increasing and the maximum of two increasing functions is increasing $T\hat{V} \geq TV$.

3. Discounting: $T(V+k) = TV+\beta k$. Notice that for each $C \in \mathcal{C}$ $W_C^j(\cdot; V)$, $W_C^j(\cdot; V+k) = W_C^j(\cdot; V) + \beta k$, thus for each $C \in \mathcal{C}$, $T(V_C + k) = TV_C + \beta k$. ∎

Since I have extended the domain of W_G, I must now verify that an agent will never make a choice such that he will have no feasible choices (i.e. for W_G he would choose to file Chapter 7 bankruptcy rather than repay. First I prove that an agent will choose to go bankrupt rather than not go bankrupt and have zero consumption.

Lemma 14 *Under Assumption 1, an agent with a good credit history will always choose to file for Chapter 7 bankruptcy rather than not and have zero consumption. Furthermore, an agent that chooses not to file for Chapter 7 bankruptcy always consumes a strictly positive amount.*

Proof The utility from choosing not to file for Chapter 7 when the budget set is empty is bounded by $U(0, \underline{h}) + \beta\bar{u}/(1-\beta)$. By choosing to file Chapter 7 the agent can guarantee lifetime utility of at least $u((\underline{y} - p_r\underline{h})/\lambda, underlineh)/(1-\beta)$, which by Assumption 1 is strictly greater. To ensure that conditional on not going bankrupt agents consume a strictly positive amount, note that from the continuity of $U(\cdot,\cdot)$, there exists some $\tilde{c} > 0$ such that $U(\tilde{c}, \underline{h}) + \beta\bar{u}/(1-\beta) < U((\underline{y} - p_r\underline{h})/\lambda, \underline{h})/(1-\beta)$, which implies that conditional on not going bankrupt an agent will consume at least $\tilde{c}$. ∎

Proof of Proposition 1 The existence and uniqueness of the value functions is an immediate consequence of Lemma 13 and the Contraction Mapping Theorem. The monotonicity properties of the value functions and the effect of a bad credit score follow immediately from Lemmas 11 & 12. ∎

If the period of punishment for Chapter 7 and Chapter 13 bankruptcy are the same length (i.e., $\alpha_7 = \alpha_{13}$), a household with only exempt home equity ($\eta \leq \chi$) will never choose to file for Chapter 13 bankruptcy.

Proposition 5 Chapter 13 Bankruptcy Characterization

If $\alpha_7 = \alpha_{13}$ a household with only exempt home equity, $\eta \leq \chi$, the household will never choose to file Chapter 13 bankruptcy.

The intuition for the result is straightforward. If the household has only exempt home equity, it does not lose any assets by filing for Chapter 7 bankruptcy. However, if it files for Chapter 13 bankruptcy, it keeps the same level of assets, but commits to pay a fraction of its income for the duration of the punishment period. Therefore, if the period of punishment is identical, then in all states of the world the household will have higher resources if it files for Chapter 7 over Chapter 13. While this is a strong result, when relating it to the real world, it should be seen as a statement that when a household has only exempt assets it would never choose to file Chapter 13 (in the model the statements are equivalent, since home equity is the only exempt asset).

The proof of Proposition 2 is an extension of Chatterjee et al. (2007). I first prove six lemmas.

Lemma 15 *Let $\hat{y} \in Y \backslash \overline{\mathcal{B}}^*_{7,R}(b,z)$, $y > \hat{y}$. If $y \in \overline{\mathcal{B}}^*_{7,R}(b,z)$, then the optimal consumption with $\hat{y}$, $c^*(b+\hat{y}) > \hat{y} - p_r\underline{h}$.*

Proof Since $\hat{y} \in Y \backslash \overline{\mathcal{B}}^*_{7,R}(b,z)$, the agent strictly prefers not declaring Chapter 7 bankruptcy, i.e. either:

$$U(c^*(b+\hat{y}),\underline{h}) + \beta\mathbb{E}V_G^{rent}(X'^*) > U(\hat{y} - p_r\underline{h},\underline{h}) + \beta\mathbb{E}V_7^{rent}(X') \tag{54}$$

or

$$U(c^*(b+\hat{y}),h'^*) + \beta\mathbb{E}V_G^{own}(X'^*) > U(\hat{y} - p_r\underline{h},\underline{h}) + \beta\mathbb{E}V_7^{rent}(X') \tag{55}$$

Let $\epsilon = y - \hat{y}$. The choices: $\check{c} = c^*(\eta + b_F + \hat{y}) + \epsilon, \check{b}' = b'^*, \check{h}' = h'^*, \check{m}' = m'^*$ were feasible choices with resources $y+b$, but were not chosen since $y \in \overline{\mathcal{B}}^*_{7,R}(b,z)$ (where the starred variables are the optimal choices under endowment $\hat{y}$), therefore either:

$$U(\check{c},\underline{h}) + \beta\mathbb{E}V_G^{rent}(X'^*) \leq U(y - p_r\underline{h},\underline{h}) + \beta\mathbb{E}V_7^{rent}(X') \tag{56}$$

or

$$U(\check{c},h'^*) + \beta\mathbb{E}V_G^{own}(X'^*) \leq U(y - p_r\underline{h},\underline{h}) + \beta\mathbb{E}V_7^{rent}(X') \tag{57}$$

Subtracting equations (54) and (56) I obtain:

$$U(\hat{y} + \epsilon - p_r\underline{h},\underline{h}) - U(\hat{y} - p_r\underline{h},\underline{h}) > U(c^*(b+\hat{y}) + \epsilon,\underline{h}) - U(c^*(b+\hat{y}),\underline{h}) \tag{58}$$

and subtracting equations (55) and (57) I obtain:

$$U(\hat{y} + \epsilon - p_r\underline{h},\underline{h}) - U(\hat{y} - p_r\underline{h},\underline{h}) > U(c^*(b+\hat{y}) + \epsilon,h'^*) - U(c^*(b+\hat{y}),h'^*) \tag{59}$$

which from the strict concavity of $U(\cdot)$ implies that $c^*(b+\hat{y}) > \hat{y} - p_r\underline{h}$. The portfolio choice is unchanged for the household conditional on Chapter 7 bankruptcy, thus X' is the same across (56), (57), (58) and (59). ∎

Lemma 16 *Let $\hat{y} \in Y \backslash \overline{\mathcal{B}}^*_{7,F}(b,z)$, $y > \hat{y}$. If $y \in \overline{\mathcal{B}}^*_{7,F}(b,z)$, then the optimal consumption with $\hat{y}$, $c^*(b+\hat{y}) > \hat{y} - p_r\underline{h}$.*

Proof Omitted. The proof is essentially identical to the previous. ∎

Lemma 17 *Let* $\hat{y} \in Y \backslash \overline{\mathcal{B}}^*_{7,R}(b,z)$*,* $y < \hat{y}$*. If* $y \in \overline{\mathcal{B}}^*_{7,R}(b,z)$*, then the optimal consumption with* $\hat{y}$*,* $c^*(b+\hat{y}) < \hat{y} - p_r\underline{h}$*.*

Proof Omitted. The proof is essentially identical to the previous. ∎

Lemma 18 *Let* $\hat{y} \in Y \backslash \overline{\mathcal{B}}^*_{7,F}(b,z)$*,* $y < \hat{y}$*. If* $y \in \overline{\mathcal{B}}^*_{7,F}(b,z)$*, then the optimal consumption with* $\hat{y}$*,* $c^*(b+\hat{y}) < \hat{y} - p_r\underline{h}$*.*

Proof Omitted. The proof is essentially identical to the previous. ∎

Lemma 19 *Let* $\hat{y} \in Y \backslash \overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z)$*,* $y > \hat{y}$*. If* $y \in \overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z)$*, then the optimal consumption with* $\hat{y}$*,* $c^*(b+\eta+\hat{y}) > \hat{y} - p_r\underline{h}$*.*

Proof Omitted. The proof is essentially identical to the previous. Since the household has been hit by the moving shock the pertinent resources are home equity and non-exempt home equity. ∎

Lemma 20 *Let* $\hat{y} \in Y \backslash \overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z)$*,* $y < \hat{y}$*. If* $y \in \overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z)$*, then the optimal consumption with* $\hat{y}$*,* $c^*(b+\eta+\hat{y}) < \hat{y} - p_r\underline{h}$*.*

Proof Omitted. The proof is essentially identical to the previous. ∎

Lemma 21 *Let* $\hat{y} \in Y \backslash \overline{\mathcal{B}}^*_{7,\theta=0}(b,h,m,\omega,z)$*,* $y < \hat{y}$*. If* $y \in \overline{\mathcal{B}}^*_{7,\theta=0}(b,h,m,\omega,z)$*, then if the household has only exempt home equity, i.e.* $\eta \leq \xi$*, the optimal consumption with* $\hat{y}$*,* $c^*(b,h,m,\omega,z) < \hat{y} - r_m m - \mu_h p_h h$*, otherwise* $c^*(b,h,m,\omega,z) < \hat{y} - p_r\underline{h}$*.*

Proof First consider the case where the household has non-exempt home equity, if it files for Chapter 7 bankruptcy it has to liquidate the home.

The proof is essentially identical to the previous ones, but there are additional cases to consider. Since $\hat{y} \in Y \backslash \overline{\mathcal{B}}^*_{7,\theta=0}(b,h,m,\omega,z)$, the agent strictly prefers not declaring Chapter 7 bankruptcy, i.e. either the household becomes a renter conditional on not defaulting:

$$U(c^*(b+\eta+\hat{y}),\underline{h}) + \beta\mathbb{E}V_G^{rent}(X'^*) > U(\hat{y} - p_r\underline{h},\underline{h}) + \beta\mathbb{E}V_7^{rent}(X') \tag{60}$$

or the household sells its home and buys a new one:

$$U(c^*(b+\eta+\hat{y}),h'^*) + \beta\mathbb{E}V_G^{own}(X'^*) > U(\hat{y} - p_r\underline{h},\underline{h}) + \beta\mathbb{E}V_7^{rent}(X') \tag{61}$$

or the household keeps its home:

$$U(c^*(b+\hat{y},m,h),h) + \beta\mathbb{E}V_G^{own}(X'^*) > U(\hat{y} - p_r\underline{h},\underline{h}) + \beta\mathbb{E}V_7^{rent}(X') \tag{62}$$

From here the remainder of the steps are unchanged.

When the household has only exempt home equity the choices when not defaulting remain unchanged, but the bankruptcy choices change:

$$U(c^*(b+\eta+\hat{y}),\underline{h}) + \beta\mathbb{E}V_G^{rent}(X'^*) > U(\hat{y} - r_m m - \mu_h p_h h, h) + \beta\mathbb{E}V_7^{own}(X') \tag{63}$$

or the household sells its home and buys a new one:

$$U(c^*(b+\eta+\hat{y}),h'^*)+\beta\mathbb{E}V_G^{own}(X'^*)>U(\hat{y}-r_m m-\mu_h p_h h,h)+\beta\mathbb{E}V_7^{own}(X') \tag{64}$$

or the household keeps its home:

$$U(c^*(b+\hat{y},m,h),h)+\beta\mathbb{E}V_G^{own}(X'^*)>U(\hat{y}-r_m m-\mu_h p_h h,h)+\beta\mathbb{E}V_7^{own}(X') \tag{65}$$

Using the same differencing strategy as in the previous lemma and exploiting the strict concavity of the period utility function the same result obtains. ∎

Proof of Proposition 2

1. (a) If $\overline{\mathcal{B}}^*_{7,R}(b,z)$ is non-empty let $\underline{y}^B=\inf\overline{\mathcal{B}}^*_{7,R}(b,z)$ and $\bar{y}^B=\sup\overline{\mathcal{B}}^*_{7,R}(b,z)$. These both exist from the Completeness Property of $\mathbb{R}$ since $\overline{\mathcal{B}}^*_{7,R}(b,z)\subseteq Y\subset\mathbb{R}$. If they're equal, I'm done, therefore suppose $\underline{y}^B<\bar{y}^B$. Take $\hat{y}\in(\underline{y}^B,\bar{y}^B)$. Suppose by way of contradiction that $\hat{y}\notin\overline{\mathcal{B}}^*_{7,R}(b,z)$. Now, there exists a $y\in\overline{\mathcal{B}}^*_{7,R}(b,z)$ such that $y>\hat{y}$ (if not $\bar{y}^B=\hat{y}$, contradicting that $\hat{y}\in(\underline{y}^B,\bar{y}^B)$). Thus, from Lemma 15, $c^*(b+\hat{y})>\hat{y}$. By the same argument there exists a $y\in\overline{\mathcal{B}}^*_{7,R}(b,z)$ such that $y<\hat{y}$, but from Lemma 17 this implies $c^*(b+\hat{y})<\hat{y}$, a contradiction. The closedness comes from the continuity of W_G^{rent} and $U(\cdot,\cdot)$. ∎

(b)-(d) Identical to above.

2. Suppose $y\in\overline{\mathcal{B}}^*_{7,R}(\hat{b},z)$. Take $b<\hat{b}$. Since W_G^{rent} is increasing in the first argument, $W_G^{rent}(b+y,z)\le W_G^{rent}(\hat{b}+y,z)$. However, since $y\in\overline{\mathcal{B}}^*_{7,R}(\hat{b},z)$ this implies that $W_G^{rent}(\hat{b}+y,z)\le W_7^{liquidate}(0,y,z)\Rightarrow W_G^{rent}(b+y,z)\le W_7^{liquidate}(0,y,z)\Rightarrow y\in\overline{\mathcal{B}}^*_{7,R}(b,z)$, which implies $\overline{\mathcal{B}}^*_{7,R}(\hat{b},z)\subseteq\overline{\mathcal{B}}^*_{7,R}(b,z)$. A similar argument can be made for $\overline{\mathcal{B}}^*_{7,F}$. For $\overline{\mathcal{B}}^*_{7,\theta=1}$ again a similar argument can be made with $W_7^{liquidate}$ evaluated at $(\eta-\xi,y,z)$. The same holds for $\overline{\mathcal{B}}^*_{7,\theta=0}$ when $\eta>\xi$, whereas when $\eta\le\xi$ the relevant comparison is with $W_7^{keep}(h,m,y,\omega,z)$. ∎

Proof of Proposition 3

(a) Suppose $y\in\overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi_1,z)$. Take $\xi_2<\xi_1$. Since $W_7^{liquidate}$ is increasing in the first argument $W_7^{liquidate}(\eta-\xi_1,y,z)\le W_7^{liquidate}(\eta-\xi_2,y,z)$. However, since $y\in\overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi_1,z)$ this implies that $\max\{W_G^{buy}(b+\eta+y,z),W_G^{rent}(b+\eta+y,z),W_{13}^{rent}(\eta+(1-\phi)y,\phi,z)\}\le W_{\mathcal{F}}^B(\eta-\xi_1',y,z)$, which implies that $y\in\overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi_2,z)$. ∎

(b) Suppose $y\in\overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z)$. Take $x>0$. Since $W_7^{liquidate}$ is increasing in its first argument, $W_7^{liquidate}(\eta+x-\xi,y,z)\ge W_7^{liquidate}(\eta-\xi,y,z)$. However, since $y\in\overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z)$ this implies that $\max\{W_G^{rent}(\eta+y+b,z),W_G^{buy}(\eta+y+b,z),W_{13}^{rent}(\eta+(1-\phi)y,z)\}\le W_7^{liquidate}(\eta-\xi,y,z)$, and $\max\{W_G^{rent}(\eta+y+b,z),W_G^{buy}(\eta+y+b,z)\}=$

$\max\{W_G^{rent}((\eta+x)+y+(b-x),z), W_G^{buy}((\eta+x)+y+(b-x),z)$, therefore either filing for Chapter 13 bankruptcy is still less desirable than Chapter 7 $W_{13}^{rent}(\eta+x+(1-\tilde{\phi})y,z) \leq W_{13}^{rent}(\eta+(1-\phi)y,z) \leq W_7^{liquidate}(\eta+x-\xi,y,z)\}$ and therefore $y \in \overline{\mathcal{B}}_7^*(b-x,\eta+x,\xi,z)$, or $W_{13}^{rent}(\eta+x+(1-\tilde{\phi})y,z) > \max\{W_G^{rent}(\eta+y+b,z), W_G^{buy}(\eta+y+b,z), W_7^{liquidate}(\eta+x-\xi,y,z)\}$ and the household files for Chapter 13 bankruptcy, i.e. $y \in \overline{\mathcal{B}}^*_{13,\theta=1}$. $\blacksquare$

(c) Suppose $y \notin \overline{\mathcal{B}}_7^*(b,\eta,\xi,z)$, where $\xi > 0$. Take $x > 0$. Since $W_G^{buy,rent}$ is increasing in the first argument, $W_G^{buy,rent}(b+\eta+x+y,z) \geq W_G^{buy,rent}(b_F+\eta+y,z)$. Note that since $\xi > 0$, the additional home equity is forfeited in Chapter 7 bankruptcy, $W_7^{liquidate}((\eta+x)-(\xi+x),y,z) = W_G^{liquidate}(\eta-\xi,y,z)$. Thus, since $y \notin \overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta,\xi,z)$ this implies that $W_G^{rent,buy}(b+\eta+x+y,z) \geq W_G^{rent,buy}(b+\eta+y,z) \geq W_7^{liquidate}(\eta-\xi,y,z)$, which implies that $y \notin \overline{\mathcal{B}}^*_{7,\theta=1}(b,\eta+x,\xi+x,z)$. $\blacksquare$

(d) This follows directly from Proposition 1 and the monotonicity of the budget set. $\blacksquare$

15 Computational Details

In order to calibrate the model I employ a nested fixed point algorithm to match relevant moments from the model with the data. Solving the model is a computational challenge because of the complexity of the fixed point problem. With long-term mortgage debt, in order to solve the recursive functional equation for the price requires forecasting future mortgage and unsecured debt choices, in addition to default decisions. Those optimal policy choices respond to changes in both the mortgage and unsecured interest rates. The introduction of the two iid shocks in income and house prices helps smooth out the policy choices of households, to help prevent large changes in the optimal choice of m' or b' in response to small changes in prices which could lead to cycling. I discretize the state space and the choice parameters.

The outline of the algorithm is as follows:

1. **Loop 1** - Guess a vector of the structural parameters Θ^0
   (a) **Loop 2** - Make an initial guess for the price schedules q_b^0 and q_m^0
   (b) Compute the policy choice $(\breve{b}', \breve{h}', \breve{m}')$ that yields the maximal resources in the current period, and denote it by $\breve{a}$.
      i. **Loop 3** - Make an initial guess for W^0 on the domain $[\breve{a} - \underline{c}, \bar{a}]$, and define v^0 for $a < \breve{a} - \underline{c}$ as $u(\underline{c}) + \beta\bar{u}/(1-\beta)$, where $\underline{c}$ is a minimal consumption level.
      ii. Compute $\mathbb{E}_{\delta',y',z'} V^H(b', h', m', y', \delta', z')$ for each choice of b', h', m', and the implied discrete choies $B7^*$,$B13^*$, f^*, S^*, R^* and P^*.
      iii. Compute the new value functions, W^1, by maximization given $\mathbb{E}_{\delta',y',z'} V(b', h', m', y', \delta', y')$
      iv. Compute the portfolio policy functions
      v. If $\|W^1 - W^0\| < \epsilon_W$ end **Loop 3**, otherwise set $W^0 = W^1$ and go to B.
   (c) Given the default decisions B^* and f^*, use Equations 9, 8, 5, 36, & 37 to compute the new implied price schedules q_b^0 and q_m^0.
   (d) If $\|q^1 - q^0\| < \epsilon_q$ end **Loop 2**, otherwise set $q^0 = \nu q^0 + (1-\nu)q^1$ and go to (ii).
   (e) Compute the invariant distribution μ over $A \times Z \times \times Y \mathcal{S}$.
2. Compute model moments $\mathcal{M}^{\text{MODEL}}$.
3. If $\sum w_i(\mathcal{M}_i^{\text{MODEL}} - \mathcal{M}_i^{\text{DATA}})^2 < \epsilon_{\mathcal{M}}$ end **Loop 1**. Otherwise, return to 1.

16 Foreclosure and Bankruptcy Information by State

Table 13: Foreclosure Deficiency and Homestead Bankruptcy Exemption by State

State	Foreclosure Deficiency	Max Homestead Exemption	Federal Allowed
Alabama	Yes	5,000*	No
Alaska	No	54,000	No
Arizona	No	150,000	No
Arkansas	Yes	17,425*	Yes
California	No	50,000†	No
Colorado	Yes	45,000	No
Connecticut	Yes	75,000	Yes
Delaware	Yes	50,000	No
D.C.	Yes	17,425*	Yes
Florida	Yes	∞	No
Georgia	Yes	10,000*	No
Hawaii	Yes	17,425*	Yes
Idaho	Yes	104,471	No
Illinois	Yes	7,500*	No
Indiana	Yes	7,500	No
Iowa	No	∞	No
Kansas	Yes	∞	No
Kentucky	Yes	5,000	No
Louisiana	Yes	25,000	No
Maine	Yes	35,000	No
Maryland	Yes	0	No
Massachusetts	Yes	100,000	Yes
Michigan	Yes	17,425*	Yes
Minnesota	No	200,000	Yes
Mississippi	Yes	75,000	No
Missouri	Yes	15,000	No
Montana	No	100,000	No
Nebraska	Yes	12,500	No
Nevada	Yes	550,000	No
New Hampshire	Yes	100,000	No
New Jersey	Yes	17,425*	Yes
New Mexico	Yes	30,000*	Yes
New York	Yes	50,000	No
North Carolina	No	18,500	No
North Dakota	No	80,000	No
Ohio	Yes	5,000	No

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Table 13 – Continued

State	**Foreclosure Deficiency**	**Max Homestead Exemption**	**Federal Allowed**
Oklahoma	Yes	∞	No
Oregon	Yes	25,000‡	No
Pennsylvania	Yes	17,425*	Yes
Rhode Island	Yes	200,000	Yes
South Carolina	Yes	17,425*	Yes
South Dakota	Yes	30,000	No
Tennessee	Yes	5,000†	No
Texas	Yes	∞	Yes
Utah	Yes	20,000*	No
Vermont	Yes	75,000	Yes
Virginia	Yes	5,000*	No
Washington	No	40,000	Yes
West Virginia	Yes	25,000	No
Wisconsin	Yes	40,000*	Yes
Wyoming	Yes	10,000*	No

*Can be doubled for couples
†Can be multiplied by 1.5 for couples
‡33,000 for couples