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Doctoral Thesis

Essays on Bankruptcy, Mortgage Default and Regional Migration

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Declaration of Authorship

I, Florian Oswald, declare that this thesis titled "Essays on Bankruptcy, Mortgage Default and Regional Migration", and the work presented are my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Florian Oswald, on August 3, 2015

Abstract

This thesis is about the role of housing as a consumption good and a risky asset, and how it interacts with other choices like consumption, default, and migration over the lifecycle.

In the first chapter the focus is on a quasi natural experiment in the State of Nevada, which abolished deficiency judgments for purchase mortgage loans made after October 2009. We test the effect of the law change on mortgage supply and demand, as well as on mortgage default. We find strong evidence that lenders tightened their lending standards. Households, by contrast, neither increased their mortgage applications, nor do they appear to have changed mortgage default behaviour.

The second chapter develops the theme of mortgage default and consumption insurance in a more structural way. We estimate a model of consumption, housing demand and labor supply when individuals may file for bankruptcy and default on their mortgage over the lifecycle. Bankruptcy and mortgage default comply with the basic institutional framework in the US, allowing for the choice between chapter 7 or chapter 13 bankruptcy.

The final chapter estimates a lifecycle model of consumption, housing choice and migration in the presence of aggregate and regional shocks, using the Survey of Income and Program Participation (SIPP). Using the model I estimate the value of the migration option and the welfare impact of policies that may restrict mobility. The option to move is equivalent to 4.4% of lifetime consumption. I also find that, were the mortgage interest-rate deduction to be eliminated, the aggregate migration rate would increase only marginally by 0.1%. In a new steady state the elimination of the deduction is equivalent to an increase of 2.4% of lifecycle consumption.

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Contents

List of Tables

List of Figures

Introduction

This thesis is about the role of housing as a consumption good and a risky asset, and how it interacts with other choices like consumption, default, and migration, over the lifecycle. For the vast majority of consumers in developed economies, their home is the single largest asset they possess. In most cases, purchase of the house goes in hand with a longterm debt contract, i.e. a mortgage. The recent crisis painfully reminds us about the implications of house price uncertainty together with mortgage debt, and in this thesis I study some of those implications with the help of economic models, which propose a theory of consumer behaviour, and which are confronted with consumer data in empirical estimation exercises.

In the first chapter, which is joint work with Wenli Li, the focus is on a quasi natural experiment in the State of Nevada, where the legislation concerning mortgage default was changed in late 2009. In particular, Nevada abolished deficiency judgments for purchase mortgage loans made after October 2009 and collateralized by primary single family homes. In the first chapter of this thesis, we test the effect of the law change on mortgage supply and demand, as well as on mortgage default. Using unique mortgage loan level application and performance data, we find strong evidence that lenders tightened their lending standards in response to the law change. Particularly, lenders reduced approval rates and loan sizes for affected mortgages by about 5 percent. Households, by contrast, did not increase their mortgage applications because of the law change. More importantly, the law change did not appear to have affected mortgage default and house foreclosure outcomes. These results thus cast a cautionary note on the effectiveness of policy recommendations that intend to use deficiency laws to curb mortgage defaults.

The second chapter, joint with Costas Meghir and Wenli Li, develops the theme of mortgage default and consumption insurance in a more structural way. Looking again at the United States, we analyse the role that different legal frameworks concerning consumer bankruptcy and mortgage default have on consumer welfare. In order to do so, we estimate a rich model of consumption, housing demand and labor supply in an environment where individuals may file for bankruptcy on unsecured debt and default on their mortgage. Uncertainty in the model is driven by both house price and income shocks, while bankruptcy and mortgage default comply with the basic institutional framework in the US, allowing for the choice between chapter 7 or chapter 13 bankruptcy. The model is estimated using micro data on credit reports and mortgage performance, combined with individual level data from the American Community Survey.

The final chapter is an extension of this theme into the migration literature. I look at the impact being a homeowner on regional migration in the US, and what the effects of removing the mortgage interest deduction would be on mobility, housing and welfare. In particular, I estimate a lifecycle model of consumption, housing choice and migration in the presence of aggregate and regional shocks, using the Survey of Income and Program Participation (SIPP). Using the model

I estimate the value of the migration option and the welfare impact of policies that may restrict mobility. The option to move is equivalent to 4.4% of lifetime consumption. I also find that, were the mortgage interest-rate deduction to be eliminated, the aggregate migration rate would increase only marginally by 0.1%. Following a general equilibrium correction, house prices are reduced by 5%, which results in a 1% increase in home ownership. In a new steady state the elimination of the deduction is equivalent to an increase of 2.4% of lifecycle consumption.

Chapter 1

Recourse and Residential Mortgage Market: The Case of Nevada

1.1 Introduction

In the United States, state laws govern residential mortgage defaults and house foreclosure processes. In most states, mortgage loans are recourse loans, that is, lenders can apply the difference between mortgage balance and proceeds from foreclosure sales to debtors' other assets or earnings. The state of Nevada changed its mortgage default legislation in 2009 from recourse to non-recourse, and in this paper we use the so-created quasi natural experiment to analyse the effects on borrower default as well as the response of lenders.

The extent and precise manifestation of lender recourse varies from state to state.[1] Regardless of this, theory predicts that recourse should deter default. This

[1] We refer the reader to Ghent and Kudlyak (2009) for a detailed description and categorization of states into groups of recourse and non-recourse states.

is because defaulting would put other assets of the debtor at risk through a so-called deficiency judgment, which the lender could obtain in court against the borrower (see Ambrose et al. (1997), and Corbae and Quintin (2015)). Empirically, however, the findings regarding the relationship between default and legal provisions have been mixed. For instance, Clauretie (1987) finds that whether a state allows for deficiency judgments does not affect mortgage default rates significantly, consistent with the observation that deficiency judgments are not carried out much, if at all, in practice. This is due to high costs associated with pursuing such judgments (see Leland (2008), and Brueggeman and Fisher (2011)).[2] By contrast, Ghent and Kudlyak (2009) find lower default rates in recourse states, particularly for higher-priced homes whose owners are likely to have other financial resources that can be seized by mortgage lenders. Adding to this discussion, Guiso et al. (2013) illustrate that response to the hypothetical survey question "would you default given a fall in home equity of x%" is independent of whether the respondents state is recourse or not. Many policy discussions have also centered on this provision. In an opinion piece Feldstein (2008) makes the point that turning nonrecourse mortgage loans into recourse loans may be an effective way to solve the mortgage debt overhang problem and, thus, the mortgage crisis following the 2008 drop in house prices.[3]

In this paper we show that the current debate on deficiency judgements as a useful tool to curb mortgage defaults is incomplete and perhaps even misleading. The reason for this is that borrowers *and* lenders respond to differences in regulations. Without deficiency judgements, lenders may decide not to lend to riskier

[2]It's costly and time consuming to persue deficiency judgments on foreclosures. Additionally, debtors can file for bankruptcy and get rid of the unsecured deficiency debt.

[3]This suggestion has been controversial as summarized in Adam Levitin's blog at http://www.creditslips.org/creditslips/2008/12/the-role-of-rec.html

borrowers, lend less, or lend at higher interest rates. Borrowers may decide not to apply for mortgages or apply for smaller ones. Analysis of the default behavior of approved mortgage loans is, thus, subject to selection bias. In particular, a finding that borrowers are less likely to default in states without deficiency judgements may simply be because approved borrowers in those states are less risky.

To illustrate the point, we conduct a unique event study using proprietary mortgage loan level application and performance data. In 2009 Nevada, one of the crisis states, made significant changes to its deficiency judgment law. For homeowners who entered into a mortgage in conjunction with a purchase of a single family primary home after October 1, 2009, their mortgage lenders will not be able to pursue a deficiency judgment, should the house be taken in a foreclosure. We test whether lenders responded to the law change by altering their mortgage approval rates, mortgage loan size, and interest rate; We also test whether there were any changes in mortgage applications or mortgage defaults on behalf of borrowers.

Our identification strategy uses both cross-sectional as well as time-series variation in a difference-in-difference-in-difference estimator. The cross-sectional difference concerns primary single home purchase loans (henceforth "primary mortgages") versus refinanced loans, versus investment single family properties, and several other mortgage loan types. The time difference simply compares primary mortgages before and after the policy change. This identification strategy has an advantage over those that rely exclusivley on cross sectional differences in state laws to detect the effects of recourse, because state laws exhibit very little variation over time in genereal.

The paper has three main results. First, we uncover evidence that lenders tightened their lending standards by reducing approval rates and loan sizes for those affected borrowers. More specifically, the abolishment of deficiency judgments for primary mortgages leads to a reduction of about 5 percent in both mortgage approval rates and mortgage sizes. Mortgage interest rates for approved loans, on the other hand, did not change in any statistically significant way. Second, we don't find that mortgage applications for purchase loans for one-to-four family owner-occupied homes increased more than for similar mortgages made before the law change, and similarly for refinance loans. Finally, we do not find that borrowers' default behavior responded to the change in Nevada law in any statistically significant way. What is more, we do not find any evidence that the change in recourse law makes borrowers' default behavior more sensitive to home equity. Even though our results do not dispute that mortgage deficiency judgments may still be a useful tool to reduce mortgage defaults, they suggest that any such policy may be effective by reducing mortgage lending. Our paper thus casts a cautionary note on the promotion of deficiency judgments as a tool to prevent mortgage defaults per se.

In addition to the researches cited above, our paper is also related to two other strands of literature. The first is the literature that studies the impact of various aspects of state laws on lending cost. For example, Clauretie and Herzog (1990) and Ciochetti (1997) document greater lender costs in states that require judicial foreclosure and statutory right of redemption. These findings are replicated in Mian et al. (2011), who show that "states without a judicial requirement for foreclosures are twice as likely to foreclose on delinquent homeowners." Lin and White (2001) and Jeremy Berkowitz and Hynes (1999) show that differnt bankruptcy exemptions do and do not affect, respectively, whether a mortgage application was approved. Pence

(2006) finds that lenders approve smaller loans in default-friendly states everything else the same.

The second is the vast literature examining various aspects of mortgage borrowers' decision to default. Among the recent studies, Gerardi et al. (2007) and Foote et al. (2008) focus on negative equity as an important condition for defaults for mortgages originated in the state of Massachusetts. Bajari et al. (2008) and Elul et al. (2010) study both negative home equity and illiquidity as two important drivers of the rise in mortgage defaults during the recent crisis.

The rest of this chapter is organized as follows. Section 1.2 discusses the law change in Nevada and its potential impact on debtors and creditors. Section 1.3 presents our data sources. Section 1.4 reports our empirical analysis and section 1.5 concludes.

1.2 The Nevada Deficiency Judgment Law and Its Impact

1.2.1 The Nevada Deficiency Judgment Law

Up until late 2009, the state of Nevada was a typical recourse state, allowing lenders to pursue deficiency judgments. In practice this means that the lender was able to pursue the borrower for the difference between the balance owed on a mortgage loan and what the lender would sell the house for at auction within six months of the auction having taken place.

In October 2009, Nevada passed a law – Assembly Bill No. 471 – that made significant changes to Nevada's deficiency judgments law. Under the new legislation, a financial institution holding a residential mortgage may not be awarded a deficiency judgment under the following circumstances: (1) the real property is a single-family house owned by the debtor; (2) the debtor used the money loaned from the bank to buy the house (as in a typical mortgage); (3) the house was owner-occupied; and (4) the loan was never refinanced. What this means is that, for many homeowners who enter into a mortgage in conjunction with a purchase after October 1, 2009, their mortgage lender will not be able to pursue a deficiency judgment should the house be taken in a foreclosure. Rather, upon foreclosure, the risk that the house has depreciated in value shifts back to the bank. Mortgages that do not satisfy these conditions continue to be subject to the prior law, i.e. loans issued *before* October 2009 continue to be recourse loans.[4]

1.2.2 The Impact of Deficiency Judgments on Mortgage Lending, Borrowing, and Default

The impact of the deficiency law on borrowers' default behavior hinges crucially on the borrowers' non-housing assets. If the borrower has other assets that can be collected after house foreclosure, then the permission of deficiency judgment will deter the borrower from becoming seriously delinquent. The more assets the

[4]Aside from recourse, in Nevada, lenders may foreclosure on mortgages in default using either a judicial or non-judicial foreclosure process. The judicial process of foreclosure involves filing a lawsuit to obtain a court order to foreclosure and is used when no power of sale is present in the mortgage. The borrower has 12 months after the foreclosure sale to redeem the property. When a power of sale clause exists in a mortgage or deed of trust, the non-judicial process is used. Borrowers have no right of redemption under the power of sale.

borrower has, the stronger the deterrence will be. Another important factor that affects the impact of the deficiency law on borrowers' default behavior is the cost of collecting deficiency judgments on behalf of the lenders. If their cost is high, then the effect of the policy will be smaller. Finally, in a dynamic setting, future local house price movement, borrower's income, and the cost of defaulting (less access to future credit) will all factor into borrowers' decision. See Ghent and Kudlyak (2009) and Corbae and Quintin (2015) for more discussion.

If lenders are not allowed to collect on debtors' other assets, they will be reluctant to foreclose on the house, especially when foreclosure costs are high, because there is no financial gain from doing so. Furthermore, if lenders perceive default probabilities to rise as a result of the elimination of deficiency judgments, they will tighten their lending standards by lending to less risky people, lending smaller amount of loans, or lending at higher mortgage rates. Borrowers, on the other hand, may decide to apply for mortgages when they otherwise would not habe, or apply for larger loans, if they do not risk their other assets in the event of being foreclosed.

Based on this simple theory, we seek to test several hypothesis. First, are lenders less willing to lend, lend a smaller amount, or lend at higher rates to primary single family purchase mortgage loans after October 2009? Second, do borrowers apply for more and/or larger primary single family purchase mortgage loans after October 2009? Finally, are single family primary mortgage loans made after October 2009 more likely to become delinquent than single family loans made earlier? Are lenders less likely to foreclose on a single family property with loans originated after October 2009 than other loans?

1.3 Data and Empirical Methodologies

1.3.1 Data and Data Sampling

We use two main data sets. The first is data collected in accordance with the Home Mortgage Disclosure Act (HMDA), covering almost all mortgage applications as well as originations in US. It records each applicant's final status (denied/approved/originated), purpose of borrowing (home purchase/refinancing/home improvement), occupancy type (primary residence/second or investment homes), loan amount, race, sex, income, as well as lender institution.[5] HMDA is available through the Federal Financial Institutions Examination Council (FFIEC).

The second dataset is the LPS Applied Analytics, Inc. data, which provides information from homeowners' mortgage applications concerning their financial situation, characteristics of the property, terms of the mortgage contract, and information about securitization, plus updates on whether homeowners paid in full or defaulted, whether lenders started foreclosure and whether the home was sold in foreclosure. LPS covers some two-thirds of installment-type loans in the residential mortgage servicing market for the post-2005 period that we are analyzing. LPS is a proprietary dataset purchased by the Federal Reserve System.

Both data are then merged with county level monthly unemployment rates obtained from the Bureau of Labor Statistics and monthly zip code level house price index available from CoreLogic. When the zip code house price index is not available due to low transaction volume, we substitute with the county level house price

[5] Only lenders who doe not do business in any metropolitan statistical area are not required report (e.g., small community banks) to HMDA.

index; in case the county level house price index is not available either, we use the Nevada state house price index.

We use HMDA to examine lenders' mortgage loan approval decision and mortgage loan size decision, and to detect whether there is any changes in mortgage applications for the affected mortgages after the implementation of the new deficiency judgment law. As our benchmark, we restrict the sample to first lien mortgages made in Nevada for one-to-four family properties around October 2009 – six months before and after, as well as one year before and after.[6] We delete those applications that are withdrawn without an approval decision or closed for incompleteness. We also drop all loans insured by Federal Housing Administration (FHA), Veterans Administration (VA) or Farmers Home Administration (FmHa) because deficiency judgments are prohibited on FHA loans and strongly discouraged on VA and FmHa loans. We also drop mortgage loans with private mortgage insurance as in Ghent and Kudlyak (2009) and loans for manufacturing housing.

We use LPS to analyze lenders' interest rate decision conditional on mortgage loan approval, borrowers' default behavior, and lenders' foreclosure decision. We focus on first lien mortgages for single family properties made in Nevada around October 2009 and follow the performance of these loans till the end of 2012. As with the HMDA data, we delete from the sample loans insured by the government including FHA, VA, and FmHa and loans with private mortgage insurance.

[6] HMDA does not distinguish single family properties from two-to-four family properties.

1.3.2 Empirical Methodology

We use various regression techniques to study the impact of the deficiency law change in Nevada on lenders as well as borrowers' behavior. As mentioned earlier, mortgage loan application approval decision and mortgage loan size come from HMDA. For the hypothesis regarding borrowers' mortgage application decision, we aggregate the data to the county level and by purpose of the loan – whether the loan is for purchase or refinance. We measure borrowers' default behavior by becoming for the first time 60 days or more delinquent, and 90 days or more delinquent as reported by LPS. The measurement of foreclosure decision comes from the same source. Note that foreclosure is a legal process in which a lender attempts to recover the balance of a loan from a borrower who has stopped making payments to the lender by forcing the sale of the asset used as the collateral for the loan. We thus treat foreclosure as a lender's decision rather than a borrower's. Mortgage interest rate at origination also comes from LPS.

Our identification comes from the interaction of two terms, whether the loan is a purchase loan for single family homes and whether the loan is made after October 2009. We construct a binary variable Z_{it} that acts as a treatment indicator for loan i in year t, according to the following rule, where the function $m(i)$ gives the type of mortgage i, and where t^* is October 2009.

$$Z_{it} = \begin{cases} 1 & \text{if } m(i) = \text{primary and } t \geq t^* \\ 0 & \text{else} \end{cases} \tag{1.1}$$

This setup implies that our control group is a composite of primary mortgages taken out before t^*, and other mortgage types taken out over the entire period. Recall that only mortgages of type *primary* are affected by the law change. In the baseline version of the model, we only consider refinance mortgages as *other* mortgage types.[7]

A generic regression in our analysis then takes the following form,

$$y_{it} = \alpha Z_{it} + \beta X_{it} + \varepsilon_{it}, \tag{1.2}$$

where y_{it} is the outcome variable of interest, Z_{it} is the treatment indicator discussed above, and X_{it} is a vector of control variables. For the HMDA data, X_{it} includes the gender of the applicant, race, income, whether the applicant comes from an area with 30 percent or more minorities, whether the lender is a commercial bank or its subsidiary, independent mortgage bank, thrift, or credit union. When we aggregate the data to test for trend in mortgage application, we can no longer control for any mortgage loan level or applicant level information. Instead, X_{it} will include county unemployment rates and zip code house price growth rates. For the LPS data, it includes borrowers' credit score at origination and mortgage loan contract information such as mortgage loan age, loan to value ratio at origination, whether the loan has full documentation, of fixed interest rate, the level of the current interest rate, and whether the loan is sold to private investors.[8] For tests on mortgage lending and mortgage default, we further control for county fixed effects, monthly time fixed effects, and separate linear time trends from each county. The tests on mortgage

[7] Given rich information contained in the data, we will conduct robustness analysis using other information such as primary versus investment purchase loans as identification.

[8] We observe virtually no subprime loans, and very few interest only and balloon mortgage loans during our sample period.

demand, due to limited sample size after aggregation, include county fixed effects, a linear time trend and its square. Finally, we cluster standard errors at the loan level.

We use ordinary least square regressions (OLS) when the dependent variable y_{it} is continuous and Probit regression when the dependent variable is binary. When testing for mortgage loan size, we use Tobit analysis because the data are censored in the sense that rejected loans effectively have zero loan amount. As an alternative, we also use Heckman's test to control for selection bias. Unfortunately, LPS does not include any rejected loans, we thus use OLS for our interest rate analysis.

1.4 Empirical Analysis

Our empirical analysis consists of three parts. First, we investigate how lenders respond to the deficiency law change in terms of mortgage loan approval rates, loan sizes, and interest rates. Then we examine whether borrowers respond to the law change with regard to loan applications. Finally, we study the relationship between changes in deficiency judgments and mortgage default and house foreclosure.

1.4.1 Mortgage Lending

We use three measures for lending standards: mortgage approval rates, approved mortgage loan sizes, and interest rates of approved mortgage loans. As discussed earlier, we use HMDA data for the analysis on approval rates and mortgage loan sizes and LPS data for the test on mortgage interest rates.

1.4.1.1 Descriptive Statistics

Table 1.1 reports summary statistics for the HMDA sample. For the six months before and after October 2009, there are in total 27,889 mortgages originated for one-to-four family primary residence with no government guarantee or private insurance. Of the 27,889 applications, 72 percent are for refinance. About 9 percent of the applications are affected by the change in deficiency judgments. The overall mortgage approval rate is 66 percent. About 70 percent of the applications are filed by male. Close to 80 percent of the applicants are white and a little over 2 percent are black. Nearly half of the applications have cosigners. There exists substantial income disparity among the applicants with the average (nominal) income at application at \$106,000 and the median income at \$73,000. The average loan amount is \$222,000 and the median is \$183,000. About 3 percent of the applicants live in areas with over 30 percent of the residents are minorities. The majority of the applications are filed at commercial banks (65 percent), followed by independent mortgage banks (19 percent), thrifts (9 percent), and credit unions (5 percent). Unemployment rates are high in all counties of Nevada with both mean and median at over 12 percent. House prices declined for most of the state during that period.

Table 1.2 reports summary statistics for the LPS sample. Between April 2009 and April 2010 excluding October 2009, 10,987 mortgage loans are made for first lien single family primary mortgages without government guarantees or private insurance. Note that this number is somewhat smaller than the 18,406 approved mortgage loans calculated from HMDA. This is because we delete from LPS sample mortgages with private insurance and 2-to-4 family mortgages while such information is not available in HMDA. Including these two categories add a little over 1,000 observations to the sample. The remaining differences comes from the imperfect coverage of LPS data of the Nevada market.

Of the 10,987 mortgages, 45 percent are for refinance. This number is substantially lower than the 72 percent at application indicating that mortgage approval rates are lower for refinance mortgages during that period. About 5 percent of the mortgages are affected by the law change. The mean interest rate at origination is 4.98 percent and the median is 4.88 percent and almost all of the mortgages are fixed-rate mortgages (over 98 percent). The mean credit score at origination is 717 and the median is 771.[9] About 41 percent of the mortgages have full documentation. A mere 2 percent are jumbo mortgages, 18 percent are sold to private investors. Finally, the unemployment rates are about 12.3 percent on average and almost all areas experience recent monthly house price decline of about 1 percentage point on average.

1.4.1.2 Results

Approval and Loan Size. We chart the raw data for mortgage approval rates and approved average mortgage loan sizes measured as deviations from their respective October 2009 values in figures 1.1 and 1.2. Figure 1.1 indicates that loan approval rates seem to be trending up for unaffected refinance loans while stayed more or less flat for affected purchase loans. For approved mortgage sizes, the pattern is less clear.

We conduct two analysis using HMDA. The first is a Probit analysis where the dependent variable takes the value of 1 if the loan is approved and zero otherwise.

[9] The credit score system used by LPS ranges from 300 to 850.

The second is a Tobit analysis where the dependent variable is the actual loan amount for approved loans and zero for rejected loans. We report the regression results in table 1.3. The key variable, one-to-four family purchase loans made after October 2009, contributes negatively and statistically significantly to lenders' approval rate as well as mortgage loan size upon approval. In particular, a one-to-four family mortgage purchase loan made after October 2009 has an approval rate that is 3.71 percentage points lower than that of a similar loan made earlier or a single family refinance loan, or 5.62 percent less likely to be approved and the loan size is $10,447, or 4.71 percent smaller after approval than loans not affected.

In terms of the other control variables, for approval rates, all else equal a refinance mortgage loan is about 19 percent less likely to be approved. This result is likely due to the fact that loans made earlier during housing booms are of lower standards and are thus less likely to be approved for refinance once lenders tighten their lending standards after the crisis. As expected, higher income increases the probability of being approved while higher loan amount reduces the probability of being approved. Specifically, a $1000 increase in income raises the approval rate by about 2 basis points while a $1000 increase in loan amount reduces the approval rate by about 3 basis points. Living in minority areas substantially lowers the approval rates. Non-white, female, and applicants without cosigners all have much lower mortgage approval rates. Lending institutions also affect loan approval rates. In particular, compared with specialized mortgage banks, commercial banks are less likely to approve mortgages while credit unions are more likely to approve.

In terms of loan size of approved mortgages, refinance loans are on average $66,000 smaller. Applicants with higher income borrow more with a $1000 increase in income corresponding to about $317 increase in loan size. Borrowers living in minority areas get smaller loans, as do non-white, female applicants, or applicants without cosigners. Compared with mortgage banks, commercial banks approve smaller loans while thrifts and credit unions giving out larger loans. Higher local unemployment rates reduce loan sizes.

Interest Rate To further investigate whether lenders lend at higher interest rates to borrowers affected by the change in the deficiency law, we run an ordinary least squares regression (OLS) using LPS for loans made between April 2009 and April 2010 excluding October 2009. The results are reported in table 1.4.

According to our analysis, interest rates on first lien single family primary purchase mortgage loans made after October 2009 are not statistically different from those made after October 2009 or first lien single family primary refinance mortgage loans. This could stem from our earlier results that the approved first lien single family purchase loans are already of relatively higher quality and relatively smaller size after October 2009.

For the other control variables, mortgage rates for refinance loans are, on average, about 11 basis points lower. An increase of 10 percentage points in mortgage loan-to-value ratio raises the interest rate by about 3 basis points. An increase of 10 in credit score, on the other hand, reduces the interest rate by about 2 basis points. Loans sold to private investors and loans with adjustable-rate mortgages all have lower interest rates but jumbo mortgages have higher interest rates. Finally, areas with high local unemployment rates also face higher mortgage interest rates.

1.4.1.3 Robustness Analysis

Approval Rate and Mortgage Loan Size To test the robustness of our results on mortgage loan approval rate and mortgage loan size, we conduct four additional analysis. First, we use the Heckman model to adjust for selection bias. Then we extend our sample to include loans made between October 2008 and October 2010, but excluding October 2009, exactly one year before and one year after the deficiency law change. As another exercise we include investment single family property loans as part of the control group for the primary single property purchase loans that are affected by the law change. Finally, we conduct two placebo tests, one assuming the law change occurred in April 2008 and the other assuming the law change occurred in April 2011. The results are reported in Table 5, where we display the value of the main coefficient of interest, "purchase loan made after reform ", for each model.

The Heckman model generates a much bigger effect on approval rates, a 10 percent reduction in approval rates, but the effect on loan size is roughly unchanged from the benchmark. Extending the benchmark sample to include loans made one year before October 2009 and one year after, on the other hand, produce much larger effects on both approval rates and approved mortgage loan sizes. Particularly, the approval rates are reduced by close to 9 percentage points and the loan size is reduced by about $\$24,000$. Including investment property loans does not change the benchmark results by nearly as much. Tests using the two placebo dates generate very different results from the benchmark. For both fake dates, the effects on both mortgage approval rates and mortgage loan sizes are statistically significant but have positive signs. All these experiments thus confirm that after the change in deficiency judgement law, lenders tightened their lending standards in terms of loan approval rates and loan size for affected borrowers.

Mortgage Interest Rate For mortgage interest rates, we conduct three robustness tests, extending the sample by including loans made one year before and one year after the deficiency law change, including investment properties, and including multifamily properties, respectively. The results are presented in Table 6.

Compared with the results on mortgage approval rates and mortgage loan sizes, the results on mortgage interest rates turn out to be less robust. Lenders actually reduce interest rates for affected mortgages in the longer sample regression and the regression including investment properties. These results are plausible because, as pointed out earlier, the new purchase loans made after October 2009 are of higher quality and small sizes.

1.4.2 Mortgage Application

In this subsection, we test mortgage applicant's behavior. Theory predicts that those that are affected by the change in the deficiency law should increase their demand for mortgages after the law change. Using the constructed HMDA sample, we calculate by month, county, and loan type (purchase versus refinance), the total number and value of mortgages made for one-to-four family houses. Figure 1.3 charts the demand in average loan sizes as deviations from its October 2009 level. As can be seen, compared with the average loan size of purchase mortgages, there is a downward trend in average refi loan sizes.

In our regression analysis, we regress the number of applications or the amount applied for on the key variable identifying loans that are affected by the law change, whether the loans are refinanced loans, average income of the MSA, the fraction of MSAs that have over 30 percent minorities, lagged average local unemployment rates, lagged average local house price growth rates, a time trend and its square, and, finally, county dummies.[10] The regression results are reported in table 1.3.

As can been seen, there does not appear to exist a structural break for loan applications for one-to-four primary purchase mortgage loans after October 2009 in terms of total number and dollar amount of mortgage applications and the average size of mortgage applications. Regarding other control variables, refi loans explain a large fraction of total loan demand. County dummies (not reported) that capture applicant as well as local characteristics beyond those already included in the regressions also play important roles

Robustness Analysis We conduct two additional robustness tests, expanding sample periods to one year before and after the law change and include loans for investment properties. According to the results reported in table 1.8, we do not detect any trend break in demand for single family primary purchase mortgages after October 2009.

1.4.3 Mortgage Default and House Foreclosure

This subsection seeks to test whether primary mortgage borrowers that borrowed after October 2009 are more likely to default and whether lenders are less willing to

[10]We chose not to have separate time dummies given the much smaller sample size.

foreclose on these borrowers. As before, the control groups are single family purchase loans made before October 2009 and single family refinance loans made during the whole sample period. We define defaults to be the first time that the loan becomes 60 days delinquent or 90 days delinquent, respectively. The foreclosure decision is defined as entering foreclosure process.

1.4.3.1 Descriptive Statistics

We use LPS for the default and foreclosure analysis. In particular,we focus on mortgage loans originated six months before and six months after the change in the deficiency judgment laws in October 2009 which spans April 2009 to April 2010 excluding October 2009. During this period, 10,987 mortgage loans were originated for owner-occupied primary home mortgages without mortgage insurance and by private mortgage lenders.

We follow these mortgage loans from the time of their origination to the first time the loan becomes 60 day, 90 day delinquent, enters into foreclosure, or reaches the end of the sample period December 2012. Table 9 reports the summary statistics for 60+ delinquency sample. In total, we have 343,120 observations. The monthly 60 day delinquency rate is 0.08 percent. The average loan age is 21 months and the median is 24 months. The mean mortgage loan-to-value ratio at origination is 68 percent with a median of 65 percent. The average credit score is 760, on the high end of the credit score range of 300 and 850. The monthly unemployment rate averages 13 percent while the monthly net house price growth rate averages about 0.0055 percent with large variances. The sample statistics for the 90 days delinquency and foreclosure sample are very similar except that the 90 day delinquency rate averages

0.04 percent monthly for the 90+ day delinquency sample and the foreclosure rate is 0.02 percent monthly for the foreclosure start sample. Figure 1.4 shows the cumulative 60-day delinquency rate for loans six months before and after the policy change, respectively.

1.4.3.2 Results

As discussed in the empirical methodologies, we run Probit regressions with the dependent variable being the binary variable that takes the value of 1 if the loan becomes delinquent or being foreclosed by the lender and 0 otherwise. We cluster standard errors at the loan level. Table 10 reports our regression results including marginal effects of each explanatory variable and its associated standard error.

The variable of interest, single family mortgage loans made after October 2009, is not statistically significant in any of the three regressions. During that period, refinance loans are more likely to become delinquent. The older the mortgage loan is, the more likely it becomes 60 days, 90 days delinquent or enters into foreclosure though the speed of the increase declines. As expected, mortgage loans with high mortgage loan-to-value ratios at origination are more likely to become delinquent or being foreclosed. Current interest rate as well as adjustable-rate-mortgage loans also contribute positively to default and foreclosure probabilities. By contrast, having high credit scores at origination reduces default as well as foreclosure probability. County, time fixed effects and separate county linear time trends are included in all three regressions.

1.4.3.3 Robustness Analysis

We conduct four additional analysis to test the robustness of our benchmark results. Specifically, we study loans that were made one year before and one year after the change in deficiency law; we look at subsamples where the appraised house value is above the median and where current mortgage loan-to-value ratio is above 90, respectively; and we include in the benchmark sample refinance loans for primary homes. The results on the key variable, primary purchase loans for single family homes made after October 2009 are reported in Table 11. As can be seen, none of the estimates are statistically significant for any of the default and foreclosure definition.

1.5 Conclusion

This paper studies whether the change in deficiency judgments in the state of Nevada had a measurable effect on mortgage lending and borrowing in addition to mortgage default and foreclosure. In doing so, the paper makes a contribution to several strands of the literature, all of which seek to understand the relationship between real estate laws and borrower and lender behavior. In contrast to some existing studies, the paper does not find any significant change in affected borrowers' mortgage default and lenders' foreclosure decisions. However, it does find strong evidence that lenders have tightened their lending standards substantially both in terms of loan approval rate and loan size though not on mortgage interest rates. It further reveals that there are no changes in mortgage applications from households.

The paper thus casts a cautionary notes on using deficiency judgments as a deterrence for mortgage default or mortgage foreclosure. While it does not dispute the finding that deficiency judgments may deter mortgage default, it argues that it may also has the side effect of discouraging mortgage lending. Further policy analysis requires more structural analysis which we pursue in a separate project.[11]

[11] See "Consumer Bankruptcy and Mortgage Default" by Wenli Li, Costas Meghir, and Florian Oswald.

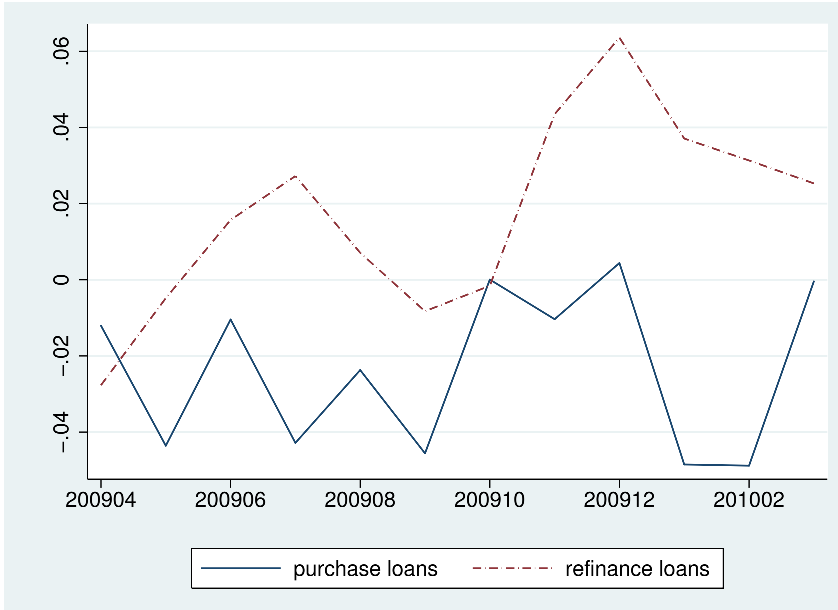

Figure 1.1: Relative difference of mortgage approval rates for primary and refi loans to their October 2009 level. HMDA data.

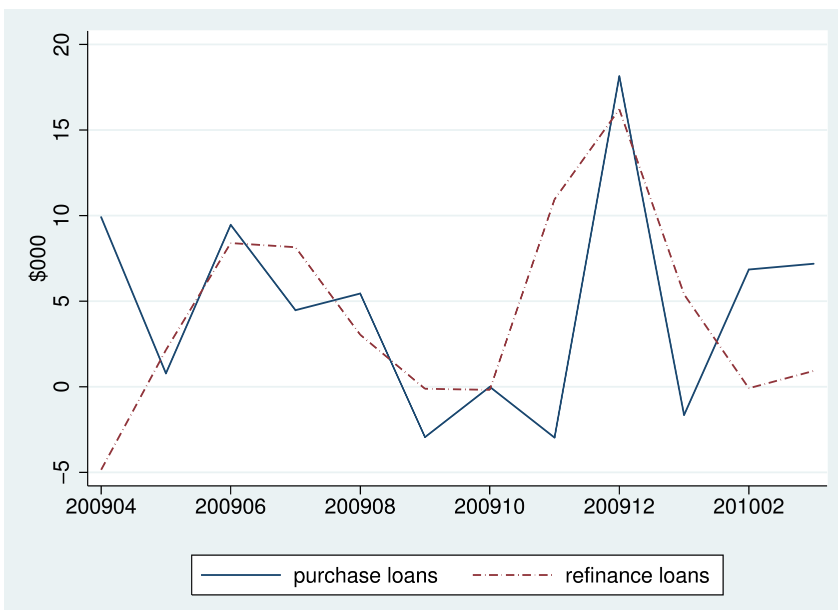

Figure 1.2: Relative difference of mortgage sizes for primary and refi loans to their October 2009 level. HMDA data.

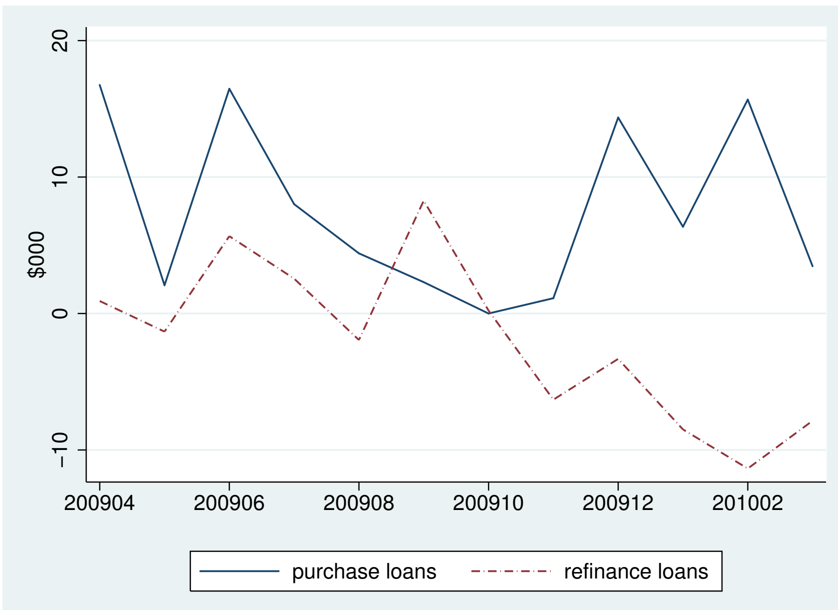

Figure 1.3: Average difference in the value of mortgage loans applied for. Primary and refi loans, relative difference to their October 2009 level. HMDA data.

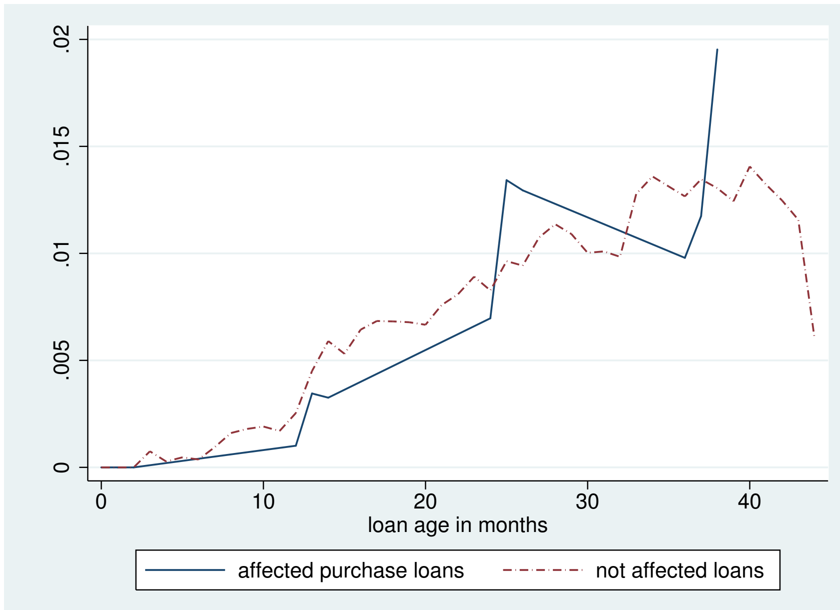

Figure 1.4: Cumulative 60 Days or more Delinquency Rates for Loans Made 6 months before and after october 2009. Affected loans include single family purchase loans for primary residence made after October 2009; not affected loans include single family purchase loans for primary residence before October 2009 and single family refi loans for primary residence. Source: LPS Applied Analytics.)

	mean	std. deviation
approval rate*	0.6594	0.4739
refinanced mortgage loans*	0.7159	0.4510
loans affected by law changes*	0.0878	0.2831
female*	0.2733	0.4456
gender unknown*	0.0682	0.2520
race: black*	0.0229	0.1495
race: non-white and non-black*	0.0886	0.2842
race: unknown*	0.1157	0.3199
no cosigner*	0.4711	0.4992
income ($ thousands)	106.4254	191.4229
loan amount ($ thousands)	222.0114	200.2909
living in area with 30% or more minorities*	0.0262	0.1596
lender: commercial bank and their subsidiaries*	0.6463	0.4781
lender: independent mortgage banks*	0.1911	0.3932
lender: thrifts*	0.0906	0.2870
lender: credit unions*	0.0527	0.2234
lagged local unemployment rate (%)	12.0379	1.5494
lagged net local house price growth rate	-0.0032	0.1195
Total number of observations	27,889	

Table 1.1: HMDA Sample Summary Statistics. Stars indicate a binary variable that takes the value 1 if an observation belongs to the category.

	mean	std. deviation
refinance mortgage loans*	0.4493	0.4974
loans affected by the law change*	0.0473	0.2122
current interest rate	4.9805	0.4506
mortgage loan-to-value ratio at origination	66.4874	22.0924
credit score at origination	717	182
full document*	0.4059	0.4910
jumbo loan*	0.0198	0.1392
loan sold to private investor*	0.1844	0.3878
adjustable-rate mortgage*	0.0179	0.1328
lagged local unemployment rate	12.3008	1.7558
lagged gross local real house price growth rate	-0.0007	0.1171
Total number of mortgage loans	10,987	

Table 1.2: LPS Summary Statistics: Purchase or refinance loans for owner-occupied single family housing originated between April 2009 and April 2010 excluding October 2009. These loans are not government guaranteed. Stars indicate a binary variable that takes the value 1 if an observation belongs to the category.

	Mortgage Approval		Mortgage Loan Size	
	marginal effects	s.e.	coefficient	s.e.
purchase loans made after reform	-0.0371***	0.0135	-10.4465***	3.2977
refinance loan	-0.1897***	0.0062	-66.0726***	3.4139
income at origination ($ 1000)	1.60e-04***	2.67e-05	0.3172***	0.0112
loan amount ($ 1000)	-2.87e-04***	2.24e-05		
MSA with over 30% minorities	-0.2496***	0.0061	-132.3559***	6.7045
being black	-0.1089***	0.0051	-45.7309***	2.4109
being non-white and non-black	-0.0681***	0.0047	-25.8185***	2.2543
race unknown	-0.0796***	0.0034	-25.5976***	3.2223
female	-0.0173	0.0154	-18.6823***	4.6003
gender unknown	0.0402***	0.0086	28.5598***	3.7594
no cosigner	-0.0594***	0.0037	-36.0006***	1.9352
lender: commercial bank	-0.0245***	0.0057	-8.9606***	1.9501
lender: thrift	-0.0115	0.0109	18.7221***	2.6794
lender: credit union	0.1258***	0.0153	15.3800***	3.2681
lagged monthly unemp. rate	0.0358	0.0306	-15.9427***	5.8650
lagged hpi growth rate	-0.0068	0.0197	-31.2756***	7.8177
linear county time trends	yes		yes	
county fixed effects	yes		yes	
time fixed effects	yes		yes	
Pseudo R-square	0.1325		0.0206	
number of observations	27,889		27,889	

Table 1.3: HMDA Benchmark Mortgage Lending: The first column shows probit marginal effects for mortgage approvals with associated standard erros and the third column shows tobit coefficients for loan sizes. * indicates statistical significance at 10 %, ** 5 %, and *** at 1 % level.

	interest rate at origination	
	coefficient	s.e.
purchase loan made after reform	-0.0398	0.0260
refinance loan	-0.1072***	0.0099
loan-to-value ratio at origination	0.0027***	0.0002
credit score at origination	-0.0018***	0.0001
full document	0.0108	0.0103
private investor	-0.0527***	0.0132
jumbo mortgage	0.4600***	0.0631
adjustable rate mortgage	-0.8055***	0.0402
lagged monthly unemployment rate	0.0573***	0.0150
lagged real hpi growth rate	0.0321	0.0352
linear county time trend	yes	
county fixed effects	yes	
time fixed effects	yes	
R-squared	0.1934	
number of observations	10,987	

Table 1.4: LPS Benchmark Mortgage Lending

	Purchase Loan after reform: Z_{it}	
	Mortgage Approval	Loan size ($)
Baseline Model	-0.0371***	-10.4465***
Heckman Model	-0.1012***	-10.8093**
loans originated: October 2008 – October 2010	-0.0870***	-24.1974***
include investment loans	-0.0566***	-10.1488***
placebo law change date: April 2008	0.1062***	52.4968***
placebo law change date: April 2011	0.0687***	63.4501***

Table 1.5: HMDA Robustness Analysis for Mortgage Lending: We display the value of the main coefficient of interest, i.e. purchase loan made after reform, in both equations for loan approval rates as well as for loan sizes. Each row shows the result for a different extension of the baseline model.

	Interest rate (%)	
	coefficient	s.d.
loans originated: October 2008 – October 2010	-0.0684*	0.0353
include investment properties	-0.1270***	0.0250
include multifamily properties	-0.0328	0.0255

Table 1.6: LPS Mortgage Lending Robustness Analysis for Interest Rates.

	#applications	amount ($1000)	Average loan size
purchase loans made after reform	55.8642	13107.88	2.3620
refinance loans	113.4092***	27813.71***	16.4886
average income of the MSA	-0.0463	-13.3958	-0.01300
MSA with over 30% minorities	-264.1975	-72401.97	-175.8475
lagged unemployment rate	5.7299	1239.245	6.7488
lagged house price growth rate	-24.2818	-2485.247	-6.0640
time trend	0.2149	-1644.464	-23.4374
time trend squared	-0.3734	-41.6182	0.5207
county dummies included	yes	yes	yes
Adjusted R-squared	0.6693	0.6479	0.3725
number of observations	295	295	295

Table 1.7: HMDA mortgage applications and loan sizes in the benchmark specification.

	# loan applications		loan amount ($1000)		Average loan size	
sample	coefficient	s.e.	coefficient	s.e.	coefficient	s.e.
loan application: 200810 – 201010	19.3580	22.1870	4481.328	5140.752	3.6045	9.0657
include investment properties	33.3558	27.3476	7709.468	6304.198	3.1862	13.2608

Table 1.8: Mortgage Applications – Robustness Analysis (HMDA)

	mean	median	standard deviation
60 day mortgage delinquency rate	0.00082	0	0.0286
age of the loan (months)	20.5853	24	11.6763
mortgage loan-to-value ratio at origination	67.8904	65.44	18.0439
refi mortgage*	0.6356	1	0.4813
loans affected by the law change*	0.0550	0	0.3289
current interest rate	4.9543	4.8750	0.4645
credit score at origination	760	773	44
full document*	0.5251	1	0.4994
jumbo loan*	0.0184	0	0.1344
loan sold to private investor*	0.0232	0	0.1505
adjustable-rate mortgage*	0.0170	0	0.1293
lagged local unemployment rate	12.8822	13.1000	1.7929
lagged local house price growth rate	0.0050	-0.0044	0.1392
Total number of mortgage loans	10,987		
Total number of observations	343,120		

Table 1.9: Dynamic LPS Summary Statistics: Purchase loans for owner-occupied housing originated between April 2009 and April 2010 excluding October 2009 and followed until the loan first becomes 60 days delinquent or the end of the sample period, December 2012. These loans are not government guaranteed and with no private mortgage insurance. * indicates dummy variables.

	60 days delinquent	90 days delinquent	Foreclosure start
purchase loans made after reform	3.47e-05	2.35e-06	6.05e-07
refi loans	1.12e-04***	6.01e-06***	3.21e-06***
loan age (months)	3.01e-05***	1.36e-06***	7.79e-07***
loan age squared	-3.94e-07***	-1.51e-07***	-1.07e-08***
loan-to-value ratio at origination	5.77e-06***	3.34e-07***	1.97e-07***
credit score at origination	-1.86e-06***	-6.81e-08***	-2.61e-08***
current interest rate	8.87e-05***	4.49e-06***	1.84e-06***
full document	5.12e-05**	2.21e-06*	6.96e-07
private investor	3.90e-05	-1.82e-06	-7.00e-07
jumbo mortgage	-1.04e-04		
adjustable rate mortgage	3.13e-04***	2.54e-05***	2.19e-05***
lagged monthly unemployment rate	2.13e-05	5.81e-07	-1.64e-07
lagged real hpi growth rate	6.76e-06	2.05e-07	5.39e-07
county fixed effects	yes	yes	yes
time fixed effects	yes	yes	yes
county time trends	yes	yes	yes
Pseudo R-squared	0.1133	0.1405	0.1636
number of observations	343,120	344,836	344,890

Table 1.10: Marginal effect estimates for Mortgage Default and Foreclosure start outcomes. These are loans originated between 200904 to 201004. Dummies for interest only and balloon loans predict 90 days delinquency perfectly and are not included in the regression. The dummy for jumbo loans predicts foreclosure probability perfectly and are not included in the 90 days delinquency and the foreclosure regressions.

	60 days delinquent	90 days delinquent	Foreclosure start
originated: Oct. 2008 - Oct. 2010	-8.3-e05	-6.65e-06	-3.57e-06
house value above the mean	9.73e-05	-3.80e-07	2.49e-06
mortgage ltv above 100	3.76e-04	-3.13e-05	-6.96e-06
benchmark + investment loans	1.89e-05	1.46e-05	1.22e-07

Table 1.11: Robustness Analysis for Mortgage Default and Foreclosure starts. None of the estimated coefficients is significant.

Chapter 2

Consumer Bankruptcy and Mortgage Default

2.1 Introduction

A number of countries, inluding the US and the UK have legislation that defines the way bankruptcy is to be treated. Such legislation is an attempt to balance the legitimate rights of creditors with the need to offer some level of insurance for adverse events. Different legislation governs defaults on secured and unsecured debt and interestingly such legislation varies widely across states in the US and across countries. For example the extent to which housing equity can be used to repay outstanding debts following default on unsecured debts varies widely from 0% to nearly the entire level of housing equity. On the other side the extent to which non-housing assets can be used to repay debts following mortgage default is also regulated by legislation. Finally, the way debts are handled can also be means tested. For example, following a recent reform, only lower income people can file for chapter 7 in the US, while individuals with above median earnings must file for chapter 13.

Such legislation can have important welfare effects for a number of reasons. On the one hand, it limits to varying degrees the impact of adverse shocks on lifetime consumption. This will increase welfare. On the other, such policies will cause adverse welfare effects because they may induce greater risk taking, which in turn may lead individuals to file for bankruptcy when in principle they could repay debts (albeit at the cost of very low consumption for extended periods of time), and possibly reduce the incentive to work for accumulating assets; it will also tend to increase interest rates for both unsecured and to some extent secured debt, as the interest will have to cover the expected losses by creditors. Finally the way that debts may be partially recovered can also have important welfare implications. For example wage garnishing following filing for chapter 13 can reduce the incentive to work.

In this paper we specify and estimate a microeconomic life-cycle model of non-durable consumption, housing and labor supply allowing for both bankruptcy and mortgage default so as to understand the effects of legislation governing such events. In our model individuals can choose to buy or rent a house, the amount of liquid assets they wish to accumulate and their labor supply. At each point in time they can decide to either file for bankruptcy or default on their mortgage; this decision is made in view of the benefits that such actions will have for them under the specific institutional context that they are facing. So as to capture the effects of bankruptcy on the pricing of credit we allow the interest rate on unsecured debt to depend on the probability of bankruptcy, which will depend on the state describing the individual circumstances and on the specific legislative framework.

Our model is estimated using data from the period 2006-2010, which coincided with the enactment of both an important reform in the US bankruptcy code (BAPCPA) and the collapse of the housing market in 2007. The bankrutpcy reform in essence mandates that individuals with earnings above the state median are only eligible to file for bankruptcy chapter 13 of the bankruptcy code. This arrangement embodies in most cases a debt restructuring whereby debtors agree to make repayments to creditors according to a schedule drawn up by a bankruptcy judge. Often this takes the form of a wage garnishment, i.e. the debtor delivers part of monthly income to the creditor. Given that the alternative, chapter 7, does not require such payments, there may be an incentive to reduce labor supply for individuals with incomes near the state median, conditional on other aspects of their balance sheet, which we will explain below.

Our estimation approach relies on house price processes, bankruptcy and mortgage default rates at the county level in the US which is based on microeconomic data recording all loan and mortgage activity as well as bankruptcies. Combining such data together with information from the census allows us to estimate a rich model of individual consumption and labor supply behavior allowing for differences across education groups.

The model can be used to assess the effects of policy reforms such as BAPCPA, as well as address the tradeoffs involved in more or less consumer protection for example we could answer the question of what would have happened over the course of the last couple of years had the reform not been enacted. To be able to do so, we rely on a representation of the economy that takes into account local variation in house prices and bankrutpcy and default rates. We provide empirical evidence that local economic conditions over and above state legal arrangements matter for the determination of bankruptcy and default rates.

There has been a lot of interest in homestead exemption levels and how they affect the rate of bankrutpcy. Convincing evidence is hard to come by, mainly because there is little variation in legal arrangements concerning bankruptcy over time, and the rate itself is an equilibrium outcome. As in the most typical example of identifying demand and supply curves of Working (1927), it is difficult to identify a causal effect of homestead exemption on bankruptcy, because the supply of credit may be restricted in areas where the incentives to file are relatively large (i.e. high exemption), so that only good quality borrowers obtain credit, and therefore the higher incentives for bankruptcy are counterbalanced by a better quality pool of risks. An incomplete list of examples of this literature might include Pavan (2008), who investigates the effect of exemption levels on bankruptcy and durable purchases and finds that exactly this is happening, i.e. welfare gains from greater insurance are cancelled out by losses due to tighter credit constraints. Her conclusion is opposed to the one of Hintermaier and Königer (2009), who find that the stock of durables has little impact on the pricing of, and thus access to, unsecured borrowing in a calibrated model. In terms of empirical contributions, Gropp et al. (1997) find, using SCF data, that all else equal borrowers in high exemption states are significantly more likely to have a loan application rejected. Fay et al. (2002) use PSID panel data to investigate the determinants of consumer bankruptcy, but they cannot examine exemption levels as they include a state fixed effect. Traczynski (2011) examines how different exemption levels may lead to different incentives for couples to divorce, relying on within state variation of exemption levels.

In terms of wider placement within the literature on consumer bankruptcy, this paper adds the housing and mortgage default dimension to the common framework of dynamic bankruptcy analysis. This framework relies on an extension of an Aiyagari (1994)-type economy which extends the way in which borrowing is possible. While in Aiyagari (1994) the assumption is that borrowing is allowed up to an amount the consumer can repay with probability one (typically this is the present discount value of lowest possible income for the rest of his life), thereby of course precluding non-repayment of debts, in this type of models non-repayment of debts is made possible by the bankruptcy law, which bounds the losses that a consumer can incur: the offered insurance then leads to moral hazard and it is this tradeoff that we eplore in this paper. The possibility of non-repayment leads banks to offer interest rates for unsecured borrowing which is based on an individual's probability of repayment of the loan. The theoretical foundation of this is laid out in Chatterjee et al. (2007), examples of applications to different aspects of risk-sharing and welfare implications are Athreya (2008), which examines the interaction of bankruptcy with social insurance, and Livshits et al. (2007), who calibrate a life-cycle model to investigate welfare differences of different bankruptcy schemes. This last contribution is close in spirit to the present paper, the difference being that here we augment the set of shocks the consumer is subject to assets they may hold. This set comprises income shocks, health shocks, and family shocks (divorce or children). See Sullivan et al. (1999) pp. 128 for another account for the importance of housing shocks as drivers of bankruptcy.

The closest paper to ours is the one by Mitman (2011) who also considers a model of consumption and housing with bankruptcy and default. However our model differs in a number of substantive ways. First, our model allows for labor supply; this is important both because by varying labor supply one can change the probability of bankruptcy and because it allows us to deal with post-bankruptcy wage garninshing when this is relevant; the anticipation of such an event can initself change behaviour limiting bankruptcy. Thus second, individuals with above median income do not have the bankruptcy option in Mitman's model. In ours they do and they have to file for chapter 13. The fact that we allow for endogenous labor supply allows us to deal with this important difference and offer a richer evaluation of the actual policy framework. Beyond these major modelling differences our model includes a more realistic long-term mortgage contract. From an estimation point of view, beyond the fact that we rely on detailed microeconomic data we use the observed house price process as opposed to Mitman who calibrates the houseprice shocks to obtain the desired level of defaults. Finally the housing market has more frictions in our model. In that dimension, our model is much closer to Attanasio et al. (2012)

In the next section we present some descriptive facts about bankruptcy, default and the instituional context. We then describe our model. We then discuss our data and the estimation approach. We then discus the estimation results and present the policy implications of our model.

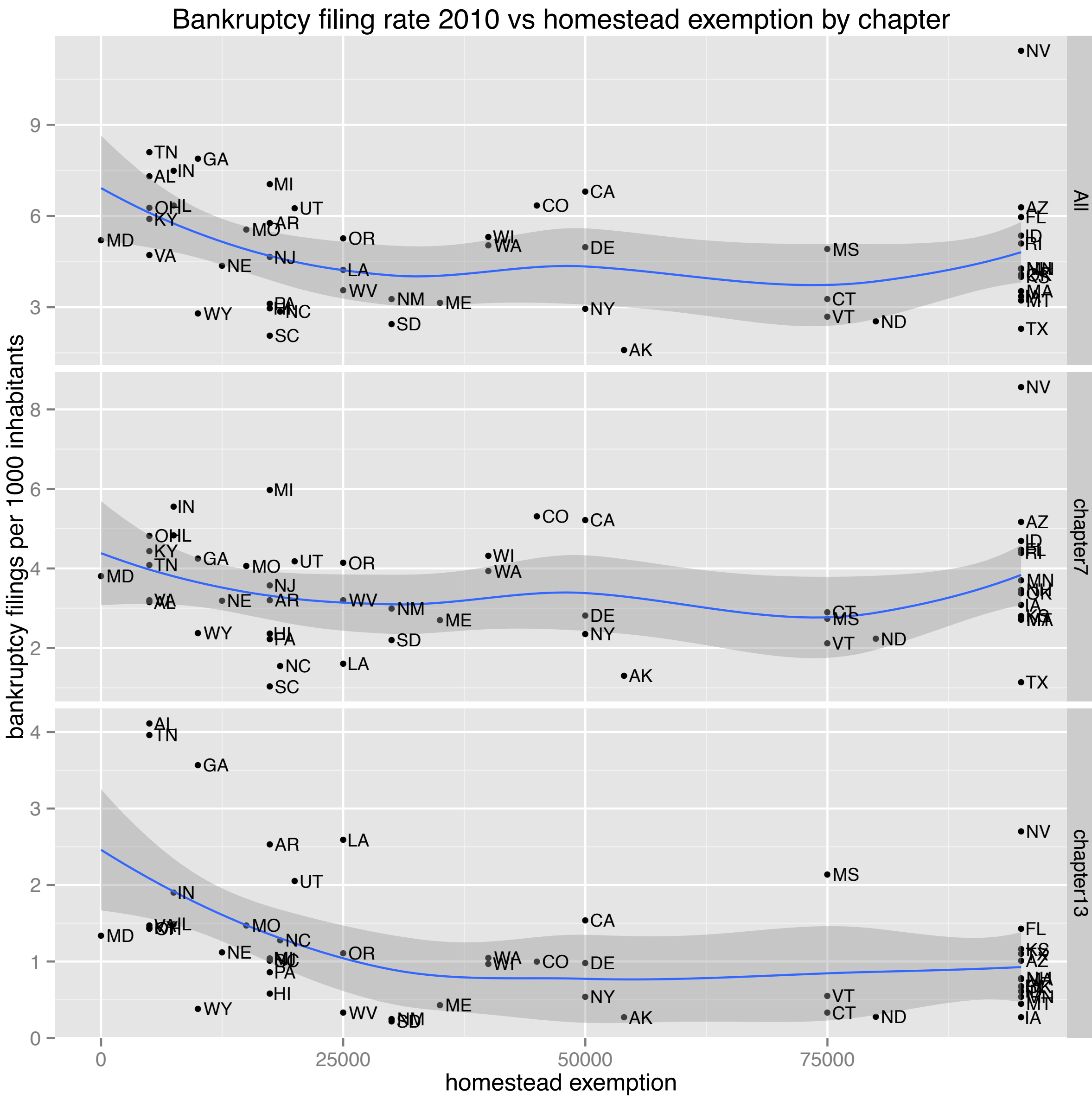

Figure 2.1: Homestead exemption vs Bankrutpcy rate. Homestead exemption values are top-coded at the 75% percentile ($91250). Blue line is a polynomial smoother with 95% confidence interval. Data: http://www.uscourts.gov/Statistics/BankruptcyStatistics/ and http://economics.sas.upenn.edu/~mitmanke/MitmanJMP.pdf

2.2 Some Descriptive Facts

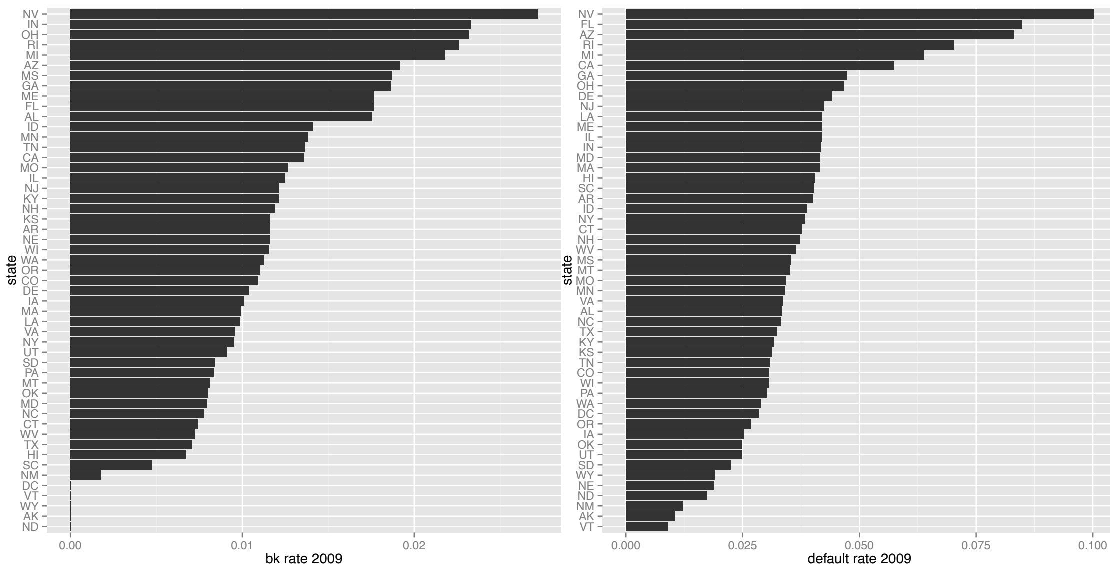

Figure 2.2: Bankruptcy and Default rates by state in 2009. Calculated as proportion of total individuals who take either choice.

A snapshot of bankruptcy and default rates are displayed in figure 2.2. Recent trends are shown in figure 2.3. Notice the spike in bankruptcies in 2005 which corresponds to the introduction of the "Bankruptcy Abuse Prevention and Consumer Protection Act" (BAPCPA), which led to a final rush before the rules changed.

Consider the regression (2.1), where we use data from the NYFed consumer credit report in conjunction with information on state ownership rates, the legal environment concering homestead exemption and recourse (recorded as to whether it is possible for the lender to obtain a deficiency judgment against delinquent borrowers), and on the fraction of state j's population filing for a new bankruptcy in quarter t, measured in percent.

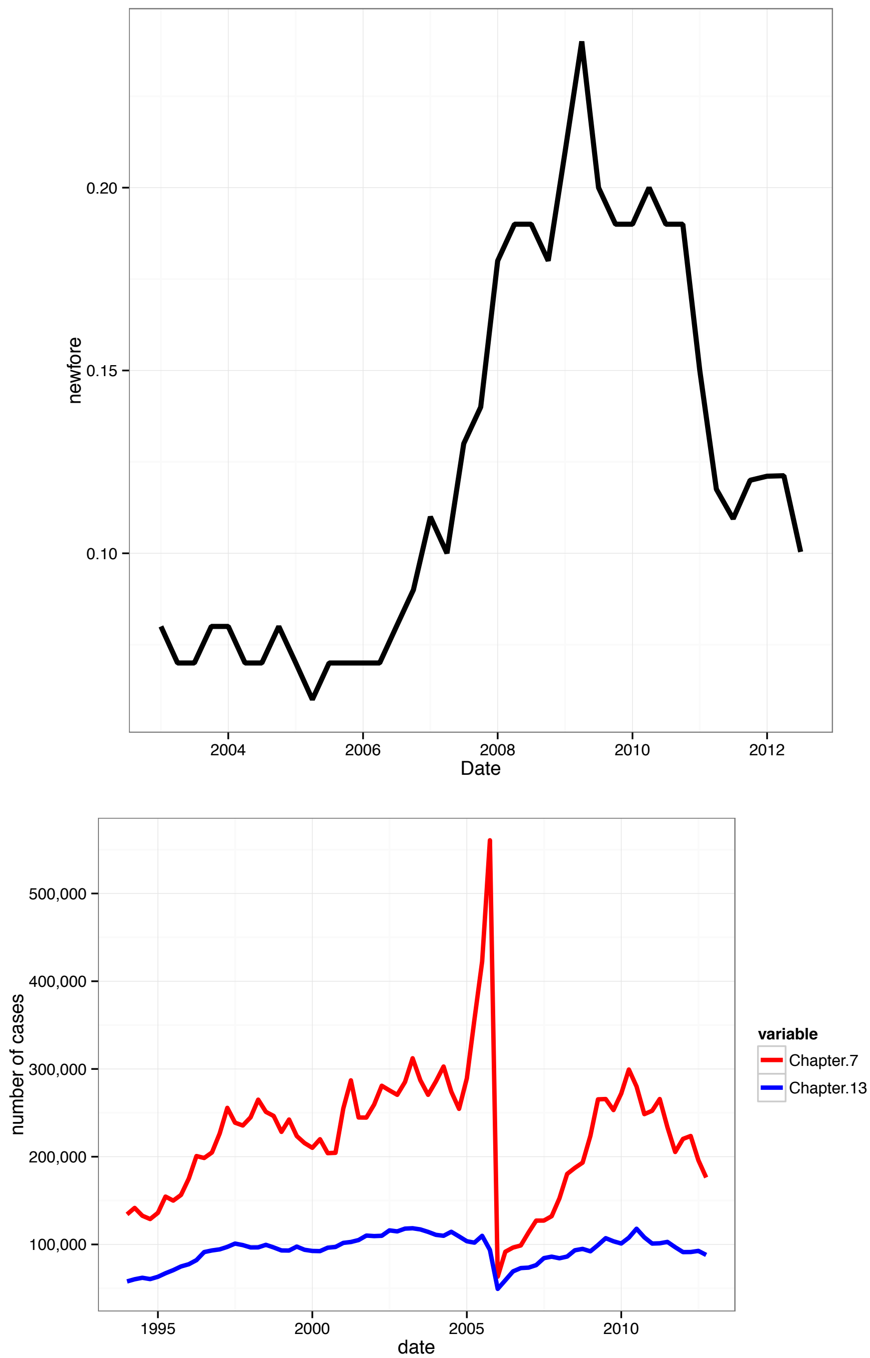

Figure 2.3: Trends in bankruptcy and default. The top panel shows shows the percentage of total population with a new foreclosure by quarter, available at http://www.newyorkfed.org/householdcredit/. The bottom panel shows data from the American Bankruptcy Institute, where per capita rates are computed using the population count from the US census. The spike in chapter 7 bankrutpcy in 2005 corresponds to the introduction of the BAPCPA reform.

$$
\begin{aligned}
newbk_{jt} &= \underset{(0.079)}{0.33} + \underset{(0.0024)}{0.0077}\text{unemployment}_{jt} - \underset{(0.00005)}{0.00035}\, p_{j,t-1} \\
&+ \underset{(0.037)}{0.24}\,\text{lagged newforeclosures}_j - \underset{(0.0009)}{0.0016}\text{ownership rate}_j + \underset{(0.013)}{0.024}\text{Recourse}_j \\
&+ \underset{(0.000037)}{0.00008}(\text{Homestead Exemption}_j/1000) - \underset{(0.0134)}{0.0807}\text{unlimited exemption}_j + u_{jt} \qquad (2.1)
\end{aligned}
$$

where p_{jt} is the house price index. From the above, we see that recourse legislation is positively related to new bankruptcies at the 10% significance level. Unlimited homestead exemption is significantly *negatively* associated with bankruptcy. All else equal, states with unlimited homestead exemption have 0.08% fewer consumers entering bankruptcy per quarter than states with a limit – if compared to the sample median of 0.17%, that is about half as much. This phenomenon could be explained by credit rationing and composition effects, whereby creditors in states with higher exemption are more selective, because incentives for bankruptcy are relatively strong. This has been shown for example in Gropp et al. (1997). However, these results show that relying on cross-sectional variation in institutional arrangements in itself does not provide a valid source of variation for estimating the model.

In terms of elasticities at the sample median for the regressors as shown in table 2.1, we see that a 1% decrease in the lagged house price index is associated with a 0.75% increase in the percentage of consumers with new bankruptcies. This is a sizeable effect, if compared to the elasticity associated with homestead exemption, which implies a 0.01% increase in new bankruptcies if exemptions are increased by 1% from the sample median. It appears that there are channels from house price risk to default on unsecured credit, i.e. bankruptcy. One could for example think that homeowners who are subject to a house price shock and at the same time are liquidity constrained could use the bankruptcy option to losen their budget constraint, so that they can keep current on their mortgage. Another possibility arises from the interaction between recourse law and bankruptcy. It could for example be that owners in foreclosure use bankruptcy to discharge any remaining debt which would be carried forward in case the lender had recourse. The elasticity of lagged foreclosures in table 2.1 indicates that increasing new foreclosures by 1% from it's median would result in a 0.17% increase of new bankruptcies in the following quarter.

variable	median	sd	elasticity
newbk	0.17	0.11	
unemp	6.23	1.91	0.28
Lhpi	367.86	126.27	-0.75
Lnewfore	0.12	0.16	0.17
own.rate	68.50	6.29	-0.62
hex	17425.00	154888.70	0.01
DeficiencyYes	0.82	0.39	0.11
ultdTRUE	0.18	0.39	-0.08

Table 2.1: Elasticites of estimates from regression (2.1), calculated at the sample median of the respective variables.

2.2.1 Regional Environments: Laws and Prices

In this section we compare different legal systems of US states and the properties of their house price processes. In our model we do not solve for the equilibrium houseing price, which is byond the scope of this paper. However we condition on an empirically estimated stochastic process: we assume that the log house price of state j evolves according to a random walk.[1]

$$\begin{aligned} p_{jt} &= p_{jt-1} + u_{jt} \\ u_{jt} &\sim N(0, \sigma_u^2) \end{aligned} \tag{2.2}$$

We report results for a series of states on the value of standard deviation of u_{jt} in conjunction with data on legal environment and bankruptcy rates in table 2.2. As is well known, the standard deviation of u in this context expresses the volatility in percentage changes of the price process. Two things transpire from this. First, the house price volatility is enormous. Second, volatility differs substantially across regions of the US. The table also summarizes the differences in the institutional framework and in the bankruptcy rates across states.

[1] We assume away any drift in the random walk process for the sake of simplicity. It would be straightforward to add.

State	Deficiency	hex.fraction	bk.rate	sigma
NC	No	0.42	0.26	3.56
WA	No	0.66	0.42	7.30
CA	No	0.81	0.41	11.44
AZ	No	2.88	0.39	13.30
MN	No	3.19	0.30	7.41
OH	Yes	0.10	0.48	3.89
IL	Yes	0.14	0.45	6.69
GA	Yes	0.18	0.63	5.85
MI	Yes	0.32	0.40	8.21
OR	Yes	0.48	0.45	7.22
CO	Yes	0.72	0.42	5.27
NY	Yes	0.93	0.27	7.32
MA	Yes	1.62	0.24	6.76
NV	Yes	9.43	0.57	13.42
FL	Yes		0.37	10.29
TX	Yes		0.26	2.70
Comp10				8.75
Comp20				10.61
DC				9.40

Table 2.2: House Prices and Homestead Exemption. Bankruptcy rates are averages over the period 1987–2012, expressed in percent. "hex.fraction" is homestead exemption over state median income. Column *sigma* corresponds to model (2.2), using Case-Shiller data 1987–2012. (sigma is in percent).

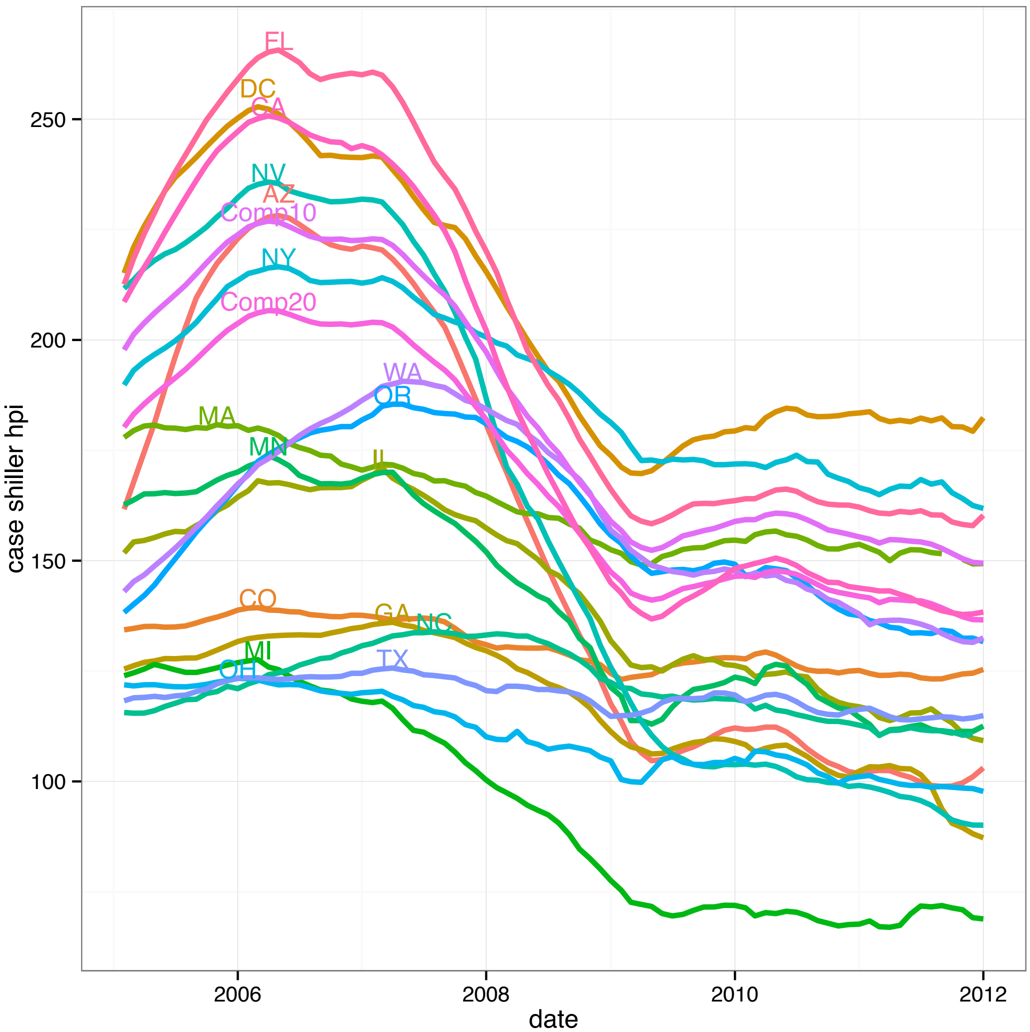

Figure 2.4: House prices histories in different states. Case-Shiller index.

2.3 Theoretical Model

2.3.1 The individual lifecycle

Individuals maximize expected lifetime utility. As we focus on house purchases and since we need to economise in computations, the active life period starts at age 30 and lasts until age $T = 60$, which in the model is the age of retirement. Individuals differ by their completed level of schooling and an unobservable type affecting a monetary fixed cost of working, but are identical in all other respects ex ante. There are two sources of uncertainty: house prices and earnings uncertainty.

2.3.2 Preferences

Households derive utility from consumption of a composite non-durable consumption good c, leisure $1 - l$ and from a housing good h.[2] Labour supply decisions (l) are modelled as choices from a discretized set of values $L = l_1, l_2, \ldots, l_m$ corresponding to the fraction of disposable time supplied to the labor market, with the convention that $l_j < l_{j+1}$ and $l_1 = 0, l_m = 1$. Houses are characterized by their size, and we allow choice over *small* and *big* houses (think of *flat* versus *house*). In terms of notation this implies $h \in \{0, 1, 2\}$, where $h = 0$ stands for renting – only one type of house is available for rent. The instantaneous utility function is

[2] we use "individuals", "households" and "agents" interchangeably.

$$
\begin{aligned}
u(c, l_j, h) &= \frac{(c \times \exp(\alpha l_j))^{1-\gamma}}{1-\gamma} \exp(\theta\zeta(h)) + \mu\zeta(h) \\
\zeta(h) &= \begin{cases} 0 & \text{if } h = 0 \\ \in (0,1) & \text{if } h = 1 \\ 1 & \text{if } h = 2 \end{cases} \\
& j = 1, \ldots, m \\
& l_1 = 0, l_m = 1, l_j < l_{j+1}
\end{aligned}
$$

where $(\alpha, \mu, \zeta, \theta, \gamma)$ is a vector of parameters. This specification is non-separable in consumption and labor as well as in consumption and housing.[3] We will restrict parameter values $\alpha < 0, \gamma > 1$, implying that utility is decreasing in labor, that individuals are risk averse and that the marginal utility of consumption is increasing in the amount of labor supplied. The consumption and labor component is augmented by a multiplicative and additive term reflecting the effect of housing on utility for owner occupiers. The multiplicative term is a nonseparable scaling factor of utility, with the convention that scaling is relative to utility of renting, in which case $h = 0$. The additive term implies that we don't have a utility function which is homogeneous, thus preferences over consumption and housing are not homothetic. The sign of μ establishes whether housing is a necessity or a luxury. The setup is similar to Attanasio et al. (2012) but for the additional utility derived from leisure.

[3]Formally: Thinking of c, h, l as continuous, consumption and labour are weakly separable from housing but consumption and housing are not separable from leisure and neither are housing and leisure separable from consumption.

The aim of the household is to maximize lifetime utility

$$U = E_0 \sum_{t=1}^{T} \beta^{t-1} u\left(c_t, l_t, h_t\right) + \beta^T \tilde{u}\left(a_T, h_T, p_T\right)$$

by means of choosing sequences $\{c_t, h_t, l_t, d_t\}_{t=1}^{T}$ of consumption, labor supply, housing and a set of discrete choices d relating to bankruptcy and default, which are detailed below. There is a standard discount factor $\beta < 1$ and a modified final period utility function $\tilde{u}$ that takes into account the amount of home equity at the end of the active lifecycle and the start of retirement. The expectation is taken with respect to contingent paths of labor productivity and house prices.

2.3.3 House Prices

Owner-occupied housing of size h trades at a unit price $p_t(h)$ in period t, with the assumption that

$$p_t(h) = \begin{cases} p_t & \text{if } h = 2 \\ \kappa p_t & \text{if } h = 1, \text{ with } \kappa \in (0, 1] \\ \eta p_t & \text{if } h = 0, \text{ with } \eta \in [0, \kappa] \end{cases}$$

i.e. smaller houses trade at a constant fraction of larger ones and rental is a fraction η of the house price. The evolution of house prices is assumed to be a unit root process as outlined in equation (2.2). There is a markov transition matrix Γ_p associated with process p.

2.3.4 Labor productivity

Labor productivity is composed of a deterministic age and education profile and a persistent random process similar to Meghir and Pistaferri (2004).[4]

$$
\begin{aligned}
\ln w_{it} &= \mu_t^e + z_{it}^e \\
z_{it}^e &= \rho z_{it-1}^e + \nu_{it}^e \\
\nu^e &\sim N\left(0, \sigma_{\nu,e}^2\right)
\end{aligned}
\tag{2.3}
$$

where μ_t^e an education type e-specific age profile and z^e is a persistent random component which we model as a random walk. The transition matrix associated with z^e is denoted Γ_z^e. We denote the wage level by $w(t, z)$. When unemployed, i.e. when choosing $l = 0$, the household is endowed with unemployment benefit $b > 0$. For the sake of brevity, we will denote $y(z, t) = w(z, t) \times l^*$ as implied labor income (l^* stands for the labor supply policy function). There is an element of unobserved heterogeneity which we model as a heterogeneous monetary fixed cost of working $F(k)$ for K discrete types $k = 1, \ldots, K$.

2.3.5 Default Institutions

There are two distincts credit default institutions in the model: there is default on unsecured debt and default on secured housing debt. We will refer to the former as "bankruptcy" and to the latter as "default" for simplicity.

[4]Note that throughout the paper we focus on lifecycle effects only, i.e. we do not account for cohort-specific effects.

In 2005 the Bankruptcy Abuse Prevention and Consumer Protection Act (BAPCPA) was introduced, making it more difficult for some consumers to file under chapter 7 of the bankruptcy act and instead forcing them to choose chapter 13 instead. In general terms, chapter 7 amounts to full discharge of debt while chapter 13 is a debt restructuring. The main aspect of eligibility for chapter 7 concerns a means test, whereby chapter 7 is not a choice if the individual's monthly income is above the state median. Under chapter 7, no debt repayments need be made (i.e. there is complete discharge of unsecured debts) but non-exempt assets are seized, while under chapter 13 the consumer must commit to a repayment plan that lasts on average for 5 years, but may otherwise keep their assets. One is tempted to expect that owners with important amounts of non-exempt home equity (maybe because they reside in states with low exemption level, or because they are rich in equity) would prefer to make debt repayments, if they are in a situation to do so, whereas owners in high exemption states may prefer the chapter 7 option, since this guarantees their home equity without the onerous debt repayment plan. The extent of the owner's preference for either option will depend on the amount of equity, their rank in the state income distribution, and the details of the repayment plan, i.e. what wage garnishments the bankrutpcy judge deems just.[5]

We model the distinction between both chapters. In particular, we incorporate the means test which requires consumers with greater than state median income to file for chapter 13. Given that homeowners are the ones predominantly affected by this restriction, it seems like an important feature of the budget set of the consumers

[5] Note that garnishments must not exceed 25% of disposable income under Federal Law.

in our data. We will perform a counterfactual policy experiment where we undo the reform and allow all consumers to file under chapter 7, regardless of their income.

With this distinction in mind, we model bankruptcy as follows. Depending on their position in the income distribution, a consumer may choose either chapter 7 or 13. In chapter 7 they are subject to the restrictions imposed through homestead exemption levels, i.e. they may only keep their homes if equity is less than the state exemption level. In chapter 13, on the other hand, they may keep their house regardless of the exemption level since they sign up to a repayment plan, which stipulates debt repayments for as long as they are in *bankruptcy state*. Associated with filing for bankruptcy we allow for certain costs: first the individual is excluded from financial markets for five years on average.[6] In addition bankruptcy involves psychic costs λ^{bk} associated with the stigma of a bad credit record.

The so–called homestead exemption is a legal clause which exempts a certain amount of home equity from liquidation, to different extents in different states. In practice, this means that if an owner finds themself with unsecured debt and at the same time has equity in the home below the exemption level, they could file for bankruptcy without risking to loose the home in a forced sale, since the unsecured lender is prevented from claiming the exempt equity. In the model, therefore, an owner with less than exempt equity stays in their house during bankruptcy (if it is optimal for them to do so). If an owner in excess of the exemption limit files, they loose the house, which is sold at market price, but they get to keep the exeption level from the proceeds of the sale.

[6]In the model, the length of exclusion is random and one exits exclusion at a constant probability. We adopt this strategy purely out of computational reasons. Having a counter variable would increase the state space five-fold, which is not an option.

The second institution concerns default on mortgage debt. It is important to distinguish the case where the individual no longer finds it optimal (or affordable) to continue repaying a mortgage on a house following, say, an income shock, to the case where the house price has fallen placing them in negative equity. In the former case the house is sold and the mortgage repaid; the individual then moves either to a smaller house or rents. In the latter (negative equity case) there is an incentive to default. However, even then default may not occur in the model because of the costs involved. Owners may decide to default strategically if it is optimal to do so; they may also default if they are cash-flow constrained.[7]

In practice, default means that the owner becomes a renter, but is relieved of all outstanding mortgage debt. Credit scores of defaulters deteriorate by 200–300 points according to some observers, so we apply one period with no access to unsecured borrowing and psychic cost λ^{def} as a punishment. One issue that warrants a comment is so–called recourse legislation. According to a commonly used classification (see Ghent and Kudlyak (2009)), there are eleven US states in which a mortgage lender is practically prohibited to claim other assets of a home owner who defaults on a mortgage when the sale of the property does not cover the outstanding debt. Those states are classified as non-recourse states, whereas in the other states, a lender may lay claim to other assets to cover remaining outstanding debt after default. It is in those states and cases that remaining mortgage debt gets converted into unsecured debt, and which those defaulting then seek to discharge in an ensuing bankruptcy, should this be necessary. We use a factor $\psi \in [0, 1]$ to control what fraction of remaining debt gets carried over in certain legal systems.

[7] see Bajari et al. (2008) and Guiso et al. (2013) for discussions of these issues

2.3.6 Financial Market

There are two types of financial institutions in the model, one specializing in unsecured lending and one in mortgage lending. Both have access to international financial markets and take the interest rate r as given.

Mortgage Market

There is a unique mortgage contract for all types of individuals. For computational convenience, we assume that a mortgage contract by default lasts until the end of working life at period T. Mortgages are modeled to resemble fixed term repayment mortgages (FRM), which are characterized by constant mortgage payments. The mortgage interest rate r^m, is such that $r^m > r$, to reflect the risk premium. However, we have simplified the problem by assuming that all consumers face the same rate. Although this is by no means a perfect assumption it can be justified in part by the fact that the main driver of default is house price volatility (and not fluctuations in interest rates). Moreover, in the model we impose a minimum downpayment amount. The following rules apply to a mortgage contract:

- remaining mortgage debt is charged at the exogenous interest rate r^m.
- Buyers must make a fixed downpayment $\chi \in [0, 1]$ proportional to house value at purchase.[8]
- given remaining mortgage debt m at age j, the period t payment is $\xi(m, r^m, j) = (1 + r^m)\frac{m}{T-j}$. This formula is set up so that by the end of active life in period T the mortgage is paid off.

[8] At present we assume it is 10% fixed.

- mortgage debt evolves from period t to $t+1$ according to $m_{t+1} = m_t - \frac{1}{1+r^m}\xi(m, r^m, t) = m_t \left(\frac{T-j-1}{T-j}\right)$
- upon sale, the remaining mortgage needs to be repaid at once.

Housing equity in period t is $hp_t - m_t$, where m_t is the outstanding mortgage debt. This setup of the repayment schedule is a slight modification from an industry standard FRM in that it keeps the proportion of capital to interest repaid with each installment constant over the lifetime of the loan; in reality the porportion of capital in each installment increases with the age of the loan, the modeling of which would require an additional state variable that records the age of the loan, complicating the computations. This setup implies constant mortgage payments over the life of the contract, and linearly decreasing mortgage debt. An example for different levels of downpayments is given in figure

2.3.7 Unsecured debt market

Unsecured borrowing means that the liquid asset a can be made negative up to a certain endogenously determined amount $\bar{a} < 0$. The interest rates for saving and borrowing are denoted r and r^b, respectively. Borrowing and saving is assumed to take place in a one period discount bond fashion as in Chatterjee et al. (2007) or Athreya (2008) for example. In our model there is no asymmetric information so that the bank can compute the probability of default. The interest rate it charges is accordingly adjusted at the individual level, assuming a competitive market where all financial intermediaries make zero profits. The zero profit condition combines

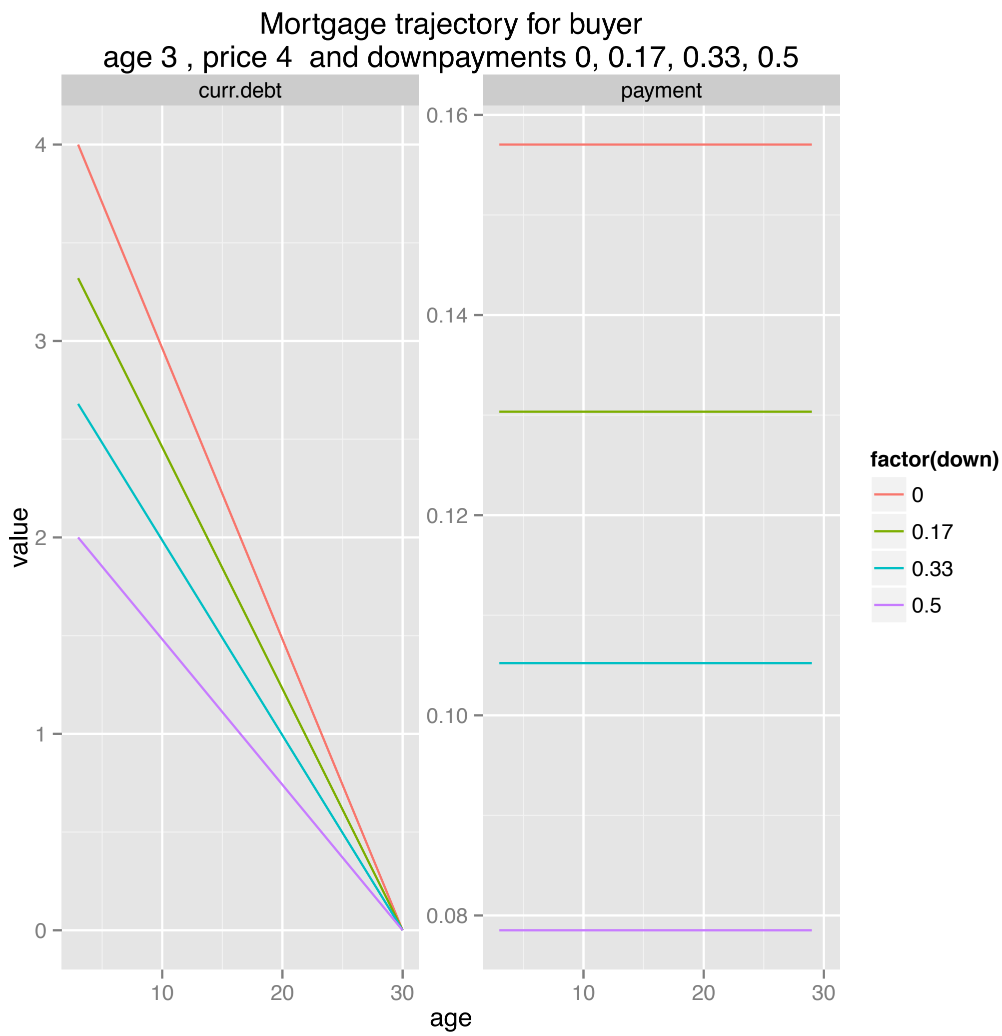

Figure 2.5: Example Mortgage Trajectories

expected (partial) repayment of the loan in the case of bankruptcy, which differs by chapter, with full repayment in case of no bankruptcy.

If the individual is eligible to file under chapter 7 and does not own a house, no further repayments will be made. On the other hand if she does own a house, any value over and above the homestead exemption (applicable in the state of residence) can be used to cover loan repayments: the housing equity effectively acts as security for the "unsecured" loan. Thus the equlibrium price of borrowing will depend on the amount of equity in the house. The expected repayment in this case is denoted EP^7:

$$EP^7 \quad = E_{p'|p} \quad \min\left[\max\left((1-\phi)ph - m - \overline{e}, 0\right), -s\right], \; \forall s < 0 \tag{2.4}$$

where the expectation is taken over future house prices, given current ones. The inner max operator in (2.4) defines non-exempt equity, whereby $(1-\phi)ph - m$ is home equity net of proportional transaction costs ϕ and state homestead exemption level $\overline{e}$.

When filing for for chapter 13 a fraction τ will be deducted from earnings for a maximum of I years. In this case the expected repayment is denoted by EP^{13}, and it is a function of endogenous future labor supply decisions of the individual, which depend on future random events and housing decisions. Thus expectations are taken over all these future unknown events up to the smaller of maximal lifetime and $t+I$ periods ahead, conditional on period t, when the loan $s<0$ is taken out.

$$EP_t^{13} = \min\left[\sum_{i=1}^{\min(T,t+I)} E_{t+i|t}\left(l_{t+i}(S_{t+i})w(t+i, z_{t+i})\tau\right), -s\right] \tag{2.5}$$

where $l_{t+i}(S)$ is the optimal labor supply function in period $t+i$ when the state is S, and where $s < 0$ denotes the amount of unsecured debt borrowed.

Taking all these factors into account, the equilibrium price for unsecured debt q, conditional on the individual circumstances and the default insititutions applicable, is defined as a solution to the equation

$$q(\cdot) \times s = \frac{1}{1+r}[(1 - \pi^7 - \pi^{13}) \times s + \pi^{13} EP^{13} + 1(y < y^m) \times \pi^7 \times EP^7] \qquad (2.6)$$

where the left hand side is the amount forwarded to the consumer, and where $\pi^j,\ j = 7, 13$ are the endogenous probabilities that the individual files for bankruptcy under the respective chapters. Finally, $1(y < y^m)$ denotes income being below the median and hence permitting filing under chpater 7. The lender needs to calculate these together with the expected repayments conditional on filing under chapter 13 or under chapter 7. The expression then defines the discount q which is a function of the determinants of the default probability and the expected repayments as well as the amount (s) the individual has to repay. Note that when the individual either does not borrow ($s > 0$) or borrows a relatively small amount that can be repaid with certainty ($-s < \pi^{13} EP^{13} + 1(y < y^m) \times \pi^7 \times EP^7$) then the implicit price becomes $q = \frac{1}{1+r}$, where r is the internationally fixed interest rate. In what follows the dependence of the equilibrium price on individual circumstances will be left implicit to keep the notation simpler.

2.3.8 Consumer choice

Consumers can either be owners or renters, and either type can be in a bankruptcy punishment state, or not. While in a punishment state, there is no borrowing possible, be it secured or unsecured (i.e. no new house purchase is possible), and a utility penalty is incurred. Exit from the punishment state occurs each period with exogenous probability δ. Whether an individual is in the punishment state or not is part of their state space. In addition the renter's state space is a compact subset of $\mathbb{R}^3 \times \{k_1, \ldots, k_K\} \times \{1, \ldots, T\}$ denoted $\mathcal{R}$ with typical element $R = (a, z, p, k, t)$, whereas the owner's space is defined as $\mathcal{S} \subset \mathbb{R}^4 \times \{1, 2\} \times \{k_1, \ldots, k_K\} \times \{1, \ldots, T\}$ with typical element $S = (a, z, p, m, h, k, t)$. The variables contained in S denote assets, labor productivity, house price, mortgage debt, house size, unobservable type and age. Notice that the renter's space does not contain mortgage debt and house size. In each period $t < T - 1$, the renter's problem in the non-bankruptcy state is to choose the maximal value among three discrete choices "rent", "buy" and "file for bankruptcy chapter 7" and "file for bankruptcy chapter 13", although this last choice is subject to a means test. While in punishment state, they can only rent.

The owner's problem in the non-bankruptcy state is to choose among "stay", "sell", "default", "file for bankruptcy chapter 7/13" and "file for bankruptcy chapter 7 and default", whereas during punishemt, this reduces to "stay", "sell" and "default".

In each of those cases, there are two intraperiod choices to make, i.e. how much to consume and how much labour to supply. In period $T - 1$ unsecured borrowing is not permitted, since final period assets must be non-negative. Also notice that the mortgage contract is structured in a way that the debt is paid off by the last period. We describe the setting for the final period T at the end of this subsection.

2.3.9 The Choice of Renters

Denote the maximal expected lifetime utility for a renter of age t as W if not in a bankruptcy state. Otherwise it is denoted by $\tilde{W}_j$ for bankruptcy state $j = 7, 13$. Let s denote the end of period savings choice (i.e. $s = a'$). We write the problem as follows:

$$W(a, z, p, k, t) = \begin{cases} \max\left(W^{\text{rent}}, W^{\text{buy}}, W^{\text{file.7}}, W^{\text{file.13}}\right) & \text{if } a < 0, y < \overline{y} \\ \max\left(W^{\text{rent}}, W^{\text{buy}}, W^{\text{file.13}}\right) & \text{if } a < 0, y \geq \overline{y} \\ \max\left(W^{\text{rent}}, W^{\text{buy}}\right) & \text{if } a \geq 0 \end{cases} \tag{2.7}$$

The restriction on the discrete choice set of the renter in (2.7) makes explicit the fact that one only can file for bankruptcy if there are effectively unsecured debts to discharge. In addition we implement the BAPCPA means test by preventing individuals with labor income above a threshold $\overline{y}$ to file for chapter 7. We define the conditional value functions next.

Value of Renting

The value of renting is given by

$$W^{\text{rent}}(R) = \max_{\substack{s \in \mathbb{R} \\ l \in L}} u(c, l, 0) + \beta E_{z'|z,p'|p}\left[W(R')\right] \tag{2.8}$$

subject to

$$c + q(z, p, t, s) \times s = \mathbf{1}[l > 0]\left(w(t, z) \times l - F(k)\right) + \mathbf{1}[l = 0]\, b + a - \eta p > 0 \tag{2.9}$$

where R is the current state space and R' the state space as it evolves. Equation (2.9) is a standard budget constraint that requires expenditures (LHS: consumption c and saving/borrowing s) to be equal to cash-on-hand (labour income plus assets minus rent). If no labor is supplied ($l = 0$) the unemployment benefit applies, and if labor supply is positive, the unobserved type-dependent fixed cost F is incurred.

Value of Buying

The value function for the buyer is

$$W^{\text{buy}}(R) = \max_{\substack{s\in\mathbb{R}\\ h_0\in\mathcal{H}\\ l\in L}} u(c, l, h_0) + \beta E_{z'|z,p'|p}\left[V(S')\right] \tag{2.10}$$

subject to

$$\begin{aligned} c + q(\cdot) \times s &= \mathbf{1}\left[l > 0\right]\left(w(t, z) \times l - F(k)\right) + \mathbf{1}\left[l = 0\right] b \\ &+ a - \xi(m_0, r^m, t) - \chi p(h_0) > 0 \end{aligned} \tag{2.11}$$

Compared to the renter's problem, the budget constraint of the buyer (2.11) is augmented by two terms ξ and χp, which stand for mortgage payment and down-payment, respectively. The function q now depends on the additional state variables mortgage debt and house size, (m, h).

Renter Bankruptcy Chapter 7

The value of filing for bankruptcy under chapter 7 as a renter is similar to the value of staying a renter with the exception that current assets are set to $a = 0$ in the budget constraint since all assets are used against the debt. Moreover, the various penalties are applied (no borrowing and psychic cost of bankruptcy λ^{bk}). The future value in the bankruptcy state 7 is denoted by $\tilde{W}_7$.

$$\begin{aligned} W^{\text{file.7}}(R) &= \max_{\substack{s\in\mathbb{R}_+ \\ l\in L}} u(c,l,0) + \beta E_{y'|y,p'|p}\left[\tilde{W}_7(R')\right] - \lambda^{bk} \qquad (2.12) \\ \text{subject to} & \\ c + \frac{1}{1+r}s &= \mathbf{1}\left[l>0\right]\left(w(t,z)\times l - F(k)\right) + \mathbf{1}\left[l=0\right]b - \eta p > 0, (\mathbf{??}) \end{aligned}$$

As a result of filing for bankruptcy underchapter 7 all assets are used against the debt and the remaining amount is forgiven. However, the individual suffers the utility (stigma) cost λ^{bk} and cannot borrow until she exits this state. This happens with probability δ in each period. Thus the expected duration of this state is $\frac{1}{\delta}$. The value $\tilde{W}_7$ in the bankruptcy state is

$$\begin{aligned} \tilde{W}_7(a,z,p,t) &= \max_{\substack{s\in\mathbb{R}_+ \\ l\in L}} u(c,l,0) \qquad (2.13) \\ &+ \beta E_{z'|z,p'|p}\left[\delta W(R') + (1-\delta)\tilde{W}_7(R')\right] - \lambda^{bk} \\ \text{subject to} & \\ c + \frac{1}{1+r}s &= \mathbf{1}\left[l>0\right]\left(w(t,z)\times l - F(k)\right) + \mathbf{1}\left[l=0\right]b + a - \eta p > 0, (\mathbf{??}) \end{aligned}$$

Renter Bankruptcy Chapter 13

Individuals may notbe elgible for Chapter 7, or indeed may choose Chapter 13. This problem is actually very similar to the previous one except that a wage garnishment tax τ is levied from labor income. Hence moving into the bankruptcy state we have

$$\begin{aligned} W^{\text{file.13}}(R) &= \max_{\substack{s\in\mathbb{R}_+\\ l\in L}} u(c,l,0) + \beta E_{y'|y,p'|p}\left[\tilde{W}_{13}(R')\right] - \lambda^{bk} \qquad (2.14)\\ \text{subject to} & \\ c + \frac{1}{1+r}s &= \mathbf{1}\left[l>0\right]\left(w(t,z)\times(1-\tau)\times l - F(k)\right) + \mathbf{1}\left[l=0\right]b - \eta p > 0, \end{aligned}$$

The corresponding punishment state, following filing for chapter 13 is given by

$$\begin{aligned} \tilde{W}_{13}(a,z,p,k,t) &= \max_{\substack{s\in\mathbb{R}_+\\ l\in L}} u(c,l,0) \qquad (2.15)\\ &+ \beta E_{z'|z,p'|p}\left[\delta W(R') + (1-\delta)\tilde{W}_{13}(R')\right] - \lambda^{bk} \\ \text{subject to} & \\ c + \frac{1}{1+r}s &= \mathbf{1}\left[l>0\right]\left(w(t,z)\times(1-\tau)\times l - F(k)\right) + \mathbf{1}\left[l=0\right]b + a - \eta p > 0, (\textbf{??}) \end{aligned}$$

2.3.10 The Problem of the Owner

The discrete choice problem of an owner not in a bankruptcy state is

$$V(a,z,p,m,h,k,t) = \begin{cases} \max\left(V^{\text{stay}}, V^{\text{sell}}\right) & \text{if } a \geq 0, hp_t - m_t \geq 0 \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{def}}\right) & \text{if } a \geq 0, hp_t - m_t < 0 \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{file.7}}, V^{\text{file.13}}\right) & \text{if } a < 0, hp_t - m_t \geq 0, y < \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{file.13}}\right) & \text{if } a < 0, hp_t - m_t < 0, y \geq \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{def}}, V^{\text{file.7}}, V^{\text{file.13}}, V^{\text{file.def}}\right) & \text{if } a < 0, hp_t - m_t < 0, y < \\ \max\left(V^{\text{stay}}, V^{\text{sell}}, V^{\text{def}}, V^{\text{file.13}}, V^{\text{file.def}}\right) & \text{if } a < 0, hp_t - m_t < 0, y \geq \end{cases} \qquad (2.$$

where $a \geq 0$ denotes someone with positive financial assets and $hp_t - m_t$ is the net equity in the house over and above the mortgage m. Importantly, not all discrete choices are available everywhere on the state space, as can be seen from the restrictions for each case. For example, filing for bankruptcy is only an option if there is in fact unsecured debt, i.e. on the region where $a < 0$. Additionally, the admissible chapter of bankruptcy depends on labor income lying below the threshold $\bar{y}$, as before. Similarly for the default choice, which is only an option if home equity is negative. Owners with home equity in excess of the exemption level face eviction should they file for bankruptcy under chapter 7. The level of homestead exemption determines whether an owner filing under chapter 7 stays on in the house or is evicted. We define the sub-problems in sequence below. Define the current state space as $S = (a, y, p, m, h, k, t)$ and remember that $h \in \{1, 2\}$ stands for "flat" and "house".

Value of Staying as Owner

The value of staying in the current home is

$$\begin{aligned} V^{\text{stay}}(S) &= \max_{\substack{s \in \mathbb{R} \\ l \in L}} u(c, l, h) + \beta E_{z'|z,p'|p}\left[V(S')\right] \qquad (2.17) \\ \text{subject to} & \\ c + q(z, p, m', h, t, s) \times s &= \mathbf{1}[l > 0]\left(w(t, z) \times l - F(k)\right) + \mathbf{1}[l = 0]\, b + a - \xi(m, r^m, t) \end{aligned}$$

This problem is very similar to the buyer's above with the exception that there is no downpayment in the budget constraint as this is a one-off payment made at the time of purchase.

Value of Selling the Home

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

$$\begin{aligned} V^{\text{sell}}(S) &= \max_{\substack{s\in\mathbb{R}\\ l\in L}} u(c,l,0) + \beta E_{z'|z,p'|p}\left[W(R')\right] \qquad (2.18)\\ \text{subject to} & \\ c + q(z,p,t,s)\times s &= \mathbf{1}\left[l>0\right](w(t,z)\times l - F(k)) \\ &+ \mathbf{1}\left[l=0\right] b + a - \eta p + ((1-\phi)ph - m) \end{aligned}$$

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

Value of Default

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

$$
\begin{aligned}
V^{\text{def}}(S) &= \max_{\substack{s>0\\ l\in L}} u(c,l,0) + \beta E_{z'|z,p'|p}\left[W(d+s,z',p'k,t+1)\right] - \lambda^{\text{def}} \qquad (2.19)\\
\text{subject to}&\\
c+\frac{1}{1+r}s &= \mathbf{1}[l>0](w(t,z)\times l - F(k)) + \mathbf{1}[l=0]\,b\\
&+ a-\eta p,\\
d &= \psi((1-\phi)ph-m)
\end{aligned}
$$

Owner Bankruptcy chapter 7

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

$$
\begin{aligned}
V^{\text{file.7}}(a,z,p,m,h,k,t) &= \max_{\substack{s>0\\ l\in L}} u(c,l,h) + \beta E_{z'|z,p'|p}\left[\tilde{V}_7(S')\right] - \lambda^{\text{bk}} \qquad (2.20)\\
\text{subject to}&\\
c+\frac{1}{1+r}s &= \mathbf{1}[l>0](w(t,z)\times l - F(k)) + \mathbf{1}[l=0]\,b - \xi(m,r^m,t) > 0
\end{aligned}
$$

This value is only defined if current assets are negative, $a < 0$. Crucially, the household may only stay in the house if net home equity lies below the homestead exemption level $\overline{e}$, i.e. iff $(1-\phi)(ph-m) < \overline{e}$. The case of filing for chapter 7 with excess equity is described next.

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

$$\begin{aligned} V^{\text{file,def}}(S) &= \max_{\substack{s>0 \\ l\in L}} u(c,l,0) - \lambda^{\text{bk}} - \lambda^{\text{def}} \\ &+ \beta E_{z'|z,p'|p}\left[\tilde{W}_7(R')\right] \\ c + \frac{1}{1+r}s &= \mathbf{1}[l>0](w(t,z)\times l - F(k)) - \eta p > 0 \end{aligned} \tag{2.21}$$

The assumption is that any remaining mortgage debt is discharged in the chapter 7 bankruptcy.

Owner Bankruptcy Chapter 13

The main difference to chapter 7 bankruptcy is that the owner may keep the house (and all other assets) no matter how much equity there is after signing up to a chapter 13 repayment plan. Consequently we don't have to compute a value of eviction and we also rule out the possibility to file for chapter 13 and default on the mortgage at the same time.[9]

$$\begin{aligned} V^{\text{file.13}}(a,z,p,m,h,k,t) &= \max_{\substack{s>0 \\ l\in L}} u(c,l,h) + \beta E_{z'|z,p'|p}\left[\tilde{V}_{13}(S')\right] - \lambda^{\text{bk}} \\ &\text{subject to} \\ c + \frac{1}{1+r}s &= \mathbf{1}[l>0](w(t,z)\times l\times(1-\tau) - F(k)) + \mathbf{1}[l=0]b - \xi(m,r^m,t) > 0 \end{aligned} \tag{2.22}$$

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

Owner Bankruptcy punishment States

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

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

where the value for *stay* is given by

$$\tilde{V}_j^{\text{stay}}(S) = \max_{\substack{s>0 \\ l\in L}} u(c,l,h) + \beta E_{z'|z,p'|p}\left[(1-\delta)\tilde{V}_j(S') + \delta V(S')\right] - \lambda^{\text{bk}} \quad (2.23)$$

subject to

$$\begin{aligned} c + \frac{1}{1+r}s &= a + \mathbf{1}[l>0](w(t,z)\times l \times (1-\tau(j)) - F(k)) - \xi(m, r^m, t) > 0, \\ \tau(j) &= \begin{cases} \tau & \text{if } j = 13 \\ 0 & \text{otherwise.} \end{cases} \quad (2.24) \\ j &= 7, 13 \end{aligned}$$

the value for *sell* is given by

$$\begin{aligned} \tilde{V}_j^{\text{sell}}(S) &= \max_{\substack{s>0 \\ l\in L}} u(c,l,0) + \quad (2.25) \\ &\quad \beta E_{z'|z,p'|p}\left[(1-\delta)\tilde{W}_j(R') + \delta W(R')\right] - \lambda^{\text{bk}} \\ c + \frac{1}{1+r}s &= \mathbf{1}[l>0](w(t,z)\times l\times(1-\tau(j)) - F(k)) \\ &+ a + (1-\phi)ph - m - \eta p > 0 \end{aligned}$$

and finally the value for *default* in the punishment state is given by

$$\begin{aligned} \tilde{V}_j^{\text{def}}(S) &= \max_{\substack{s>0 \\ l\in L}} u(c,l,0) - \lambda^{\text{bk}} - \lambda^{\text{def}} \\ &+ \beta E_{z'|z,p'|p}\left[(1-\delta)\tilde{W}_j(R') + \delta W(R')\right] \\ c + \frac{1}{1+r}s &= \mathbf{1}[l>0](w(t,z)\times l \times (1-\tau(j)) - F(k)) \\ &+ a - \eta p \end{aligned} \tag{2.26}$$

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

Final Period

We close the model by defining the final period value function as a function of the state of the individual. We also need to avoid creating an artificial incentive for the household to go bankrupt one or two periods before retirement and we allow for this by estimating a penalty for such an action.

2.4 Data

Our data is drawn from several sources. We use a confidential version of the Federal Reserve Bank of New York Consumer Credit Panel which we merge with LPS Mortgage Loan Level Data to compute bankruptcy and default rates at county level. We supplement this with county level house prices obtained from Zillow Research[10], as well as county level demographic and economic characteristics from the American Community Survey (ACS).

The NY Fed Consumer Credit Panel is assembled mainly from quarterly credit bureau data, which the Federal Reserve Board, the New York Fed, and the Philadelphia Fed purchased from Equifax, one of the three major credit reporting agencies in the United States. The dataset contains a random subsample of credit users (a 5% random sample that is representative of all individuals in the US who have a credit history and whose credit file includes the individual's social security number). This is individual level data which includes comprehensive summaries of key characteristics of the different types of debt held by individual borrowers (e.g., total credit-card balances and limits). In addition, the dataset includes loan-level information on these borrowers' mortgage. More specifically, the data contain demographics (e.g. individual age, location by state, zipcode, and census tract, credit risk score), information on mortgages[11], information on other debts such as auto, student, department, installment loans etc (e.g. current balance, past-due indica-

[10] http://www.zillow.com/research/data/

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

tors, credit limit, payments). A detailed description of the panel can be found at http://www.newyorkfed.org/research/staff_reports/sr479.pdf.

The second source is the LPS Mortgage Loan Level Data, formerly known as "McDash" data. We combine this with the consumer panel because the panel does not have very detailed information on mortgage terms. Merging with the LPS data gives us information on first liens (loan origination date, origination amount, lien status, and zipcode). This data have been used extensively over the past few years to study mortgage defaults. The LPS data set is divided into a "static" file, whose values generally do not change over time, and a "dynamic" file. The static data set contains information obtained at the time of underwriting, such as the loan amount, house price, (origination) FICO score, documentation status, source of the loan (e.g., whether it was broker-originated), property location (zip code), type of loan (fixed-rate, ARM, prime, subprime, etc.), the prepayment penalty period (if any), and the termination date and termination status if the loan has indeed terminated. The termination types include "paid off," foreclosure (and other negative termination events such as REO sale), and the transfer of the loan to another servicer. The dynamic file is updated monthly, and among other variables, it contains the status of the loan (current, 30 days delinquent, 60 days, etc.), the current interest rate (since this changes over time for ARMs), current balance, and investor type (private securitized, GNMA, FNMA, FHLMC, portfolio). LPS covers about 70% of the market after January 2005 and it oversamples prime mortgages.

We match the FRBNY Consumer Credit Panel with LPS based on mortgage loan origination date, origination amount, the zipcode of the property, purpose of the mortgage (purchase versus refinance), lien status (first lien versus second lien or home equity), type of mortgage (agency loans or not)) and occupancy type (primary residence, second homes or investment properties).

The final dataset we use is the American Community Survey (ACS) Public Use Microdata Sample. Merging ACS county level data onto the previous datasets results in a panel by county over time which contains information on average bankruptcy filing rates (for chapter 7 and 13 respectively), average default rates, on default and bankruptcy rates, average educational attainment, and average employment in a certain region over time. This information will allow us to relate education to bankruptcy and mortgage default rates, which introduces an element of heterogeneity in the model. Additional to that we use PSID data to estimate a life-cycle profile for the income process.

2.5 Model Implications

For illustrative purpose, we show some simulation paths of individual histories in figure 2.6. Those plots combine discrete and continuous choice policy functions for a random set of individuals. sThe mechanism connecting interest rate and probability of bankrutpcy is illustrated for an arbitrary simulated individual in figure 2.7.

2.6 Estimation

A number of parameters are set based on earlier results from the literature. Table 2.3 lists the values of those. We rescale the house price so that it reflects the ratio of price to median income and set the initial log house price p_0 to 12, which roughly

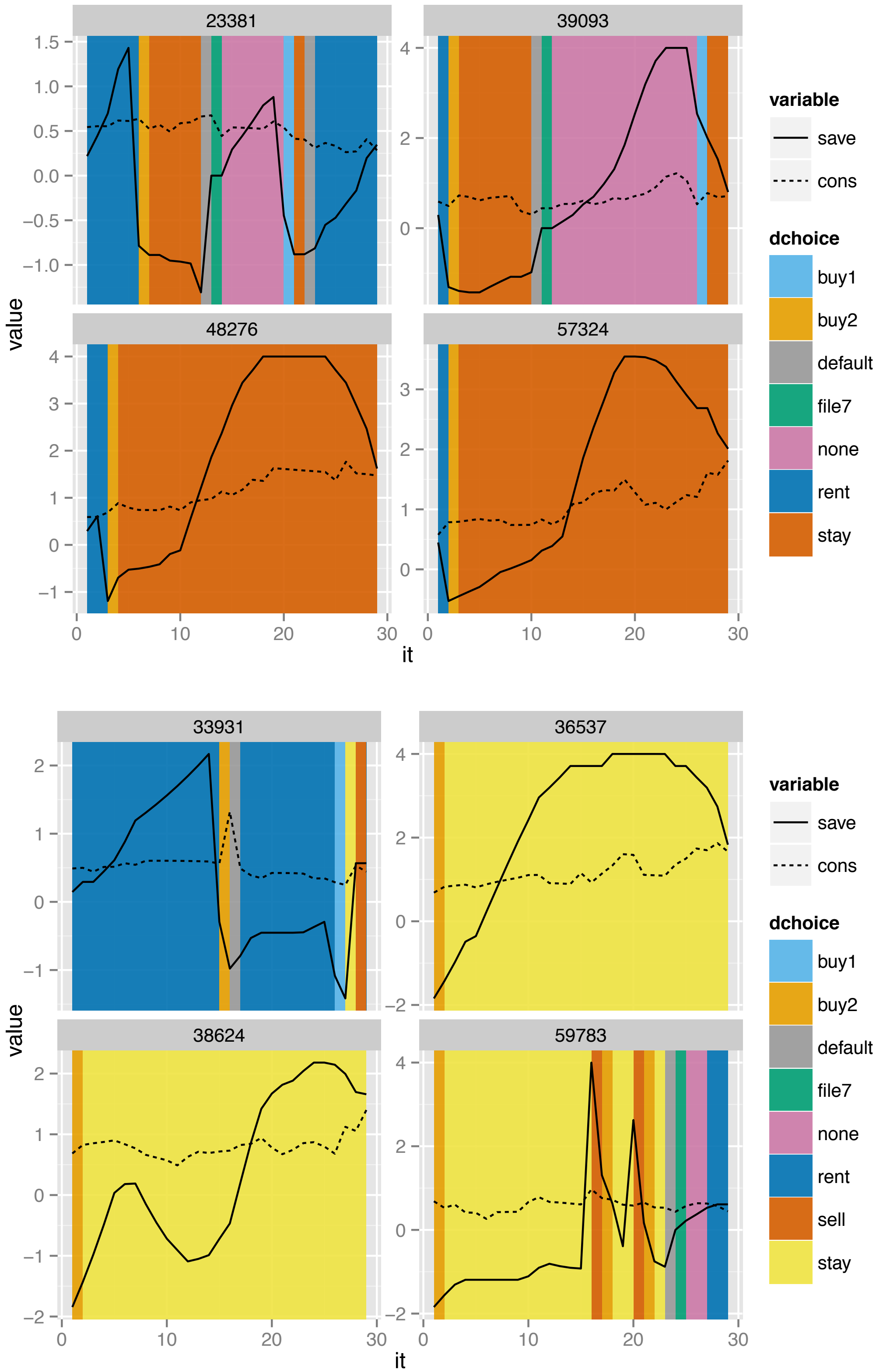

Figure 2.6: Individual simulation histories from the baseline model. Color codes illustrate the discrete choice taken at that age. Keep in mind that 2 important state variables (income and house price) are missing from this graphic to avoid clutter.

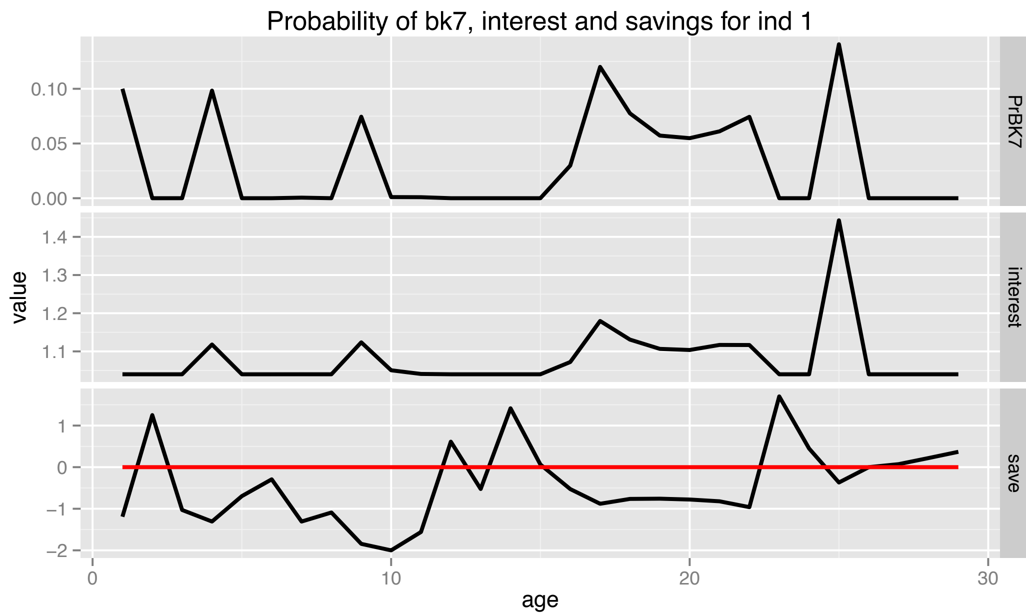

Figure 2.7: Mechanism between probability of bankruptcy, savings, and interest rate. Depending on the value of other (not shown) state variables, with negative savings, there is positive probability of bankruptcy (chapter 7 in this case), and an interest rate premium to pay.

corresponds to the average value in our ACS dataset for 2006. We choose the values of α and γ in conjunction so as to pin down the amount of labour supplied, the value of the intertemporal elasticity of substitution, and the value of the Frisch labor supply elasticity. We set the weight of leisure in utility α so that on average individuals work 35% of their time. We want to target the intertemporal elasticity of substitution (IES) estimated by Blundell et al. (1994) of 0.75. The IES for consumption is given by $-\left[\alpha(1-\gamma)-1\right]^{-1}$, therefore we require $\gamma = 2, \alpha = 0.33$.

Beyond this set of parameters the rest are estimated using the data described earlier and within the context of our model. The estimation approach we use combines simulation with the MCMC approach developed by Chernozhukov and Hong (2003). The criterion we minimize is a distance criterion between data moments and simulated moments from the model. One of the key advantages of this approach is that it can cope with criteria that are not differentiable, which is often the case when dealing with simulated moments. [12]

2.6.1 Empirical Moments

To estimate the model we combine a basic set of moments, as listed in Table 2.4 together with indirect inference. Indirect inference involves matching the coefficients

[12] Our function is evaluated on a set of N parallel Markov chains, which differ in their respective "tempering". Intuitively, chains with higher index n are subject to larger shocks to the current parameter vector, therefore they perform exploration of the parameter space over a wider area. Additionally, chains can communicate with one another according to some rule. This mechanism allows chains to make large jumps over the parameter space, moving away from areas where the objective function has a relatively large value and towards regions with better, smaller values. For a technical description see Baragatti et al. (2013).

	value	meaning
$1+r$	1.040	gross risk free interest rate
$\frac{1}{1+r}$	0.962	inverse of gross risk free interest rate
β	0.950	discount factor
χ	0.200	downpayment as proportion of house value
$(1+r^m)$	1.060	mortgage rate
p_0	13.000	median log house house price 2006
$p2y$	12.000	initial price to income ratio in simulation
ϕ	0.940	proportional fixed cost of selling
ρ_z	0.950	AR1 coefficient on wage AR1 component
ρ_p	0.900	AR1 coefficient on price AR1 component
δ	0.200	prob of exiting bk state
η	0.000	rental rate as a fraction of house price
κ	0.600	flat price as a fraction of house price
ψ	0.100	fraction of mortgage debt rolled-over under Recourse
τ_{bk}	0.100	prop of wage garnished in chapter 13 bankruptcy
$\overline{w}$	1.000	chapt. 7 income meanstest as a fraction of med income
$\overline{e}$	0.500	homestead exemption as a fraction of med. income
α	-0.333	disutility from labour
γ	2.000	CRRA
b	0.250	unemployment benefit
a_L	-2.000	minimal assets (times med. income)
a_H	4.000	maximal assets (times med. income)
p_L	0.300	minimal price (times p0)
p_H	1.100	maximal price (times p0)
HS	0.130	proportion of individuals less than HS

Table 2.3: Exogenous parameters

moment	data
Bankruptcy rate %	0.5
bankruptcy ch. 13 (prop)	0.2
bankruptcy ch. 7 (prop)	0.3
default rate (prop)	0.030
default rate age 30-40 (prop)	0.033
default rate age 41-50 (prop)	0.030
default rate age 51-60 (prop)	0.025
duration	8.000
flats (prop of total)	0.105
ownership rate (prop)	0.716
ownership rate age 30-40 (prop)	0.613
ownership rate age 41-50 (prop)	0.740
ownership rate age 51-60 (prop)	0.804
unemployment rate (prop)	0.068

Table 2.4: List of aggregate moments. (prop) means that the number is given as a proportion of the total population, i.e. for bk=0.004, the observed number of bankruptcies would be population * bk. These are computed from our baseline set of states. Refer to Section **??**, group 5.

of auxiliary regressions obtained from the actual data to those obtained when the same regressions are fit to simulated data. In particular we wish to allow for ex ante heterogeneity in the model by specifying preferences as well as wages to be functions of education. Other sources of heterogeneity (ex-post) are the wage shocks and of course the house prices.

In estimating the model we need to define the source of variation that identifies it. Unfortunately, the variation in the institutional framework cannot be used for identification of the model. This is because the institutions themselves may be endogenous, in the sense that they are designed to fit the local context. Moreover, the composition of people borrowing and hence defaulting will vary as a result of different equilibria in each market. Changes in institutions may have been informative but on the one hand these are very rate and secondly we would need more than one discrete item of variation. As a result we decided to estimate the model based on a single institutional context. We then use the model to simulate the impacts of alternative institutions. For this purpose we group states into 5 distinct groups according to bankrupcty–relevant legislation (amount of homestead exemption and whether or not deficiency judgements are allowed). Our reference group is the largest one, labelled group 5 in table A.1, which we observe annually from 2006 to 2012.

We use time variation from housing prices (which we take as exogenous) to identify the model. This relies on local county level shocks to generate variabilty in the bankruptcy rates. We also need a source of information to identify the way that ex-ante heterogeneity, which we associate with education, affects decisions. For this we use cross sectional variation. The difficulty is that the data on defaults and bankruptcy does not include information on education. However, we can exploit variation acoss counties in the level of education to identify the model. This requires us to control for factors that affect bankruptcies and are correlated with education but are not accounted for in the model. To achieve this we first construct a county level data set by matching into ACS county level data information on bankruptcy and mortgage default. We then regress these on the proportion of indivuals with a college degree that live in the county, as well as other confounding characteristics that are not included in the model and whose impact needs to be accounted for. The idea is to generate a "synthetic" county level dataset which nets out heterogeneity between counties, resulting in an environment that is closely comparable to the one in our model. A plot of percentage of low-educated vs log bankruptcy rate is in figure 2.8.

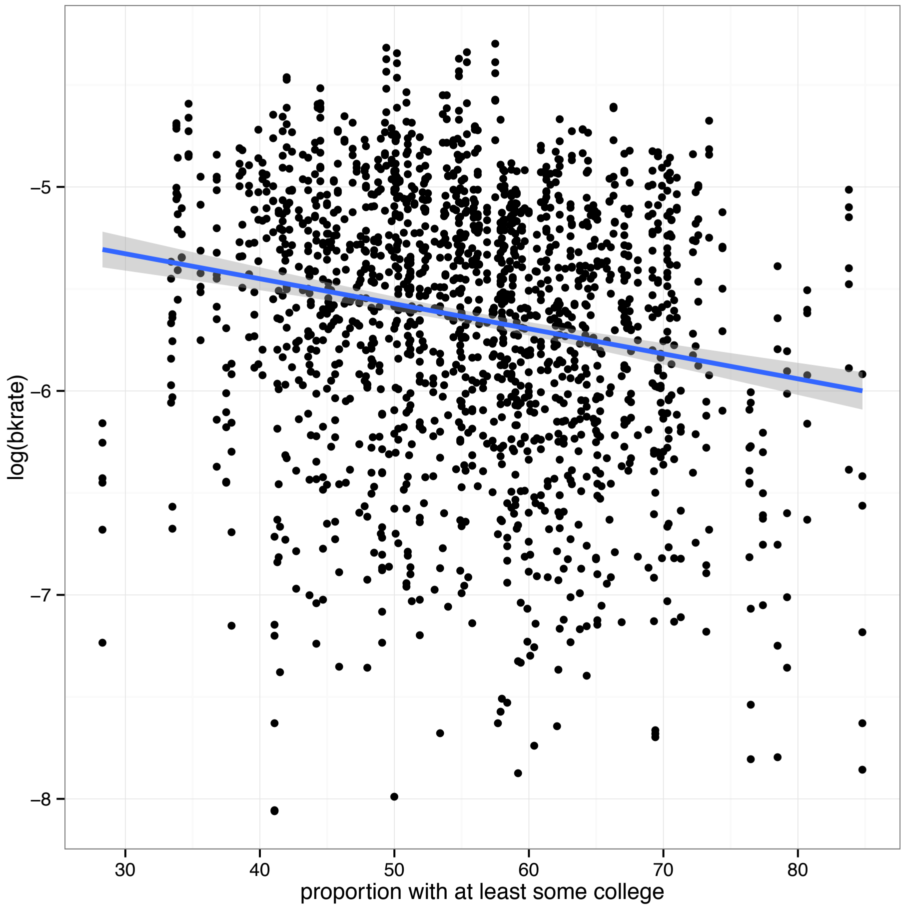

Figure 2.8: Bankruptcy vs fraction of low-educated

To generate the auxilary coefficients used in estimation we run regressions of the per capita mortgage default rate, the bankruptcy rate, the rate of filing for chapter 7 and 13 respectively and the proportion in small homes (flats), i.e. those with less than three rooms. In each auxiliary regression also we include the proportion with less than college degree, house prices divided by median income and the proportion

	mean	Standard Deviation
Bankruptcy Rate	0.006	0.002
Mean House Value / Median Income	2.522	0.768
Percentage less than HS	14.530	5.481
Percentage of HS.grad	32.335	6.278
Percentage of HS.grad+	53.139	9.736
Percentage of Graduate	8.658	3.927
Percentage of divorced females	12.242	1.734
Percentage of divorced males	10.178	1.860
Ownership Rate	71.769	8.598
Default Rate	0.015	0.010
Bankruptcy Rate Chapter 7	0.003	0.002
Bankruptcy Rate Chapter 13	0.002	0.002
Percentage Flat owners	8.037	3.454
Median Earnings	47006.016	8344.394
Homestead Exemption	8153.907	1773.698
Homestead Exemption / Median Income	0.179	0.053

Table 2.5: Summary statistics from the ACS-NYFed data

of males and females who are divorced. Summary statistics from the dataset we are using are given in table 2.5. The numbers represent means and standard deviations across counties.

The result of the auxiliary regressions are summarised in table 2.6. We are particularly interested in the coefficient on house prices and on the proportion of low educated people, which we match with our model. Our assumption is that the associations of these variables with the various outcome variables can be replicated by our model once we condition on the remaining variables, which absorb cross county heterogeneity. The coefficient on education is a function of both the process of income associated with education and possibly of preferences. According to these coefficients, increased house prices (relative to median income) reduce the probability of bakruptcy and particularly under chapter 7; this is because under Chapter 7, a filer is likely to loose their assets. Consequently if there is a valuable house on the balance sheet, this provides a reason not to file. House prices are not associated with increased filings under chapter 13, which is consistent with the fact that under that chapter assets are not confiscated. Furthermore, increased house prices reduce default rates and they decrease the probability of owning at all, while increasing the probability of owning a smaller house (flat). Lower levels of education are associated with higher levels of bankruptcy and indeed higher rate of filing under chapter 13. This seems unexpected since chapter 7 allows you to write off all debts against any assets you may have, while under chapter 13 you keep your assets and a repayment plan is agreed based on withholding of wages. However, low educated people have low wages and lower labour market attachment and as a result are likely to pay much less under Chapter 13, while still being able to hold on to their houses or other assets. Of course higher earning individuals are compelled to file under 13, but as the bankruptcy rate declines rapidly with education, this effect does not dominate. We also included divorce rates, which may reflect the extent of hardship particularly for females. Finally, we also condition on the state level of homestead exemption and on county level median income. These coefficients are not used in the estimation of the model, which is based on a group of states with a homogeneous set of institutions.

	bk.rate	bk.rate7	bk.rate13	def.rate	Pr(own)	Pr(flat|own)
Intercept	-0.0021	-0.0011	-0.0010	0.0048	93.5402^{***}	-0.8768
	(0.0013)	(0.0010)	(0.0010)	(0.0035)	(2.8428)	(1.2045)
House Price	-0.0005^{***}	-0.0005^{***}	0.0000	-0.0021^{***}	-1.8661^{***}	1.1329^{***}
	(0.0001)	(0.0001)	(0.0001)	(0.0005)	(0.4422)	(0.1894)
Prop Less than College	0.0094^{***}	0.0036^{*}	0.0058^{***}	0.0158	-16.3043^{*}	1.0075
	(0.0021)	(0.0016)	(0.0016)	(0.0087)	(7.0597)	(2.9948)
Divorced Females	0.0004^{***}	0.0001^{*}	0.0003^{***}	0.0006^{*}	-2.0070^{***}	0.5623^{***}
	(0.0001)	(0.0000)	(0.0000)	(0.0003)	(0.2364)	(0.1004)
Divorced Males	-0.0002^{***}	0.0000	-0.0002^{***}	-0.0003	0.6831^{**}	0.1349
	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.2584)	(0.1094)
Mortgage Default	0.0675^{***}	0.0333^{***}	0.0341^{***}			-9.0432
	(0.0076)	(0.0060)	(0.0060)			(13.7826)
Homestead Exemption	0.0000^{***}	0.0000^{***}	0.0000^{***}			
	(0.0000)	(0.0000)	(0.0000)			
Median Earnings	0.0000	0.0000^{***}	0.0000^{**}			
	(0.0000)	(0.0000)	(0.0000)			
Bankr.Rate (Chpt. 7)				1.6216^{***}	-454.2885^{*}	-598.5466^{***}
				(0.2404)	(195.0143)	(85.4790)
Bankr. Rate (Chpt. 13)				1.6160^{***}	1257.2595^{***}	-228.2523^{**}
				(0.2405)	(195.1241)	(85.5037)
R^2	0.3581	0.1809	0.3124	0.2184	0.2550	0.1750
Adj. R^2	0.3508	0.1716	0.3046	0.2109	0.2477	0.1657
Num. obs.	627	627	627	627	627	627

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 2.6: Auxiliary Regressions. Notice that p and *low* have been rescaled for readibility by multiplying both data series with a factor of 0.01.

2.7 Estimation Results

Table (2.7) shows the current values of the parameters being estimated, which are used in our current simulations. It is hard to interpret these in isolation. However there are some interesting features. First, there is a strong ownerhip premium (μ),

	value	meaning
θ	0.10	partial deriv of cons w.r.t housing in utility
ϕ	0.50	utility weight of flat relative to house
μ	3.00	ownership premium
$\lambda^{bk,H}$	1.10	cost of bankruptcy High Educ
$\lambda^{bk,L}$	1.00	cost of bankruptcy Low Educ
$\lambda^{def,H}$	0.70	cost of default High Educ
$\lambda^{def,L}$	1.00	cost of default Low Educ
$\lambda^{bk,def,H}$	50.00	cost of default and bankruptcy High Educ
$\lambda^{bk,def,L}$	50.00	cost of default and bankruptcy Low Educ
F	0.10	Fixed cost of work

Table 2.7: Parameter estimates. Currently the estimation is only based on matching the moments in table (2.4). Including the auxiliary regression parameters into the estimation is work in progress.

which ensures that even low wealth individuals will much prefer to own than to rent. Secondly, increasing the size of the house reduces the marginal utility of consumption making housing and housing substitutes ($\theta < 1$). Finally a flat is worth about half a larger house in terms of utility.

The cost of bankruptcy is higher for high educated individuals, while the cost of default is higher for the low educated, which is driven by the fact that many low educated individuals file under chapter 13. The cost of doing both at the same time is effectively infinite and this just reflects the fact that these events are almost never seen to occur simultaneously.

2.8 Policy Experiments

Bankruptcy law is a form of insurance against the worst kind of shocks. In effect it puts a floor on consumption when events occur that prevent individuals from repaying debts. This of course allows individuals to borrow amounts that they may not be able to repay, contrary to the standard Ayagari model where the amount borrowed is bounded by the amount individuals can repay with certainty. Like most insurance systems it comes with its share of moral hazard, which depends on the institutional framework providing this insurance. For example if there is unlimited homestead exemption there is an incentive to store all assets in housing and then default on ones debt. It is this kind of behaviour that the BAPCA tried to eliminate by requiring individuals with higher incomes to file under Chapter 13. But then again, income can be manipulated through changes in labour supply, which is one of the moral hazard issues with chapter 13. Our model includes all these elements and now we proceed to understand the effects on behavior and the welfare value of alternative arrangements for managing bankruptcy and mortgage default taking into account the effects on the cost of credit and of course the changes in the behaviour of individuals.

The key policy parameters we consider are the amount of homestead exemption and whether non-housing equity can be used to repay mortgage loans following default. In addition, given the recent reforms on who can file under chapter 7 vis a vis chapter 13 an interesting question is how should this be regulated and what is the effect on behaviour of wage garnishings. We consider these issues based on our model simulations.

In this section we report results from policy experiments where we change three parameters: firstly, the extent to which lenders have recourse (controlled by a parameter ϕ, which is the proportion of debt that is rolled over); secondly we vary the level of means testing that is applied before an individual is allowed to file for chapter 7; and finally we will be looking at the effects of changing the level of homestead exemption.

2.8.1 Reducing the level of Homestead exemption

In the first experiment we set homestead exemption to a value close to zero. We measure homestead exemption in terms of median income, which is normalized to unity. The baseline value of homestead exemption is 0.5, meaning that we assume that a value of half of median income may be exempt in bankruptcy, which is consistent with the legal framework we consider in our estimations.

Table 2.8 shows the key results. As we expect, filing under chapter 7 declines to a third of its baseline value since fewer assets can be preserved in the event of bankruptcy, while there is a small increase in filing under chapter 13. Overall bankruptcy rates fall, which results in an interest rate reduction on average of 1 percentage point. This reflects precicely the tradeoff motivating the paper. Credit becomes cheaper and thus more available, but the level of insurance declines. It turns out that the disutility of reduced insurance outweighs the benefits of the decline of interest rates: individuals are willing to give up 0.52% of lifecycle consumption for the original higher exemption level. This is despite the reduction in the cost of credit for young people. The lifecycle profiles of average unsecured interest rates are shown in Figure 2.9 while Figure 2.10 illustrates the lifecycle profile of bankruptcy. The highest reductions occur for young individuals because they have the highest probability of bankruptcy. At the same time they are those who are most liquidity constrained. The implication of these results is that the homestead exemption provides insurance desired by consumers, despite the increased costs of credit.

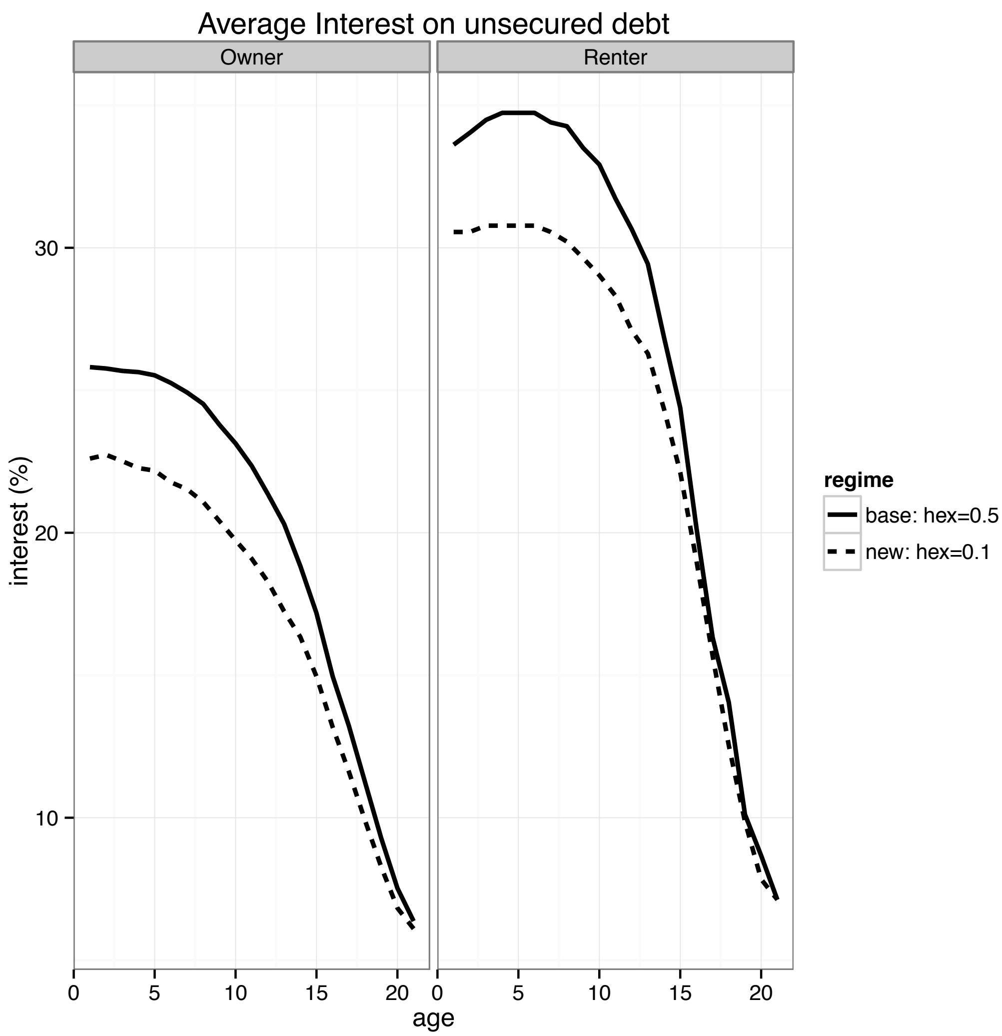

Figure 2.9: Homestead exemption experiment: This graph shows the average interest rate for unsecured debt charged to an average owner and renter over the lifecycle in both regims.

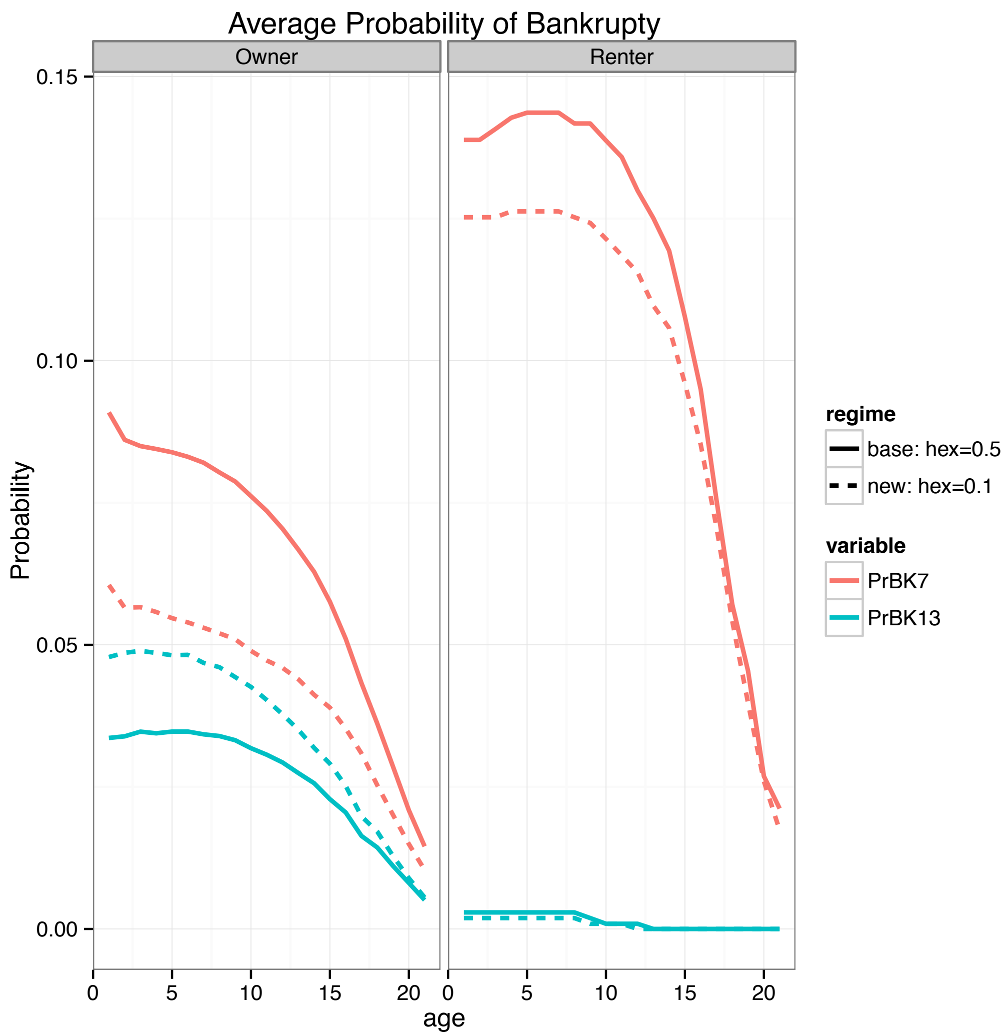

Figure 2.10: Homestead exemption experiment: Probability of Bankruptcy for average owner and renter over the lifecycle in both regims.

Variable	baseline: hex=0.5	policy: hex=0.1
Prob BK7 (%)	1.75	0.56
Prob BK13 (%)	0.75	0.77
Interest Rate (%)	6.03	5.19
Labor supply	0.99	0.99
Consumption	0.60	0.60
Mortgage Debt	2.29	2.26
Equity	3.19	3.13
Willingness to Pay (%)	-	-0.53%

Table 2.8: Statistics for setting homestead exemption (hex) to 0.1.

2.8.2 Changing the level of recourse

Another important element of the law is the extent to which mortgage debt is carried forward following default and foreclosure. If for example one defaults and after selling off the house the mortgage lender is still owed, say, $100,000 to what extent can the lender go after other assets to cover the shortfall. We experiment by increasing the level of recourse from 10% to 25% of the shortfall.

The summary of results can be found in Table 2.9. Bankruptcy rates go up because an increase in the rollover fraction means that defaulting on the mortgage creates unsecured debt. More unsecured debt means more bankruptcies, which means that interest rates are pushed up by nearly 0.5% on average. The result is a decline in overall welfare equivalent to a reduction in consumption of 0.61% over the lifecycle. Mortgage defaults decline markedly as a result of this reform while figure 2.11 shows the lifecycle profile of the reduction in interest rates for owners - renters do not have an increased incentive to default and hence do not face a higher cost of borrowing. The implication of this simulation is that increasing the amount of recourse is welfare reducing, because it reduces the amount of insurance.

Variable	baseline: rollover=0.1	policy: rollover=0.25
Prob BK7 (%)	1.75	2.01
Prob BK13 (%)	0.74	0.87
Interest Rate (%)	6.03	6.48
Labor supply	0.99	0.99
Consumption	0.60	0.60
Mortgage Debt	2.28	2.24
Equity	3.19	3.21
Willingness to pay(%)	-	-0.61%

Table 2.9: Statistics for setting rollover=0.25.

Since banks can go after a greater proportion of remaining mortgage debt after default. However, this simulation does not take into account the potential declines in mortgage interest rates, as a result of the higher level of recourse. Such a decline in mortgage rates would counteract the welfare decline shown here and may even reverse the result.

2.8.3 Making the BAPCPA meanstest more stringent

The BAPCPA meanstest states that anyone with income above state median income is barred from filing for chapter 7. In this experiment we lower the means test all the way to zero earnings, essentially barring everyone with any labor income from filing for chapter 7. We see this illustrated in figure 2.14, where effectively no one files for chapter 7, since very few people in the model have zero earnings, and if they do, they are unlikely to be able to take out any unsecured loans.

Closing down the option of chapter 7 does not change chapter 13 filings and reduces interest rates substantially. Since this latter channel is still available the level of insurance provided seems sufficient, which is reflected in a willingness to

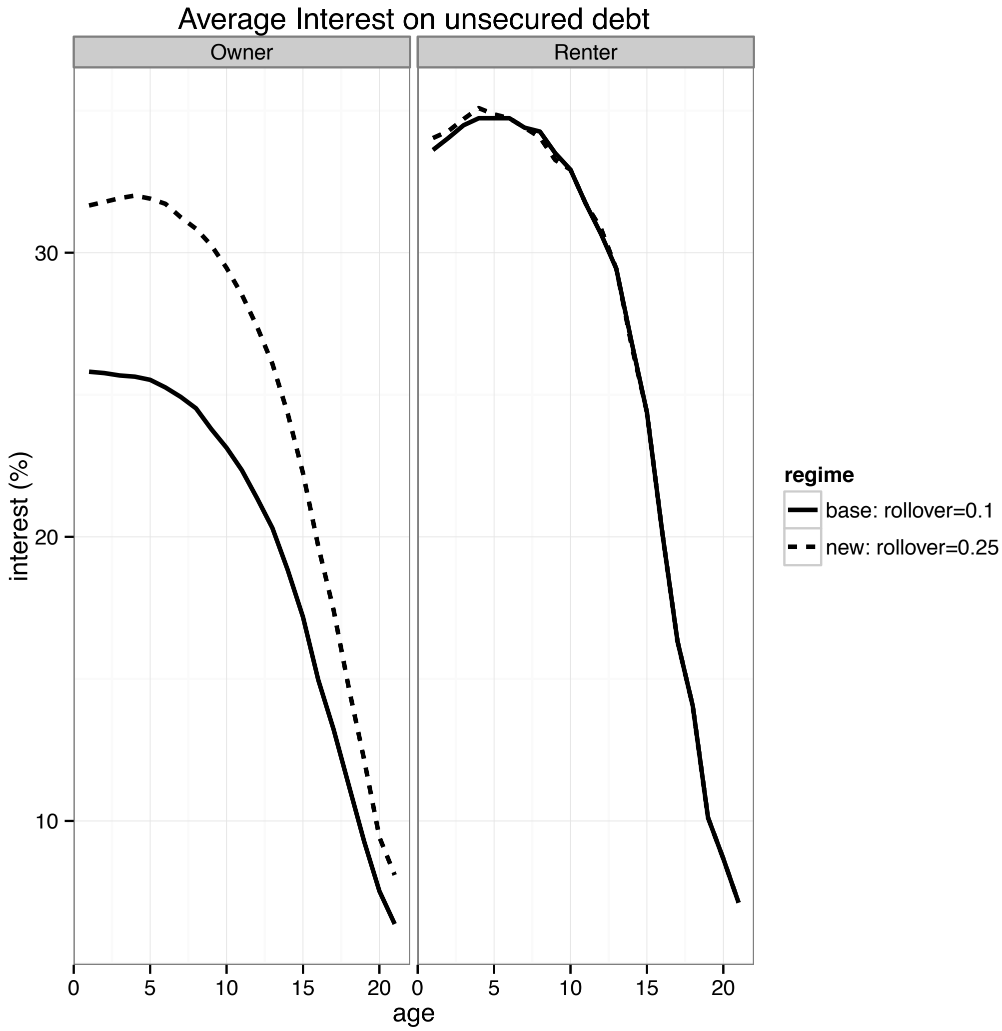

Figure 2.11: Average interest rates on unsecured debt when increasing the level of recourse given to mortgage lenders.

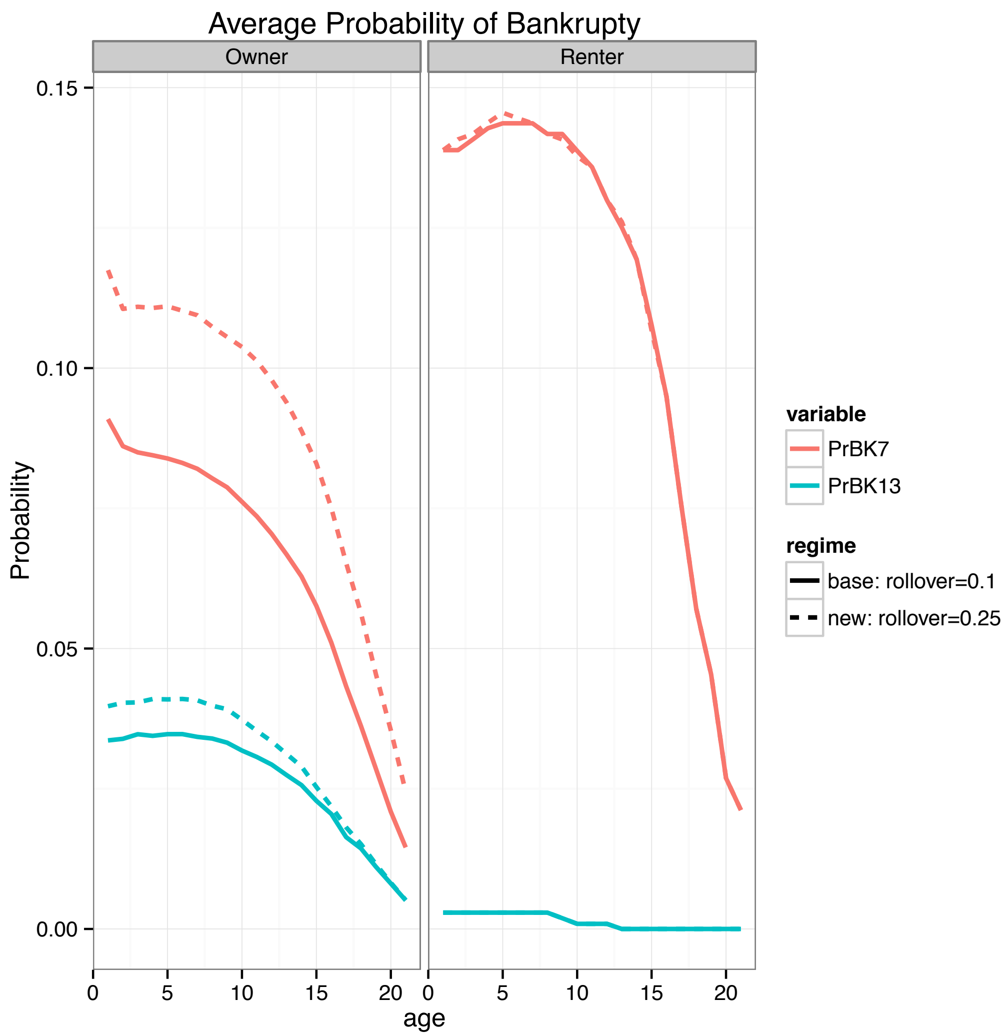

Figure 2.12: Average probability of bankruptcy when increasing the level of recourse given to mortgage lenders.

Variable	baseline: meanstest=1	policy: meanstest=0
Prob BK7 (%)	1.77	0.03
Prob BK13 (%)	0.74	0.73
Interest Rate	6.03%	4.92%
Labor supply	0.99	0.99
Consumption	0.60	0.60
Mortgage Debt	2.29	2.29
Equity	3.19	3.10
Willingness to Pay (%)	-	0.65%

Table 2.10: Statistics of reducing BAPCPA meanstest to 0: nobody with any labor income can file for chapter 7 bankruptcy.

pay for this reform of about 0.65% of lifecycle consumption. Here is an interesting example of a reform which reduces options and thus moral hazard, but leads to aggregate welfare improvements.

2.9 Conclusions

We specify and estimate a rich model of consumption, housing demand and labor supply in an environment where individuals may file for bankruptcy or default on their mortgage. Uncertainty in the model is driven both by house price shocks and income shocks, while bankruptcy is governed by the basic institutional framework in the US as implied by chpater 7 and chapter 13.

The aim of the paper is to offer a framework for understanding and evaluating alternative systems for bankruptcy protection and mortgage default. These systems provide some insurance against important adverse shocks to individuals but also generate moral hazard and increase the costs of credit. Understanding how these

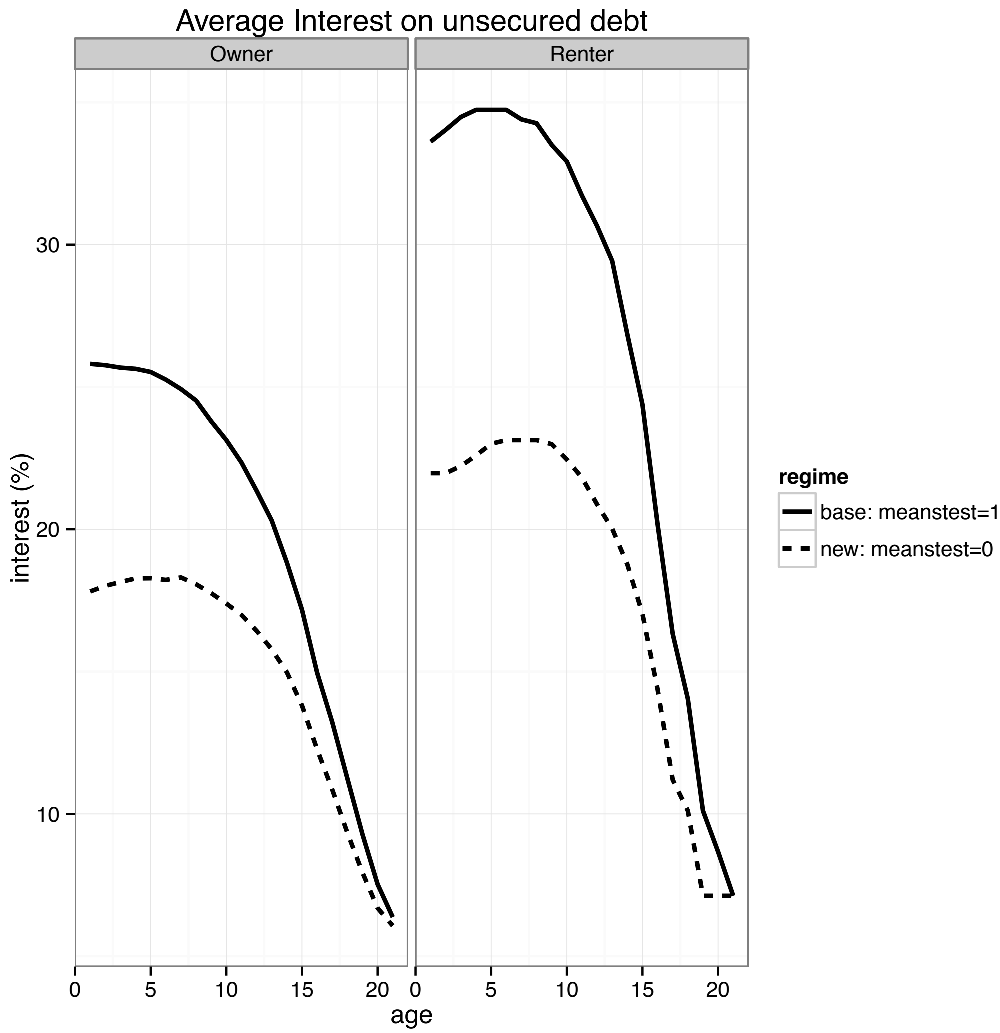

Figure 2.13: Average interest rates when the BAPCPA meanstest is made more stringent.

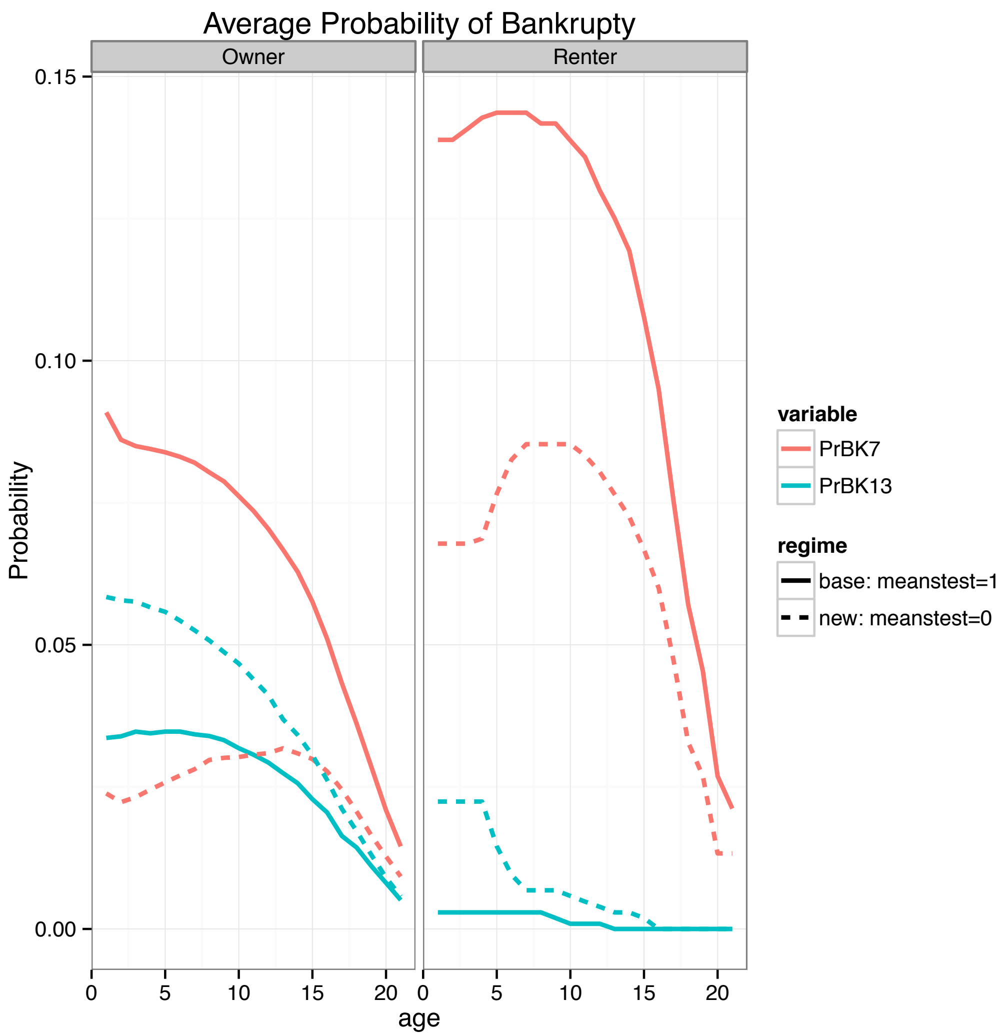

Figure 2.14: Average probability of bankruptcy when making the BAPCPA meanstest more stringent.

effects should be weighed against each other and evaluating the overall welfare effects of such legislation is key for evidence based design of legislation.

The model is estimated using a combination of data from credit records and mortgages together with individual level data from the American Community Survey. We then use the model for counterfactual simulations to address the questions raised above.

We simulate three reforms all of which tend to reduce the amount of insurance offered by the bankruptcy system: one where we reduce the homestead exemption, one where we increase the amount of non-housing assets that lenders can access after a mortgage default (degree of recourse) and one where any positive earnings disqualifies one from filing under chapter 7. The underlying trade-offs between reduction in moral hazard and changes in the cost of credit for unsecured loans are different in each case and it turns out that the first two reforms are welfare reducing, while the latter is welfare increasing. This demonstrates that bankruptcy reform invloves a delicate balancing act between the various forces at hand and consequently the way it is carried out must carefully balance the various alternatives.

Chapter 3

Regional Shocks, Migration and Homeownership

3.1 Introduction

Homeownership and the likelihood of moving across regions are negatively correlated. This negative correlation has important implications when considering the insurance mechanisms available to consumers in the face of regional shocks to housing and labor productivity in a world of incomplete markets. The possiblity of moving to another region in the event of a shock is a way to self-insure against tail risk.

The aims of this paper are first to investigate the value of this self insurance mechanism, second to analyse the reaction of regional mobility to regional shocks and third to establish how important government policies such as the mortgage interest tax deduction, which encourages ownership, interact with regional migration. To address those issues, I propose a lifecycle model of consumption and savings, housing tenure and location choice, with aggregate uncertainty which affects prices in regions differentially. Migration serves as a partial insurance device because regions are exposed to aggregate shocks to a different degree, consistent with the observed data. The lifecycle considerations have important implications for the analysis of welfare impacts of policy changes, since age groups are differentially affected.

Regional shocks to labor demand and house prices may have profound and longlasting impacts, as we are still witnessing in the aftermath of the 2007 fall in house prices and ensuing Great Recession. In this episode we have seen wide variation in the magnitude of local shocks despite underlying high national correlations. For example, the peak-to-trough decline in the Federal Housing Financing Agency (FHFA) house price index from 2007 to 2011 ranged from -2.3% in Pittsburgh, to -61% in Las Vegas.[1] The decline of the automobile industry in Detroit provides a vivid example of the effects of a permanent shock to labor income in a region: from the 1950 to the 2010 censuses, the population of Detroit declined by 61%.

Shocks to regional labor demand affect renters and owners in a similar way, i.e. labor income of both falls. The effects of a fall in house prices is more nuanced, since renters stand to benefit from cheaper rent, if this is related to prices, while owners may loose wealth invested in the house. Furthermore, if house prices reflect the value of local amenities in some kind of way, the location becomes less attractive for renters as well as for owners. For those reasons, we should expect to see different reactions in the mobility of renters and owners in response to different shocks. Labor market shocks should make both types more likely to leave the region, while price

[1] This refers to FHFA expanded house price index data for the 50 largest MSAs in the USA. Available at http://www.fhfa.gov/DataTools/Downloads/Documents/HPI/HPI_EXP_metro.txt

shocks could have differential impacts, depending on the relative importance of cheap rents, low value housing asset, lower amenity values, and moving costs for renters and owners.

In 2013, 63% of occupied housing units in the US were owned, while 37% were rented.[2] At the same time, roughly 1.3% of the population migrate across US census division boundaries per year. Conditioning on ownership we find that 1.9% of renters and 0.67% owners move. A natural question is then to ask why do we observe owners moving less? All else equal, owners face higher moving costs, both in terms of financial as well as time and effort costs. Financial costs occur because of transaction costs in the housing market upon sale of the house (e.g. agency fees or transaction taxes), while costs of effort arise from owners having to spend time finding a suitable buyer, meet with agents and lawyers etc. A comparable renter is subject to those costs only to a lesser degree. Buying a house means to make a highly local financial investment, which is subject to shocks as discussed above, is relatively illiquid, and in addition may have a location specific flow of utility. Consumers may have preferences for locations. These factors interact to shape the joint decision of housing tenure, location choice, and mortgage borrowing. What is more, they all interact to influence the decision to move in response to a shock.

In the model I develop, there are several mechanisms which affect the home ownership choice of individuals. A downpayment requirement means that only individuals with sufficient cash on hand are able to buy a house at the current price. The model assumes a preference for owner-occupied accomodation, which also influences

[2] see American Community Survey 2013, table DP04.

the buying decision next to age, the probability of moving, and beliefs about future shocks.

In terms of the decision to migrate to another region, the model predicts that the likelihood of migration is increasing in the difference of discounted expected lifetime utilities between any two regions. Those relative utilities, in turn, depend among other things on the average regional income level and the level of regional house prices, both of which vary over time. Allowing regional characteristics to vary is a significant contribution to the literature on dynamic migration models such as for example Kennan and Walker (2011), since it provides an additional reason for agents to move in response to a change in their economic environment, rather than as a result of idiosyncratic preference shocks alone. Including time-varying location characteristics, however, increases computational demands substantially. To keep those demands tractable, the model employs a factor structure which allows aggregate shocks to affect regions differently.

I estimate the model using a simulated method of moments estimator. I find that the model fits the data very well along the main dimensions of interest, which are mobility and ownership patterns over the lifecycle, ownership rates by region, as well as wealth accumulation over the lifecycle and by region. After fitting the model to the data, I first illustrate how adding ownership and assets to a dynamic migration model affects behaviour. I then show how the model reacts to large regional shocks, before I move on to compute a measure of the value of the migration option. Finally, the model is used to perform counterfactual policy simulations.

I find that owners and renters face very different incentives in the model. The probability of moving conditional on being a renter is consistently higher than the one for owners, and it varies considerably with income and assets. The model can be used to quantify the moving cost in terms of dollars, and I find that the estimates for renters and owners bracket the moving cost obtained in Kennan and Walker (2011).

Migration is a low probability event in both data and model. Nevertheless, the welfare implications are large. I conduct an experiment whereby moving away from a certain region is prohibited. I compute the expected lifetime utility of agents in the region under both scenarios, and I find that removing the option to move away from the region reduces expected utility by 5.1%. This implies that residents of this region would demand a 4.4% increase in per period consumption over their lifecycle in order to be indifferent to the baseline environment. Conditioning on age when computing expected utility reveals that the cost of not being able to move is largest for younger individuals, and it gradually fades out as agents grow older.

Government policies might help to increase labor market efficiency, housing market inefficiency or both. The main inefficiencies any policy might target are incomplete asset markets, liquidity constraints, moving and transaction costs, income taxes and imperfect rental markets. One large pre-existing intervention in this context is the mortgage interest deduction. It is interesting to consider how abolishing this tax deduction might interact with borrowing, housing tenure choice and migration.

I find that abolishing the mortgage interest deduction would have a only a negligible impact on the aggregate migration rate. At first sight one might be tempted to think that removing the deduction would result in more renters, which would mechanically translate into an increase in migration, since renters move more. The actual effect is more nuanced. First, because the mortgage tax deduction is a large scale policy, there is likely to be a general equilibrium effect. While my model is a partial equilibrium model, I can approximate the general equilibrium effect by assuming that the policy changes both taxes as well as prices. I use recent results from a stationary GE model by Sommer and Sullivan (2013) who find that house prices fall, while rents keep constant, after the policy is changed. Applying this price and rent correction to my model results in an increase in the ownership rate of roughly 1%, because more households are able to buy at lower prices. The net effect on migration is very small (0.1% of the baseline rate). The reduction in mobility is smaller than what we would expect from a pure change in composition towards more owners, because migration behaviour changes as well. Lower prices and a higher level of disposable income for the poor after redistribution of tax proceeds in all regions change the incentives to exploit regional differences with respect to the baseline. In terms of welfare, households prefer removing the deduction and would agree to giving up 2.4% of period consumption before being indifferent to the status quo.

Literature. My paper builds on Kennan and Walker (2011), who are the first to develop a model of migration with multiple location choices over the lifecycle. Their main finding is that expected income is an important determinant of migration decisions, and their framework requires large moving costs to match observed migration decisions. Gemici (2007) focuses on migration decisions of couples with two working spouses and finds that, for this subgroup, family ties can significantly hinder migration decisions and wage growth. Winkler (2010) is a recent paper that extends Gemici (2007) to include housing choices and focuses on the response of owners to individual labor market shocks.

The main differences to this paper are the way I model regional price and income dynamics and the assumption about how job search takes place. Regarding regional dynamics, I am able to allow for shocks which are correlated across regions and with an aggregate component that is persistent, while they are assumed to be independent in Winkler (2010). I follow Kennan and Walker (2011) in assuming that individuals must visit a location in order to discover the exact value of their new wage, over and above a predictable part, while Winkler (2010) assumes that job offers arrive in the current location from a random alternative location. My assumption implies firstly that individuals consider all potential locations in each period, and decide to move based on their expectations about how they will fare in each. Secondly it allows for reasons other than job offers to trigger a move, which is a feature of the data, as I will show below. Finally, it is interesting to note that when simulating the effects of abolishing the mortgage interest deduction, I correct for a GE effect on house prices, which is likely to occur as a result of the policy change, and I enforce revenue neutrality by redistributing saved tax receipts, which is not done in his paper. I find that that welfare implications strongly depend on those features.

By considering regional shocks, this paper is also related to the seminal contribution of Blanchard and Katz (1992). In light of state-specific shocks to labor demand, the authors find that after an adverse shock, the relocation of workers is one of the main mechanisms to restore unemployment and participation rates back to trend in an affected region. Related to this, Notowidigdo (2011) analyses the incidence of local labor demand shocks on low-skilled workers in a static spatial equilibrium model and finds that they are more likely to stay in a declining city than high-skilled workers to take advantage of cheaper housing.[3] The same mechanism operates in my model. Furthermore, the dynamic nature of my model allows me to evaluate the response of migration to shocks over time.

Also related is a recent literature that considers the effects of the 2007 housing bust on labor market mobility. In terms of empirical contributions, Ferreira et al. (2010), Schulhofer-Wohl (2011) and Demyanyk et al. (2013) look at whether negative equity in the home reduces the mobility of owners and report mixed findings. The first paper finds an effect, whereas the next two do not, with the difference arising from different datasets and definitions of long-distance moves. More theoretical papers like Head and Lloyd-Ellis (2012), Nenov (2012), Song et al. (2014) and Karahan and Rhee (2011) use search models of labor and housing markets to look at geographical mismatch in order to understand how a fall in house prices affects unemployment and migration rates. The last paper, in particular, formalizes the negative equity lock-in notion in a model with two locations and finds only a moderate effect of lock–in on the increase in unemployment. The present paper differs from this group of contributions by assuming multiple locations and by adopting a life-cycle framework.[4]

Finally, the paper relates to the literature on tax treatment of housing and ownership. The federal tax code in the United States allows households to deduct mortgage interest payments from Federal taxes. Glaeser (2011) and Glaeser and

[3] See Moretti (2011) for a comprehensive overview of this literature going back to Roback (1982) and Rosen (1979), and Diamond (2012) and Piyapromdee (2013) for recent applications.

[4] In general, the relationship between homeownership and labor market mobility or unemployment has been discussed in many other places, and an incomplete list might include Oswald (1996); Blanchflower and Oswald (2013), Coulson and Fisher (2002), Güler and Taskın (2011), Battu et al. (2008) or Halket and Vasudev (2014).

Shapiro (2002) respectively discuss the benefits and distortions generated by this policy, and Poterba and Sinai (2008) provide an estimate of the financial benefit to owners from it. Sommer and Sullivan (2013) is a recent contribution that analyses the policy in a GE framework. I evaluate the effect of removing the deduction on both homeownership and mobility.

This paper merges housing demand over the lifecycle, as for example Li et al. (2014), with dynamic migration decisions under aggregate and regional shocks. I find that housing is an important feature of the individual migration decision. The likelihood of moving depends not only on whether or not the individual owns their house and on their asset holdings, but also on the price and income levels in all potential destination regions. The value of the migration option to actual migrants is very large.

3.2 Empirical Background

The amount of regional migration in the US is still high by international standards. According to Molloy et al. (2011), who use three publicly available datasets (American Community Survey (ACS), the Annual Social and Economic Supplement to the CPS (March CPS), and Internal Revenue Service (IRS) data), each year roughly 1.5% of the entire population moves between two out of four census regions, and about 1.3% move between states within any one region. At a more local level, they find that 5% of the population move between counties each year, which amounts to roughly one-third of the annual flows into and out of employment according to the

Period	Geography	% of US population
Annual	county	5
	state	2
	region	1.5
5-year	county	18.6
	state	8.9
	region	4.8

Table 3.1: Migration rates at different levels of geographic aggreagation and over different time spells. Taken from Molloy et al. (2011), computed from ACS, March CPS and IRS data.

measure in Fallick and Fleischman (2004). An overview of migration rates across different regional delineations and over different time spells is shown in table 3.1.

It is somewhat unfortunate that none of the datasets employed by Molloy et al. (2011) are very well suited for the purpose of analysing migration and ownership. None of them tracks movers, so it is impossible to know the circumstances of an individual at the moment they decided to move, which is ultimately of interest in this paper.[5] I therefore use the Survey of Income and Program Participation (SIPP) in this paper, a longitudinal and nationally representative dataset.

Before presenting statistics from SIPP data, I will explain the geographic concept I will be using in this paper, which is a US Census Division. Census Divisions are nine relatively large regions which separate the United States into groups of states "for the presentation of census data"[6]. To a first approximation, those regions represent areas with a common housing and labor market. In the model, a move within any

[5]It is possible to construct a panel dataset from the CPS, but only with postal address as unit identifier. If an individual moves out, this can be inferred from the data, however, the destination of the move cannot – in particular it is unknown whether they relocated withing the city, or somewhere else.

[6]See the Census bureau's website at https://www.census.gov/geo/reference/gtc/gtc_census_divreg.html and figure B.1 for a map.

region is not considered as migration and therefore does not contribute to the overall migration rate. This implies that there is a proportion of moves across markets that do happen in the data, but which are not picked up by my geographic definition of a market.

The aggregation of states into this particular grouping is but one of many possibilities, and I adopt this particular partition based on computational constraints. In many respects the ideal concept of a region is what economists would refer to as a local labor market, and metropolitan statistical areas (MSA) or commuting zones (CZ) come close to this. Unfortunately, for the purpose of the model in this paper, the so–defined number of regions would be far too large to be computationally feasible. Hence the choice of census divisions.[7]

Descriptive Statistics on Cross Division Migration. I combine four panels of SIPP data (1996, 2001, 2004 and 2008) into a database with 102,529 individuals that I can follow over time and space. From this dataset, a couple of interesting facts emerge. Table 3.2 presents some summary annual moving rates for both state and Census Division level migration. The overall unconditional migration rate is 1.95% and 1.32% per year for cross state and cross division, respectively. The cross state figure differs from the 2% in table 3.1 because I set up the SIPP data in terms of household heads, thereby missing some moves of non–reference persons, and potentially because of sample attrition. It is quite clear from table 3.2 that there

[7]The model presented below contains 25.4 million different points in the state space at which to solve a savings problem. Increasing the number of regions to 51 (to represent US states) increases this to 815 million points in the state space. Given that estimation requires evaluation of the model solution many times over, the former state space can be handled with code that is highly optimized for speed, while the latter cannot.

is a marked distinction in the likelihood of moving across state as well as division boundaries between renters and owners, with 2.6% (1.85%) of renters versus 0.93% (0.7%) of owners moving across state (division) boundaries on average per year. In total I observe of 2684 cross Division moves made by 2329 unique individuals, implying multiple moves for some movers, see table 3.3.[8]

Moving on to migration by age, we can see in figure 3.1 firstly that renters are more likely to move at all ages, and secondly that there is a strongly declining age effect – younger individuals move more. Both of those are highly salient features of the data, and they are the main dimension along which my model's performance is going to be evaluated. Finally, a summary regarding homeownership rates and median price to income ratios by Census division is presented as an average over the years 1997–2011 in table 3.4.

Determinants of Migration. The March Supplement to the Current Population Survey (CPS) contains several questions relevant for the study of migration. Here I analyse answers to the 2013 edition of the CPS to the question "What was the main reason for moving". The results are displayed in table 3.5. It is striking to note that even though we are conditioning on moves across Division boundaries (and thus think of long-range moves), the percentage of people citing "housing" as their main motivation is roughly 24% of the total population of movers. The table also disaggregates the response to the question by the distance between origin and destination state (not Division), and we can see that the proportion of respondents does vary with distance moved, but not to an extent that would suggest that housing

[8] Just for comparison, the estimation sample in Kennan and Walker (2011) is drawn from the geo-coded version of NLSY79 and contains 124 interstate moves.

becomes irrelevant as a motivation with increasing distance. Summing up in the bottom row of the table, we see that 55% say work was the main reason, 24% refer to housing and the remaining 21% is split between family and other reasons.

In table 3.6 I present estimates from a statistical analysis of the determinants of cross division moves from SIPP data. I regress a binary indicator for whether or not a cross division move took place in a given year on a set of explanatory variables which relate to the household in question in a probit regression. The table shows marginal effects computed at the sample mean of each variable, as well as the ratio of marginal effects to the baseline unconditional probability of moving (1.32%). The results indicate that there is a pronounced age effect, with each additional year of age implying a reduction that is equal to 6% of the baseline probability. The same effect is found for whether or not children are present in the household. The effect of being a homeowner is very large and equivalent to a reduction in the propensity to move of 51% of the baseline probability. Increasing household income by $100,000 is equivalent to a 5% baseline baseline increase. Finally, having a college degree has an effect of equal magnitude than being a homeowner, but in the opposite direction: a college degree amounts to an increase of the baseline of 49%. According to this model, the effect of being a homeowner on the baseline moving probability is equal to an age increase of 8.3 years, thus taking a 30-year old to age 38; also, a household which owns the house would have to experience an increase in household income of $1m in order to make up for the implied loss in the probability of moving across divisions from being an owner. The house price to income ratio does not play a significant role in this specification.

	Cross State	Cross Division
Overall	1.95 %	1.32 %
Renter	2.60 %	1.85 %
Owner	0.93 %	0.70 %

Table 3.2: Annual moving rate in percent of the population. Households are categorized into "Renter" or "Owner" based on their homeownership status at the beginning of the period in which they move. SIPP data.

	1	2	3	4	5
Renter	1202	98	12	2	1
Owner	936	73	5	0	0

Table 3.3: Distribution of the number of moves per mover by homeownership status. Households are categorized into "Renter" or "Owner" based on their homeownership status at the *first* move. SIPP data.

Division	Abbreviation	Ownership Rate	$\frac{p}{y}$
South Atlantic	StA	0.63	2.59
West North Central	WNC	0.69	2.08
East North Central	ENC	0.66	2.30
New England	NwE	0.60	2.99
Middle Atlantic	MdA	0.57	2.66
Pacific	Pcf	0.51	3.74
West South Central	WSC	0.60	1.95
East South Central	ESC	0.65	1.85
Mountain	Mnt	0.61	2.83

Table 3.4: Census Division housing characteristics. Shows average ownership rates over 1997–2011 and median price to income ratios for the same period. The (unobserved) house price for renters is computed assuming an implied user cost of owning of 5%, i.e. $p_{rent} = \frac{rent}{0.05}$.

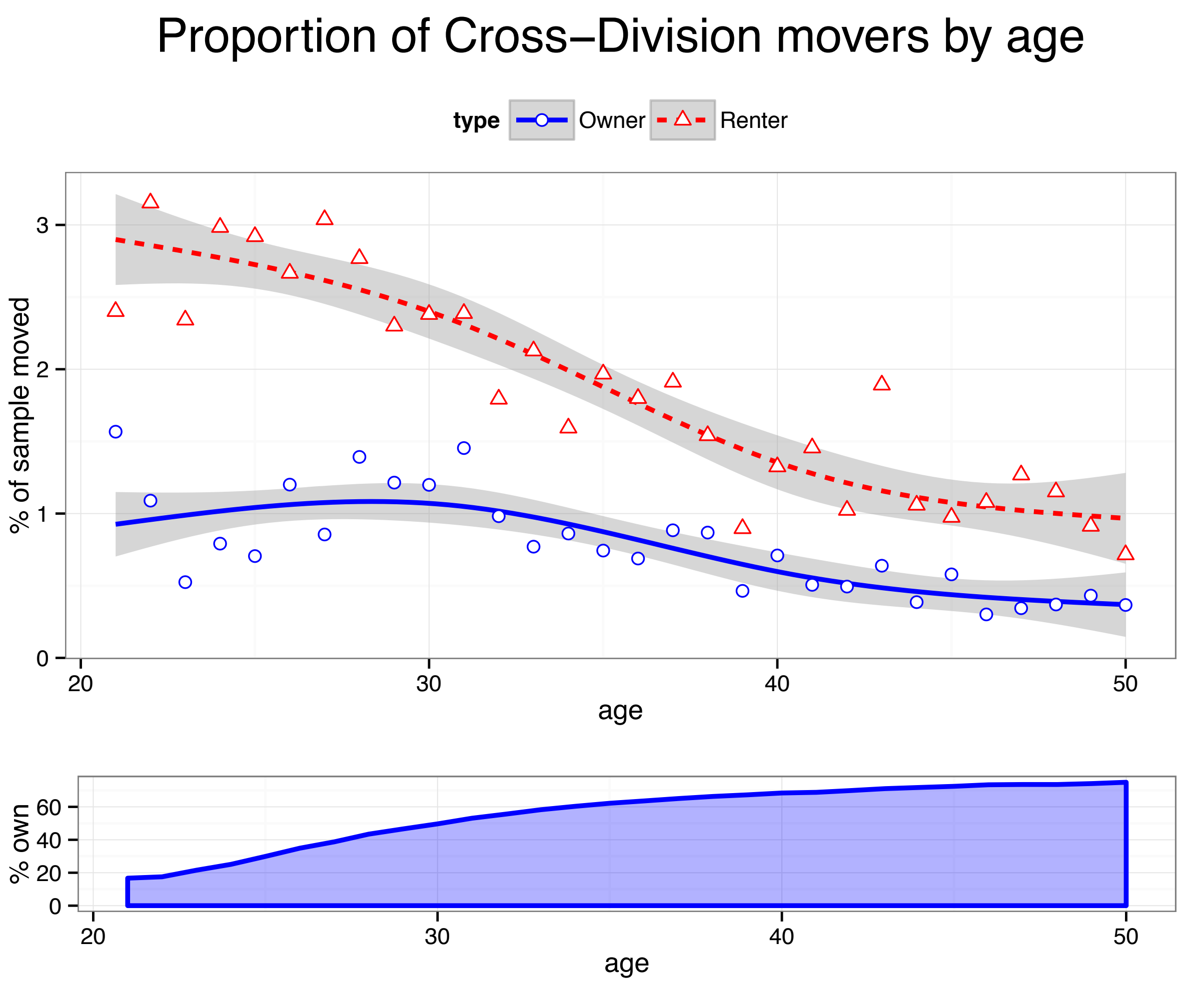

Figure 3.1: SIPP sample proportion moving across Census Division boundaries by age (upper panel) and proportion of owners by age (lower panel).

	Main Reason			
Distance Moved (KM)	Work	Housing	Family	Other
<718	47.9 %	23.2 %	22.7 %	6.1 %
(718,1348]	55.3 %	25.7 %	16.7 %	2.3 %
(1348,2305]	51.6 %	24.1 %	22.5 %	1.8 %
(2305,8087]	65.5 %	22.7 %	11.1 %	0.7 %
Total	55 %	23.9 %	18.3 %	2.7 %

Table 3.5: CPS 2013 data on main motivation of moving, conditional on a cross Division move. This selects a sample of 20-50 year-olds and aggregates the response to the question "What was the main reason for moving" (variable NXTRES) as follows. Work = {new job/transfer, look for job, closer to work, retired}, Housing = {estab. own household, want to own, better house, better neighborhood, cheaper housing, foreclosure, other housing}, family = {change marstat, other fam reason}, other = {attend/leave college, climate change, health, natural disaster, other}. The distance of a move is computed as the distance between geographic center of the *state* of origin (not Division) and the center of the destination state. The rows of the table categorize the distance measure into its quartiles.

	Marginal Effects	ME/baseline
Intercept	-0.0250^{***}	
	(0.0020)	
Age	-0.0008^{***}	-0.06
	(0.0001)	
Age Squared	0.0000^{***}	0.0
	(0.0000)	
Children in HH	-0.0008^{**}	-0.06
	(0.0003)	
Homeowner	-0.0067^{***}	-0.51
	(0.0004)	
Household income	0.0006^{**}	0.05
	(0.0003)	
Total wealth	0.0000	0.0
	(0.0001)	
College	0.0063^{***}	0.48
	(0.0004)	
Price/Income	0.0000	0.0
	(0.0000)	
Deviance	28793.7099	
Dispersion	1.0261	
Num. obs.	294840	

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 3.6: Determinants of cross census division moves in SIPP data. Household income and wealth are measured in 100,000 USD. This regresses a binary indicator for whether a cross division move takes place at age t on a set of variables relevant at that date. The first column shows marginal effects, the second column shows the marginal effects relative to the unconditional baseline mobility rate of 0.0132. The interpretation of this column is for example that the effect of being a homeowner is equivalent to reducing the baseline probability of migration by 51%.

3.3 Model

In the model I view households as a single unit, and I'll use the terms *household* and *individual* interchangeably. Individuals are assumed to live in census Division (or *region*) $d \in D$ for a total of T years of age. At each age t, individual i has to decide whether to move to a different region, whether to own or rent, and how much of his labor income to save. Individuals derive utility from consumption c, from owning a house h and an unobservable location preference shock.

Individuals are subject to uncertainty at both the aggregate and individual level. At the aggregate level, regional house price p and average labor productivity levels q fluctuate. This allows some scope for regional migration as an insurance mechanism. The regional fluctuations are driven by a common set of low dimensional stochastic factors denoted P and Q. This reflects the fact the regional shocks to both house prices and average labor income are highly correlated. It also allows for fluctuations in the underlying aggregate factors P and Q to have differential impacts across regions, while maintaining a degree of computational tractability. Every individual in region d faces an identical level of house price p_{dt} and mean labor productivity q_{dt} at time t. In addition to that, q_{dt} enters the individual wage equation as a level shifter. At the individual level uncertainty enters the model through an idiosyncratic component of income risk, a Markovian process that models changes in household size over the lifecycle, and a location–specific preference shock, which is assumed identically and independently distributed across agents, regions and time.

The job search process is modeled as in Kennan and Walker (2011). Individuals do not know the exact wage they will earn in the new location. The new wage is composed of a deterministic, and thus predictable, part and a component that is random. Over and above an expectation about some prevailing average level of wages the mover can expect in any given region at time t, it is impossible to be certain about the exact match quality of the new job ex ante. The new job can be viewed as an experience good where quality is revealed only after an initial period. This setup gives rise to income risk associated with moving.

3.3.1 Individual Labor Income

The logarithm of labor income of individual i at age t, residing in region d, is defined as in equation (3.1).

$$\begin{aligned} \ln y_{idt} &= \eta_d \ln q_{dt} + f(t) + z_{it} \\ z_{it} &= \rho z_{it-1} + e_{it-1} \\ e &\sim N(0, \sigma^2) \end{aligned} \tag{3.1}$$

Here q_{dt} stands for the region specific price of human capital, $f(t)$ is a deterministic age effect and z_{it} is an individual specific persistent idiosyncratic shock. The coefficient η_d allows for differential transmission of regional shocks into individual income by region d. The log price of human capital q_{dt} is allowed to differ by region to reflect different industry compositions by region, which are taken as given.[9]

[9] Underlying this is an assumption about non–equalizing factor prices across regions. It is plausible to think that within a single country, wages should tend to converge to a common level, particularly in the presence of large migratory flows from one region to the next. In assuming no relative factor price equalization across US regions I rely on a host of evidence showing that relative wages vary considerably across regions over a long time horizon (see for example Bernard et al. (2013)).

When moving from region d to region d' at date t, I assume that the timing is such that current period income is earned in the origin location d. The individual's next period income is then composed of the corresponding mean income at that date in the new region d', $q_{d't+1}$, the deterministic age $t+1$ effect, $f(t+1)$, and a new draw for z_{it+1} conditional on their current shock z_{it}. For a mover, this individual–specific idiosyncratic component is drawn from a different conditional distribution than for non-movers. Let us denote the different conditional distributions of z_{it+1} given z_{it} for stayers and movers by G_{stay} and G_{move}, respectively. This setup allows for some uncertainty related to the quality of the match with a job in the new region d', as mentioned above. The shape of G_{move} determines the probability with which a mover with current value z can expect to draw a new value z' after moving to d'. The data will be informative about whether there is mean reversion or high persistence in G_{move} for movers.

3.3.2 National factors P and Q

I assume the national state variables Q and P evolve according to a stationary vector autoregression of order one (VAR(1)). At date t, all individuals observe the price vector $\mathbf{F}_t$ containing both factors P_t and Q_t. The VAR(1) process is defined in equation (3.2), where A is a matrix of coefficients and Σ is the variance-covariance matrix of the bivariate normal innovation ν. Agents in the model have rational expectations concerning this process.

$$\begin{aligned}\mathbf{F}_t &= A\mathbf{F}_{t-1} + \nu_{t-1} \\ \nu_t &\sim N\left(\begin{bmatrix}0\\0\end{bmatrix}, \Sigma\right) \\ \mathbf{F}_t &= \begin{bmatrix}Q_t\\P_t\end{bmatrix}\end{aligned} \tag{3.2}$$

3.3.3 Mapping aggregate factors to regional prices

I assume that there is a deterministic mapping from the aggregate state $\mathbf{F}_t$ into the price and income level of any region d which is known by all agents in the model. This means that once the aggregate state is known, agents know the price p_{dt} and income level q_{dt} in each region with certainty. The mapping is defined in terms of a linear function that depends on both aggregate states Q, P and where the slope coefficients are region dependent, as shown in expression (3.3). Similarly to the aggregate case, $\mathbf{a}_d$ is a matrix of coefficients specific to region d.

$$\begin{bmatrix}q_{dt}\\p_{dt}\end{bmatrix} = \mathbf{a}_d\mathbf{F}_t \tag{3.3}$$

I provide some illustration regarding the fit this model provides to the data in section 3.5.1, where I describe the estimation of this part of the model in greater detail. Notice that the great virtue of this formulation is that the relevant price and income related state variables in each region are subsumed in $\mathbf{F}_t$, given the assumption that $\mathbf{a}_d$ is known for all d.

3.3.4 Home Ownership Choice

Ownership choice is discrete, $h_t \in \{0, 1\}$, and there is no quantity choice of housing. While renting, i.e. whenever $h_t = 0$, individuals must pay rent which amounts to a constant fraction κ_d of the current region-d house price p_d. Similar to the setup in Attanasio et al. (2012), I denote total financial (i.e. non-housing) wealth at age t as "assets" a_t. This includes liquid savings and mortgage debt. There is a terminal condition for net wealth to be non-negative by the last period of life, i.e. $a_T + p_{dT} h_{T-1} \geq 0$, which translates into an implicit borrowing limit for owners. Additional to that, in order to buy, a proportion χp_{dt} of the house value needs to be paid up front as a downpayment, while the remainder $(1 - \chi)p_{dt}$ is financed by a standard fixed rate mortgage with exogenous interest rate r^m. The mortgage interest rate is assumed at a constant markup $\hat{r} > 0$ above the risk free interest rate r, such that $r^m = r + \hat{r}$. The markup captures default risk incurred by a mortgage lender.

The equity constraint must be satisfied in each period, i.e. $a_{t+1} \geq -(1 - \chi)p_{dt}h_t, \forall t$. This means that only owners are allowed to borrow, with their house as a collateral. Selling the house incurs proportional transaction cost ϕ, such that given current house price p_t, upon sale the owner receives $(1 - \phi)p_t$.

This setup implies that owners will choose a savings path contingent on the current price, their income and debt level, the mortgage interest rate, and their current age t, such that they can satisfy the final period constraint. The setup is formally defined in subsections 3.3.8.1 and 3.3.8.2 which describe the budget constraints.

3.3.5 Moving

Moving Costs. Moving across locations is assumed to be costly in terms of utility. Denote $\Delta(d, x)$ the utility costs of moving from d at a current value of the state vector x (defined below). Moving costs differ between renters and owners. Moving for an owner requires to sell the house, which in turn requires some effort and time costs. This is in addition to any other psychological costs incurred from moving states which are common between renters and owners. I specify the moving cost function as linear in parameters α:

$$\Delta(d, x) = \alpha_{0,\tau} + \alpha_1 t_{it} + \alpha_2 t_{it}^2 + \alpha_3 h_{it-1} + \alpha_4 s_{it} \tag{3.4}$$

In expression (3.4), $\alpha_{0,\tau}$ is an intercept that varies by unobserved moving cost type τ, α_1 and α_2 are age effects, α_3 measures the additional moving cost for owners, and α_4 measures moving cost differential arising from family size s_{it}.

The unobserved moving cost type $\tau \in \{0, 1\}$, where $\tau = 1$ indexes the high type, is a parsimonious way to account for the fact that in the data, some individuals never move. This is of particular relevance when thinking about owners, who may self–select into ownership because they know they are unlikely to ever move. In the model this selection mechanism, together with any other factor that implies a high unobservable location preference, is collapsed into a type of person that has prohibitively high moving costs ($\alpha_{0,\tau=1}$ is large) and thus is unlikely to move.

Restrictions. I rule out the possibility of owning a home in region d while residing in region d'. This would apply for example for households who keep their home in d, rent it out on the rental market, and purchase housing services either in rental or owner–occupied sector in the new region d'. In my sample I observe less than 1% of movers for which this appears to be true, most likely as a result of high managment fees or a binding liquidity constraint that forces them to sell the house to be able to afford the downpayment in the new region.[10]

3.3.6 Preferences

Period utility u depends on which region k the household chooses, and whether this is different from the current region d. A move takes place in the former case, and the household stays in d in the latter case.

$$u\left(c_{it}, h_{it}, d', x_{it}\right) = \frac{c_{it}^{1-\gamma}}{1-\gamma} + \xi(s_{it}) \times h_{it} - \mathbf{1}\left[d \neq d'\right] \Delta\left(d', x_{it}\right) + \varepsilon_{ikt} \tag{3.5}$$

The period t payoff consists of utility from consumption c_{it}, from owning a house, valued differently at different household sizes s_{it}, and the idiosyncratic preference shock for the chosen region d'. Notice the moving cost $\Delta\left(d', x_{it}\right)$ is only incurred if in fact a move takes place. Household size s at age t is a binary random variable, $s \in \{0, 1\}$, relating to whether or not children are present in the household. It evolves from one period to the next in an age-dependent way as described in section 3.3.8.

[10]SIPP allows me to verify whether individuals possess any real estate other than their current home at any point in time. Fewer than 1% of movers provide an affirmative answer to this.

3.3.7 Timing

Timing within the period is assumed to proceed in two sub-periods: in the first part, stochastic states are realized and observed by the agent, and labor income is earned; in the second part the agent makes optimal decisions regarding consumption, housing and location. The chronological order within a period is thus as follows:

1. observe $\mathbf{F}_t$, z_{it} and $\varepsilon_{it} = (\varepsilon_{i1t}, \varepsilon_{i2t}, \dots, \varepsilon_{iJt})$, iid location taste shock
2. earn labor income in current region d, as a function of q_{dt} and z_{idt}
3. given the state, compute optimal behaviour in all D regions, i.e.
   (a) choose optimal consumption c_h^* conditional on housing choice $h \in \{0, 1\}$ in all regions d
   (b) choose optimal housing $h_d^*(c_h^*)$
   (c) choose optimal location, based on the value of optimal housing in each location

There is in fact no timing issue in point 3., as the optimization problem is simultaneous. However, the quasi-cronological order is helpful for emphasizing the interdependence of one choice on another.

3.3.8 Recursive Formulation

It is now possible to formulate the problem recursively. The state vector of individual i at date t is given by

$$x_{it} = (a_{it}, z_{it}, s_{it}, \mathbf{F}_t, h_{it-1}, d, \tau, t)$$

where the variables stand for, in order, assets, individual income shock, household size, aggregate price vector, housing status, current region index, moving cost type and age. Following Rust (1987), I assume additive separability between utility and idiosyncratic location shock ε as well as independence of the transition of ε conditional on x. Furthermore, I assume that $\varepsilon \sim$ EV Type 1.

The consumer faces a nested optimization problem in each period. At the lower level, optimal savings and housing decision must be taken conditional on any discrete location choice, and at the upper level the discrete location choice with the maximal value is chosen. It is useful to define the conditional value function $v(x, k)$, which represents the optimal value after making housing and consumption choices at state x, while moving to location d', net of idiosyncratic location shock ε.

Equation (3.6) is the top level problem of the consumer which requires to choose one of D potential locations. Notice that the value from each discrete choice is additively seperable in the conditional value v and the choice specific idiosyncratic shock ε. The conditional value function (3.7) represents the choices that have to be made conditional on being in a given location d while moving to location d'. This formulation conveniently nests all discrete location choice configurations (staying in d and moving from d to $d', \forall d' \neq d$). The optimization problem is subject to several constraints which are outlined below.

Equation (3.8) is a result of the distributional assumption on ε, which admits a closed form expression of the expected value function, whereby $\bar{\gamma} \approx 0.577$ is Euler's constant.

$$V_t(x_{it}) = \max_{k\in D}\{v_t(x_{it},d') + \varepsilon_{ikt}\} \tag{3.6}$$

$$v_t(x_{it},d') = \max_{c_{it}>0, h_{it}\in\{0,1\}} u(c_{it},h_{it},d_{it},d') + \beta\mathbb{E}_{z,s,\mathbf{F}}\left[\overline{v}_{t+1}(x_{it+1})\,|z_{it},s_{it},\mathbf{F}_t\right] \tag{3.7}$$

$$x_{it+1} = (a_{it+1}, z_{it+1}, s_{it+1}, \mathbf{F}_{t+1}, h_{it+1}, d', t+1)$$

$$\begin{aligned}\overline{v}_t(x_{it}) &= E_\varepsilon V_t(x_{it}) \\ &= \overline{\gamma} + \ln\left(\sum_{d'=1}^{D}\exp\left(v_t(x_{it},d')\right)\right)\end{aligned} \tag{3.8}$$

Another convient by-product of the Type 1 EV assumption is that there is a closed form expression for the conditional choice probability of making a move from d to k when the state is x, denoted as $\mathcal{M}(x,d,d')$.

$$\begin{aligned}\mathcal{M}(x,d,d') &= \Pr\left[\text{move to } d'|x,d\right] \\ &= \frac{\exp\left(v(x,d')\right)}{\sum_{d'=1}^{D}\exp\left(v(x,d')\right)} \\ &= \frac{\exp\left(v(x,d')\right)}{\exp\left(\overline{v}(x)\right)/\exp(\overline{\gamma})} \\ &= \exp\left(\overline{\gamma} + v(x,d') - \overline{v}(x)\right)\end{aligned} \tag{3.9}$$

The final period models a terminal value that depends on net wealth and a term that captures future utility from the house after period T, as shown in equation (3.10).

$$V_T(a,h_{T-1},d) = \frac{\left(a + h_{T-1}p_{dT}\right)^{1-\gamma}}{1-\gamma} + \omega h_{T-1} \tag{3.10}$$

The maximization problem in equation (3.7) is subject to several constraints, which vary by housing status and location choice. It is convenient to lay them out here case by case.

3.3.8.1 Budget constraint for stayers, i.e. $d = d'$

Starting with the case for stayers, the relevant state variables in the budget constraint refer only to the current region d. In particular, given (p_{dt}, q_{dt}), renters may choose to become owners, and owners may choose to remain owners or sell the house and rent.

Renters. The period budget constraint for renters (i.e. individuals who enter the period with $h_{it-1} = 0$) depends on their housing choice, as shown in equation (3.11). In case they buy at date t, i.e. $h_{it} = 1$, they need to pay the date t house price in region d, p_{dt}, otherwise they need to pay the current local rent, $\kappa_d p_{dt}$. Labor income is defined in equation (3.12) and depends on the regional mean labor productivity level q_{dt} as introduced in section 3.3.1. Buyers can borrow against the value of their house and are required to make a proportional downpayment amounting to a fraction χ of the value at purchase, while renters cannot borrow at all. This is embedded in constraint (3.13), which states that if a renter chooses to buy, their next period assets must be greater or equal to the fraction of the purchase price that was financed via the mortgage, or non-negative otherwise. Constraint number (3.14) defines the interest rate function, which simply states that there is a different interest applicable to savings as opposed to borrowing, both of which are taken as exogenous parameters in the model. The terminal condition constraint is in expression (3.15).

$$a_{it+1} = (1 + r(a_{it}))\,(a_{it} + y_{idt} - c_{it} - (1 - h_{it})\kappa_d p_{dt} - h_{it} p_{dt}) \quad (3.11)$$

$$\ln y_{idt} = \eta_d \ln(q_{dt}) + f(t) + z_{it} \quad (3.12)$$

$$a_{it+1} \geq -(1 - \chi) p_{dt} h_{it} \quad (3.13)$$

$$r(a_{it}) = \begin{cases} r & \text{if } a_{it} \geq 0 \\ r^m & \text{if } a_{it} < 0 \end{cases}, r^m = r + q \quad (3.14)$$

$$a_{iT} + p_T h_{iT-1} \geq 0 \quad (3.15)$$

Owners. For individuals entering the period as owners ($h_{it-1} = 1$), the budget constraint is similar except for two differences which relate to the borrowing constraint and transfers in case they sell the house. Owners are not required to make a scheduled mortgage payment – a gradual reduction of debt, i.e. an increase in a, arises naturally from the terminal condition $a_{iT} + p_{dT} h_{iT-1} > 0$, as mentioned above. Therefore the budget of the owner is only affected by the house price in case they decide to sell the house, i.e. if $h_{it} = 0$. In this case, they obtain the house price net of the proportional selling cost ϕ, plus they have to pay rent in region d. Apart from this, the same interest rate function (3.14), labor income equation (3.12) and terminal condition (3.15) apply.

$$a_{it+1} = (1 + r(a_{it}))\,(a_{it} + y_{idt} - c_{it} + (1 - h_{it})(1 - \phi - \kappa_d) p_{dt}) \quad (3.16)$$

$$a_{it+1} \geq -(1 - \chi) p_{dt} \quad (3.17)$$

3.3.8.2 Budget constraint for movers, i.e. $d \neq d'$

Renters. For moving renters the budget constraint is close to identical, with the exception that (3.11) needs to be slightly altered to reflect that labor income is obtained in the current period in region d before the move to k is undertaken.

$$a_{it+1} = (1 + r(a_{it}))\left(a_{it} + y_{idt} - c_{it} - (1 - h_{it})\kappa_{d'} p_{d't} - h_{it} p_{d't}\right) \tag{3.18}$$

Owners. The budget constraint for moving owners depends on the house price in both current and destination regions d and k since the house in the current region must be sold by assumption. The expression $(1 - \phi)p_{dt}$ in (3.19) relates to proceeds from sale of the house in region d, whereas the square brackets describe expenditures in region d'. Notice also that the borrowing constraint (3.20) now is a function of the value of the new house in d'. It is important to note that this formulation precludes moving with negative equity if labor income is not enough to cover it. This is exacerbated in cases where the mover wants to buy immediately in the new region, since in that case the downpayment needs to be made as well, i.e. if $y_{idt} < a_{it} + (1 - \phi)p_{dt} - \chi h_{it} p_{d't}$ then the budget set is empty and moving and buying is infeasible.[11]

[11] In my sample I observe 29 owners who move with negative equity (amounting to 3.4% of moving owners). 78% of those do buy in the new location, the rest rent. I do not observe whether or not an owner defaults on the mortgage. Accounting for this subset of the population would require to 1) assume that they actually defaulted and 2) it would substantially increase the computational burden. For those reasons the model cannot account for this subset of the mover population at the moment.

$$a_{it+1} = (1 + r(a_{it}))\left(a_{it} + y_{idt} - c_{it} + (1-\phi)p_{dt} - \left[(1-h_{it})\kappa_{d'} + h_{it}\right]p_{d't}\right) \quad (3.19)$$

$$a_{it+1} \geq -(1-\chi)p_{d't}h_{it} \quad (3.20)$$

3.4 Solving and Simulating the Model

The model described above is a typical application of a mixed discrete–continuous choice problem. In the next section I will introduce a nested fixed point estimator, which requires repeated evaluation of the model solution at each parameter guess, thus placing a binding time-contraint on time each solution may take.

The consumption/savings problem to be solved at each state, and its combination with multiple discrete choices and borrowing constraints, introduces several non-differentiabilities in the asset dimension of the value function. This makes using fast first order condition–based approaches to solve the consumption problem more difficult.[12]

I solve the model in a backward-recursive way, starting at maximal age 50 and going back until initial age 20. In the final period the known final period value is computed at all relevant states. From period $T-1$ onwards, the algorithm in each period iterates over all state variables and computes a solution to the savings problem at each combination of state and discrete choices variables (including housing and

[12] There has recently been a lot of progress on this front. Clausen and Strub (2013) provide an envelope theorem for the current case, and the endogenous grid point method developed by Carroll (2006), further extended to accomodate (multiple) discrete choice as in Fella (2014) are promising avenues. I found my problem not easily amenable to their solution, and focused on a robust solution (i.e. one not subject to potential local minima to the savings problem).

location choices). After this solution is obtained at a certain state, the discrete housing choice is computed, after which each conditional value function (3.7) is known. The distributional assumption on ε implies that the discrete location choice does not have to be computed, instead the main object of interest is the probability of moving function (3.9).

Once the solution is obtained, simulation of the model proceeds by using the model implied decision rules and the observed aggreate prices series $\mathbf{F}_t$ as well as their regional dependants (q_{dt}, p_{dt}) to obtain simulated lifecycle data. As I will explain in greater detail in the next section, this proceedure needs to replicate the time and age structure found in the data, which is achieved by simulating different cohorts, starting life in 1967 and all successive years up until 2012. The model moments are then computed using the empirical age distribution found in the estimation sample as sampling weights.

3.5 Estimation

In this section I explain how the model is estimated to fit some features of the data. There is a set of preset model parameters, the values of which I either take from other papers in the literature or I estimate them outside of the structural model and treat them as inputs. The remaining set of parameters are estimated using the simulated method of moments (SMM) approach, whereby given a set of parameters, the model is used to compute decision rules of agents, which in turn are used to simulate artificial data. A set of summarizing features from the artificial data should then be close to the same features of the the real data. I will first discuss estimation of the exogenous stochastic processes, and then turn to the estimation of the model preference parameters.

3.5.1 Estimation of Exogenous Processes

VAR process for aggregates Q_t and P_t

The VAR processes at the aggreate and regional level are estimated using a seemingly unrelated regression with two equations, one for each factor Q_t and $P_t, t = 1967, \ldots, 2012$. I use real GDP per capita as a measure for Q_t, and the Federal Housing and Finance Association (FHFA) US house price index for P_t. Given that I am interested in the level of house prices (i.e. a measure of house *value*), I compute the average level of house prices found in SIPP data for the year 2012 and then apply the FHFA index to construct the house value for each year.[13]

I reproduce equation (3.2) here for ease of reading:

$$\begin{aligned}
\mathbf{F}_t &= A\mathbf{F}_{t-1} + \nu_{t-1} \\
\nu_t &\sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \Sigma\right) \\
\mathbf{F}_t &= \begin{bmatrix} Q_t \\ P_t \end{bmatrix}
\end{aligned}$$

The estimates from this equation are given in table 3.7.

[13]The GDP series is as provided by the Bureau of Economic Analysis through the FRED database. All non-SIPP data used in this paper are provided in an R package at https://github.com/floswald/EconData, documenting all sources and data-cleaning proceedures.

	Q_t	P_t
Intercept	0.86	19.13*
	(0.58)	(7.31)
Q_{t-1}	1.00***	0.16
	(0.02)	(0.28)
P_{t-1}	0.00	0.89***
	(0.01)	(0.06)
R^2	0.99	0.94
Adj. R^2	0.99	0.94
Num. obs.	94	94

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 3.7: Estimates for Aggregate VAR process

Aggregate to regional price mappings

The series for q_{dt} is constructed as per capita personal income by region, with a measure of personal income obtained from the Bureau of Economic Analysis and population counts by state from intercensal estimates from the census Bureau. The price series by region comes from the same FHFA dataset as used above.

$$\begin{aligned} \begin{bmatrix} q_{dt} \\ p_{dt} \end{bmatrix} &= \mathbf{a}_d \mathbf{F}_t + \eta_{dt} \\ \eta_{dt} &\sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \Omega_d \right) \end{aligned} \tag{3.21}$$

The performance of this model in terms of delivered predictions from the aggregate state can be gauged visually in figures 3.2 and 3.3. The model parameters are shown in table B.2 in the appendix.

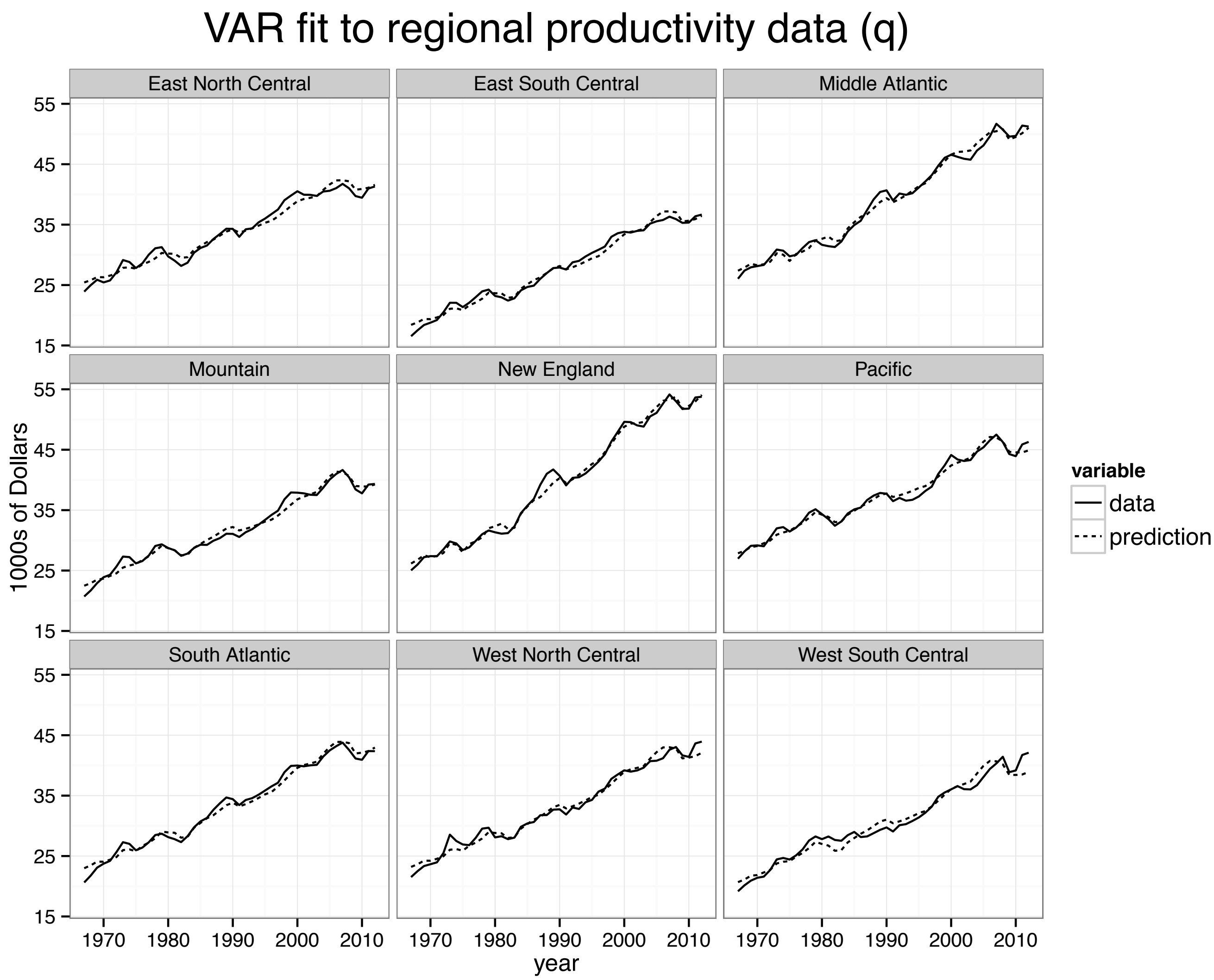

Figure 3.2: This figure shows the observed and predicted time series for mean income by Census Division. The prediction is obtained from the VAR model in (3.3), which relates the aggreate series $\{Q_t, P_t\}_{t=1968}^{2012}$ to mean labor productivity $\{q_{dt}\}_{t=1968}^{2012}$ for each region d. Agents use this prediction in the model, i.e. from observing an aggregate value $\mathbf{F}_t = (P_t, Q_t)$ they infer a value for q_{dt} for each region above.

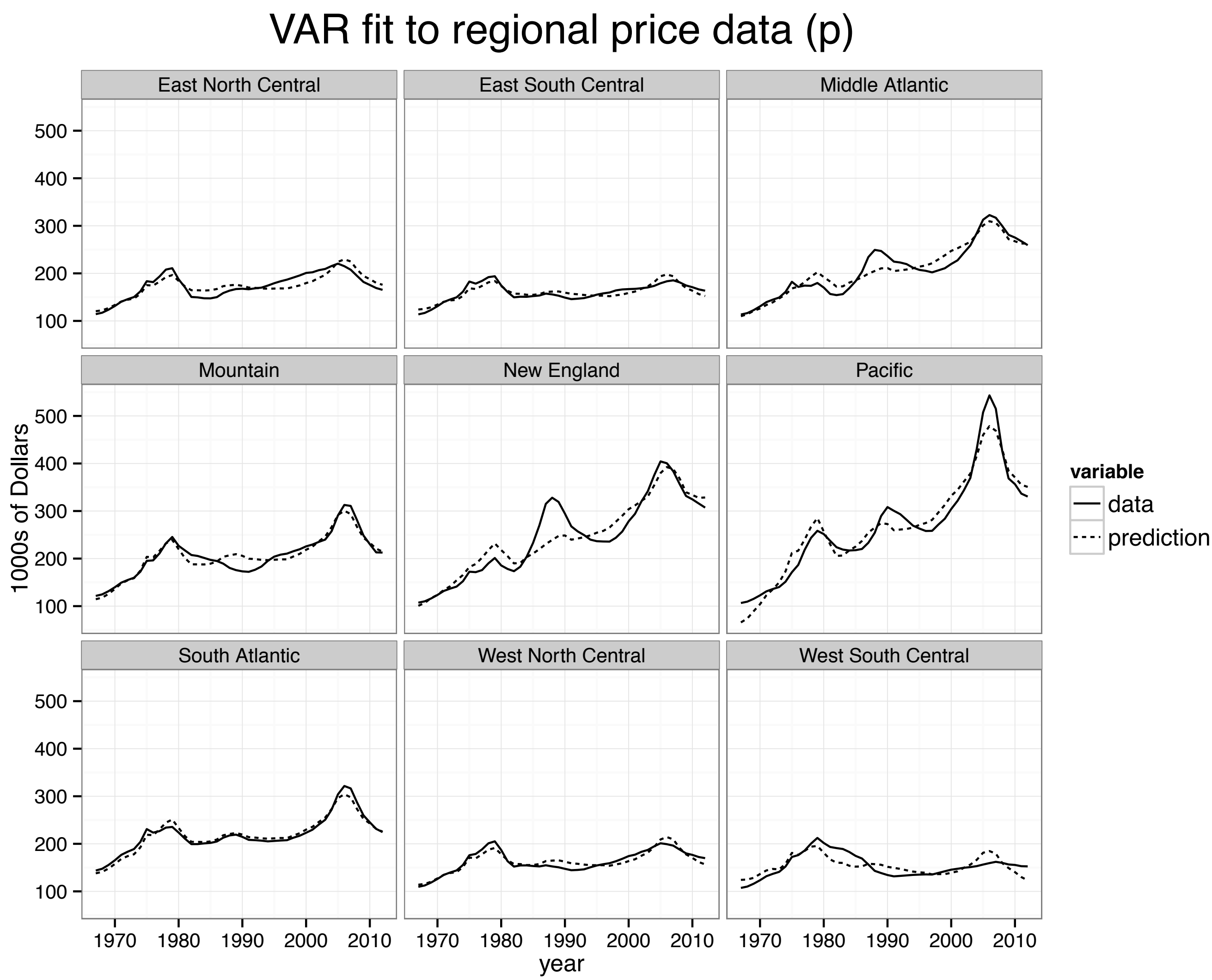

Figure 3.3: This figure shows the observed and predicted time series for house prices by Census Division. Please refer to the previous figure 3.2, which uses an identical proceedure.

Individual Income Process

This part deals with the empirical implementation of equation (3.12), which models log labor income at the individual level. I estimate the linear regression

$$\begin{aligned}\ln y_{idt} &= \beta_0 + \eta_d \ln q_{dt} + \beta_1 \text{age}_{it} + \beta_2 \text{age}_{it}^2 + \beta_3 \text{age}_{it}^3 + u_{it} \\ &= \beta_0 + (\gamma_d \times \gamma_q) \ln q_{dt} + \beta_1 \text{age}_{it} + \beta_2 \text{age}_{it}^2 + \beta_3 \text{age}_{it}^3 + u_{it} \qquad (3.22)\end{aligned}$$

where the region-specific influence of regional mean productivity q_{dt} on individual income is specified as an interaction between a regional fixed effect γ_d and the average effect γ_q of regional income. The results of this are displayed in table B.3 in the appendix. Figure B.2, also in the appendix, illustrates predicted age profiles from this model.

Copula estimates for G_{move}

The conditional distribution of z for movers is specified as the density of a bivariate normal copula G_{move}, which is invariant to date and region.[14] This means I assume that the conditional probability of drawing z' in new region d' is the same regardless the origin location. It would be straightforward to relax this assumption, but data limitations forced me to impose this restriction.

To estimate the parameters of the copula, I view z_{idt} in equation (3.1) as the residual from an ordinary least squares regression of log wages on time and region

[14] A copula is a multivariate probability distribution function which connects univariate margins by taking into account the underlying dependence structure. For example, a finite state Markov transition matrix is a nonparametric approximation to a bivariate copula, and they converge as the number of states goes to infinity, see Bonhomme and Robin (2006).

effects, as well as person specific demographic variables. The question is whether individuals with a particularly high residual z_{idt} are likely to have a high residual $z_{id't+1}$ after their move to region d'. In other words, we want to investigate the joint distribution of $(z_{idt}, z_{id't+1})$. I describe the full procedure in the appendix.[15]

Values for preset parameters

I take several parameters for the model from the literature, as shown in table 3.8. The estimates for the components of the idiosyncratic income shock process for non-movers, i.e. the autocorrelation $\rho = 0.96$ and standard deviation of the innovation $\sigma = 0.118$ are taken from French (2005). I set the financial transaction cost of selling a house, ϕ, to 6% in line with Li and Yao (2007) and conventionally charged brokerage fees. The time discount factor β is set to 0.96 which lies within the range of values commonly assumed in dynamic discrete choice models (e.g. Rust (1987)). The downpayment fraction χ is set to 20%, which is a standard value on fixed rate mortgages and used throughout the literature. The coefficient of relative risk aversion could be estimated, but is in this version of the model fixed to 1.43 as in Attanasio and Weber (1995).

To calibrate the interest rate for savings and for mortage debt, I follow Sommer and Sullivan (2013), who use the constant maturity Federal Funds rate, adjusted by headline inflation as mesured by the year on year change in the CPI. They obtain

[15] The proceedure relies crucially on the assumption that individuals have to move to the new region before they can discover z_{t+1}. I am investigating ways to account for a potential selection effect on z_t by moving estimation of this part into the structural model and jointly estimate behavioural and wage related parameters. The model provides a set of exclusion restrictions that would allow to do this in theory. Identification of a potential selection effect may be difficult, however, because the sample of movers is small.

		Value	Source
CRRA coefficient	γ	1.43	Attanasio and Weber (1995)
Discount Factor	β	0.96	Assumption
AR1 coefficient of z	ρ	0.96	French (2005)
SD of innovation to z	σ	0.118	French (2005)
Transaction cost	ϕ	0.06	Li and Yao (2007)
Downpayment proportion	χ	0.2	Assumption
Risk free interest rate	r	0.04	Sommer et al. (2013)
30-year mortgage rate	r^m	0.055	Sommer et al. (2013)

Table 3.8: Preset parameter values

an average value of 4% for the period of 1977–2008, and I thus set $r = 0.04$. For the markup q of mortgage interest over the risk-free rate they use the average spread between nominal interest on a thirty year constant maturity Treasury bond and the average nominal interest rate on 30 year mortgages. This spread equals 1.5% over 1977–2008, therefore $\hat{r} = 0.015$, and $r^m = 0.055$.

3.5.2 Estimation of Preference Parameters

The parameter vector to be estimated by SMM contains the parameters of the moving cost function (α), the parameter in the final period value function ω, the population proportion of high moving cost types (π_τ), and the utility derived from housing for both household sizes, (ξ_1, ξ_2). We'll denote the parameter vector $\theta = \{\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4, \omega, \pi_\tau, \xi_1, \xi_2\}$.

Given θ, the model generates a set of model moments $\hat{m}(\theta)$, where $\hat{m}()$ is of dimension K. After obtaining the same set of moments m from the data, the SMM proceedure seeks to minimize the criterion function

$$L(\theta) = \frac{1}{2} \left[m - \hat{m}(\theta) \right]^T W \left[m - \hat{m}(\theta) \right],$$

which delivers point estimate $\hat{\theta} = \arg\min_\theta L(\theta)$. The weighting matrix W is formed of the inverse of the diagonal elements of the variance-covariance matrix of data moments Ω, i.e. I set $W = \left(\text{diag}\left(\hat{\Omega}\right)\right)^{-1}$.

I obtain point estimates for θ by following a modification of the pseudo-likelihood estimator as introduced in Chernozhukov and Hong (2003). The modification defines N parallel instances of Chernozhukov and Hong (2003)–MCMC chains, which are differently "tempered" (i.e. they have different shock variances and rejection criteria), and are able to communicate with each other. This helps to explore large areas of the parameter space and avoids getting stuck in local minima. The proceedure is formally defined in Baragatti et al. (2013).[16] The quasi-posterior mean and confidence intervals are computed from the chain with lowest temperature analogously to Chernozhukov and Hong (2003), after accounting for the fact that I do not use the optimal weighting matrix.

Estimation Sample

My estimation sample is formed mainly out of averages over SIPP data moments covering the period 1997–2012. All moments are constructed using SIPP cross-sectional survey weights, and all dollar values have been inflated to base year 2012

[16] I've co-authored a software package that implements the proceedure at `https://github.com/floswald/MOpt.jl`.

using the BLS CPI for all urban consumers.[17] Averaging over years was necessary to preserve a reasonable sample size in all conditioning cells. However, it also introduces an initial conditions and cohort effects problem, since, for example, a 30-year-old in 1997 faced a different economic environment over their lifecycle than a similar 30-year-old in 2012 would have. The challenge is to construct an artificial dataset from simulated data, which has the same time and age structure as the sample taken from the data – in particular, agents in the model should have faced the same sequence of aggregate shocks as their data counterparts from the estimation sample. This requires to simulate individuals starting in different calendar years, taking into account the actual observed time series for regional house prices and incomes. I describe the proceedure in detail in the appendix.

Additional to SIPP data, the moment vector contains three statistics from Kennan and Walker (2011), which relate to the lifetime frequency of moves ("moved never", "moved once" and "moved more two times or more"). The reason for using external data is that I cannot compute such a statistic from SIPP, where the maximum panel length is four years.

The moment vector m is shown in table 3.9. It contains conditional means and covariances, which are largely self-explanatory. I introduce here two auxiliary models inluded in m which relate to the age profiles of both migration and ownership. Both models are linear probability models, where the dependent variable is either ownership status at the beginning of the period, h_{it-1}, or whether a move took place,

[17] http://research.stlouisfed.org/fred2/series/CPIAUCSL

denoted by $\text{move}_{it} = \mathbf{1}[d_{it} \neq d'_{it}]$:

$$h_{it} = \beta_{0,h} + \beta_{1,h} t_{it} + \beta_{2,h} t_{it}^2 + u_{h,it} \quad (3.23)$$

$$\text{move}_{it} = \beta_{0,m} + \beta_{1,m} t_{it} + \beta_{2,m} t_{it}^2 + u_{m,it} \quad (3.24)$$

Identification

Identification is achieved by comparing household behaviour under different price regimes. The variation comes from using the observed house price and labor productivity series in estimation, which vary over time and by region. The identifying assumption is that, conditional on all other model features, households must be statistically identical across those differing price regimes. In particular, this requires that household preferences be stable over time and do not vary by region.[18]

The structural parameters in θ are related to the moment vector $m(\theta)$ in a highly non-linear fashion. In general, all moments in $m(\theta)$ respond to a change in θ. However it is possible to use graphical analysis to show how some moments relate more strongly to certain parameters than others.

Regarding parameters of the moving cost function, parameters $\alpha_{0,\tau=0}, \alpha_3, \alpha_4$ represent the intercept for low moving cost types, the coefficent on ownership and the effect of household size on moving costs, respectivley. They are related to, in order, the average moving rate $E[\text{move}]$, the moving rate conditional on owning $E[\text{move}|h_t = 1]$, and the moving rate conditional on household size $E[\text{move}|s_t = 1]$. The age effects α_1, α_2 are related to the age–coefficients of the auxiliary model for

[18] The model is not non-parametrically identified; Both variation in prices and further restrictions such as functional form are needed, because price variation is at the regional (and not household-) level.

moving, defined in expression (3.24), as well as the the average proportion of movers in the last period of life $E[\text{move}|T]$. The relationship between mobility and ownership, as well as mobility and household size are also captured by the covariances $Cov(\text{move}, h)$ and $Cov(\text{move}, s)$, both of which are again related to the moving cost parameters α_3 and α_4.

The proportion of high moving cost types π_τ is related to the data moments concering the number of moves per person, and in particular the fraction of individuals who never moved, $E[\text{moved never}]$. The other two moments on the frequency of moves, $E[\text{moved once}]$ and $E[\text{moved twice+}]$ help to identify all moving cost parameters.

Given that the house price processes in each region are exogenous to the model, the parameters measuring utility from ownership, ξ_1, ξ_2 are related to a relatively large number of moments: ownership rates by region and by household size, the covariance of owning with household size, and the age–profile parameters from the auxiliary model of ownership in (3.23).

3.5.3 Parameter Estimates and Moments (Preliminary)

The model fits the data moments fairly well overall. The fit is displayed in table 3.9. The upper panel shows moments related to mobility, the lower panel shows moments related to homeownership. Regarding mobility, the fit is very good. The only statistic slightly out of line is the frequency distribution of moves per mover. There is no mechanism in the model that could generate the observed pattern in the data. One possibility would be to augment the set of moving cost types with a third type that has an even lower moving cost. The estimates for the auxiliary model defined in (3.24) representing the age profile in ownership also provide a good fit to the data.

Moving on to moments related to ownership, we see that the unconditional mean of ownership is identical to the data moment. Condition by region provides a more varied picture, with some regions overestimated and others underestimated. The reason for this is that there is heterogeneity in ownership rates by region which is not easily accounted for by the fundamentals of regional house price and mean income alone.[19] Remember that by taking prices and incomes as given, the model is restricted to only few levers that affect the homeownership rate. The main parameters in this respect are the utility premia ξ_1, ξ_2 and the weight in the final period utility ω. The model at the moment overpredicts ownership in later periods of life. This is visible from the intercept of the auxiliary model (3.23), which relates the ownership rate to an age profile. The reason for this is that in a model where age and wealth are the main dimensions of variation across households, as soon as a certain wealth threshold is crossed, all agents become owners. In other words, the model cannot account for wealthy houeholds who prefer not to own. One way to improve in this dimension would be to introduce different types of housing preferences.

Given that the CRRA coefficient γ is taken as fixed in the current implementation of the model, the moments relating to wealth resulting from the model can be viewed as some form of model validation. The model moments in table 3.10 are not included

[19] There is large degree of house price heterogeneity at the local level with is not in the model but which contributes to the average ownership rate at the regional level. Local building regulations, rent control or certain topographical features all influence the actual house price that the local level; The price index used in the model incurs some unavoidable aggregation error in this respect, and the same holds for my estimate of the average rent to price ratio.

in the SMM objective function, that is, they are not targeted by the estimation algorithm. Despite this, they are very close the data counterparts.

The estimated parameters and standard errors are shown in table 3.11.

3.6 Properties of the model

In this section I use model to illustrate several mechanisms which are implied by the inclusion of homeownership status and assets into a dynamic migration model à la Kennan and Walker (2011).

3.6.1 Probability of Migrating

In figures 3.4, 3.5 and 3.6 I plot the conditional mean of the moving probability function (3.9), conditioning on wealth, income (y), income shock (z), and by housing status (h). The plots show throughout a marked difference by housing status h, which is fully expected given the data. The average probability of moving is decreasing in the level of wealth of a houshold. Figure 3.4 illustrates that increasing wealth makes households more likely to become owners, and at the same time decreases the probability of moving.

3.6.2 The role of moving costs

Moving costs in the model are measured in terms of utility. I convert them to dollar values by finding the amount of compensating assets a' which would make an individual at state x indifferent between the value of moving with costs (v) (but extra assets) and without ($\tilde{v}$). I consider moves from region $d = 2$ to $k = 1$. In other

Moments related to mobility		
Moment	Data	Model
$E[\text{move}]$	0.013	0.013
$E[\text{move}\|T]$	0.005	0.002
$E[\text{move}\|s=0]$	0.014	0.017
$E[\text{move}\|s=1]$	0.01	0.01
$E[\text{move}\|h_{t-1}=0]$	0.019	0.026
$E[\text{move}\|h_{t-1}=1]$	0.007	0.005
$Cov(\text{move}, h)$	−0.003	−0.005
$Cov(\text{move}, s)$	−0.001	−0.001
$E[\text{moved never}]$	0.83	0.88
$E[\text{moved once}]$	0.07	0.08
$E[\text{moved twice+}]$	0.09	0.04
Auxiliary model (3.24): $\text{move}_{it} = \beta_{0,m} + \beta_{1,m} t_{it} + \beta_{2,m} t_{it}^2 + u_{it}$		
$\beta_{0,m}$	0.06	0.05
$\beta_{1,m}$	−0.002	−0.003
$\beta_{2,m}$	0.00001	0.00006
Moments related to homeownership		
$E[h_{t-1}]$	0.61	0.63
$E[h_{t-1}\|\text{ENC}]$	0.66	0.7
$E[h_{t-1}\|\text{ESC}]$	0.65	0.64
$E[h_{t-1}\|\text{MdA}]$	0.57	0.64
$E[h_{t-1}\|\text{Mnt}]$	0.61	0.63
$E[h_{t-1}\|\text{NwE}]$	0.6	0.55
$E[h_{t-1}\|\text{Pcf}]$	0.51	0.5
$E[h_{t-1}\|\text{StA}]$	0.63	0.62
$E[h_{t-1}\|\text{WNC}]$	0.69	0.69
$E[h_{t-1}\|\text{WSC}]$	0.6	0.67
$E[h_{t-1}\|s=0]$	0.53	0.58
$E[h_{t-1}\|s=1]$	0.66	0.66
$E[h_{t-1}=1, h_t=0\|T]$	0.01	0.02
$Cov(h_{t-1}, s)$	0.03	0.02
Auxiliary model (3.23): $h_{it-1} = \beta_{0,h} + \beta_{1,h} t_{it} + \beta_{2,h} t_{it}^2 + u_{it}$		
$\beta_{0,h}$	−1.146	0.051
$\beta_{1,h}$	0.08	0.023
$\beta_{2,h}$	−0.0008	0.0004

Table 3.9: Empirical targets and corresponding model moments.

Non-targetted moments		
Moment	Data	Model
E[wealth$\|t \in [20, 30]$]	51.19	43.949
E[wealth$\|t \in (30, 40]$]	130.989	102.34
E[wealth$\|t \in (40, 50]$]	209.317	214.823
E[wealth|ENC]	139.125	118.858
E[wealth|ESC]	109.666	104.056
E[wealth|MdA]	165.388	150.903
E[wealth|Mnt]	128.192	138.346
E[wealth|NwE]	203.125	166.753
E[wealth|Pcf]	183.162	182.781
E[wealth|StA]	142.203	139.88
E[wealth|WNC]	142.603	111.702
E[wealth|WSC]	100.025	96.389
E[wealth$\|h_{t-1} = 0$]	33.172	30.817
E[wealth$\|h_{t-1} = 1$]	219.356	195.733

Table 3.10: Non-targeted model and data moments. This set of moments does not enter the SMM objective function and can thus be seen as a form of external validation of the model.

		Estimate	Std. error
Utility Function			
Owner premium size 1	ξ_1	0.012	0.00053
Owner premium size 2	ξ_2	0.052	0.00234
Moving Cost Function			
Intercept	α_0	2.77	0.124
Age	α_1	0.017	0.00077
Age^2	α_2	0.001	$9.16e{-5}$
Owner	α_3	0.26	0.0116
Household Size	α_4	0.36	0.016
Proportion of high type	π_τ	0.68	0.03
Final Period			
Continuation Value	ω_2	5.1	0.22

Table 3.11: Parameter estimates. Standard errors are still work in progress at this point.

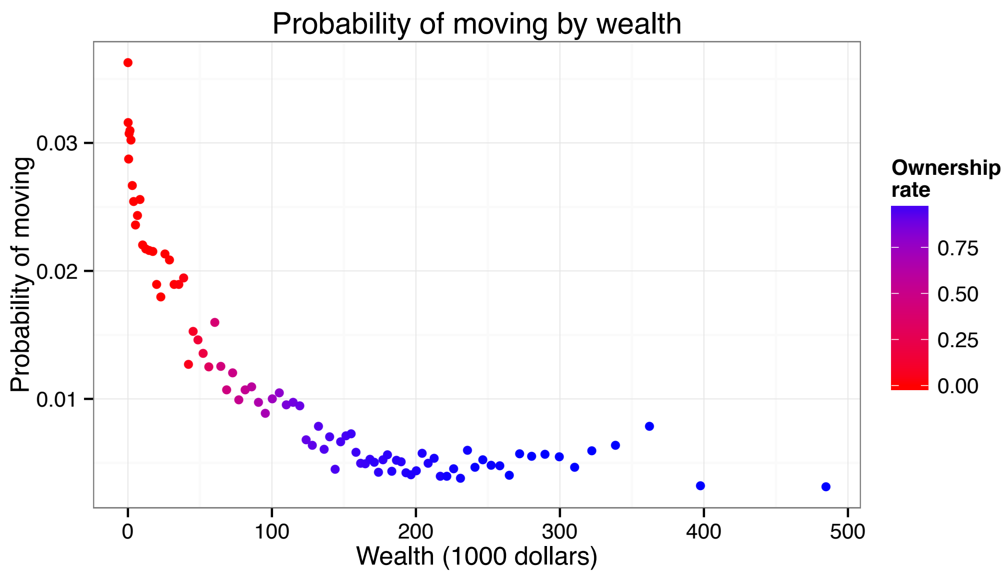

Figure 3.4: Simulated probability of moving by wealth. The figure shows that as wealth increases, individuals are both more likely to be owners (color shading), as well as less likely to move.

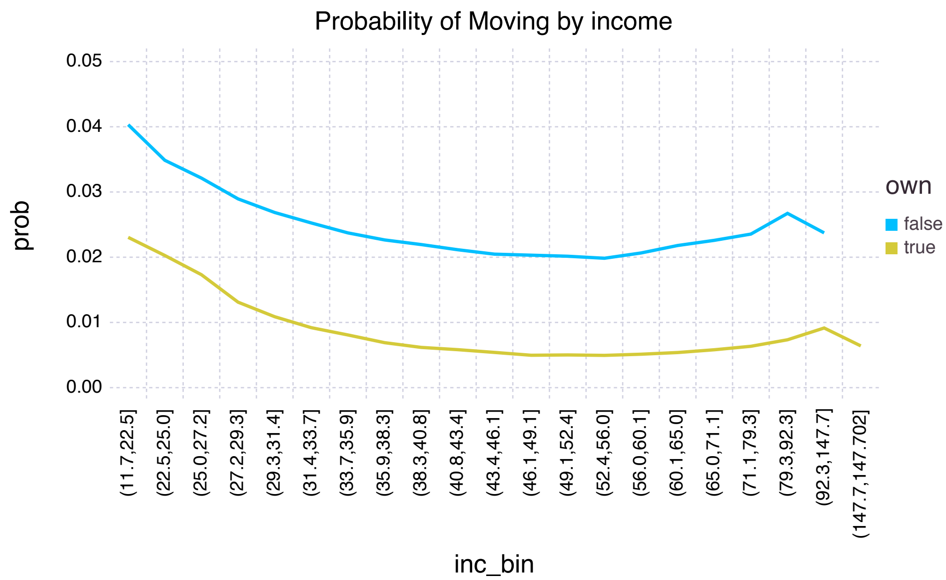

Figure 3.5: Average probability of moving by income quantiles.

words, moving costs are measured by a' which solves

$$v(2, 1, x + a') - \tilde{v}(2, 1, x) = 0.$$

The measure is taken at a state x where the individual has zero asset and where the aggreagate factors P and Y are at the midpoint of their respective grids.

Similarly to Kennan and Walker (2011), the moving costs are large. As they explain, this is because "[the estimated moving costs] do not refer to the costs of moves that are actually made, but rather to the costs of hypothetical moves to arbitrary locations."

The results are displayed in table 3.12. To calculate moving costs from my nonlinear model, I use a money metric measure. The moving costs for renters at

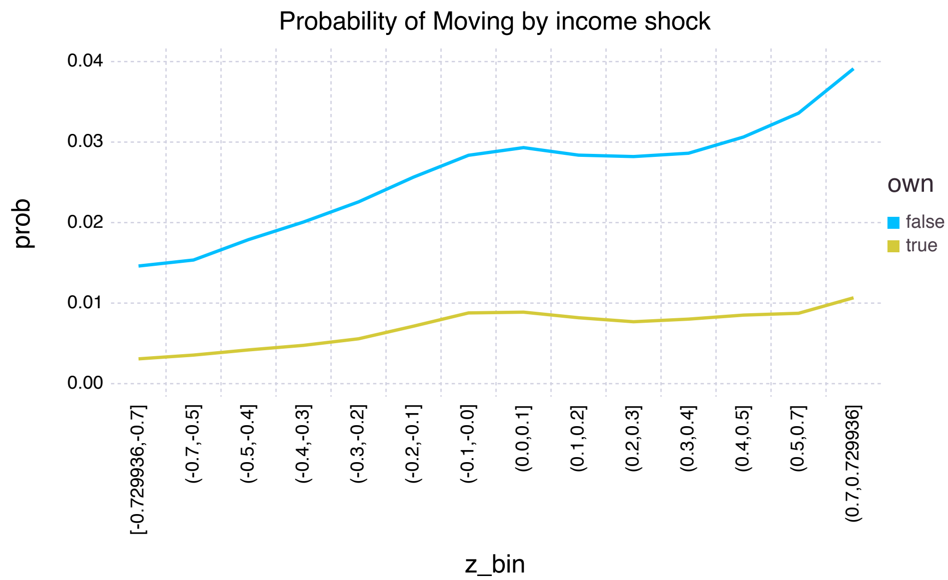

Figure 3.6: Probability of moving by income shock z

age 20 ($t = 1$) are $159,000 and $575,000 for owners. The estimates in period one bracket the average cost of $312,000 reported in Kennan and Walker (2011).

There are several reasons for why owners move less than renters. First, they have higher moving costs as implied by a positive estimate for parameter α_3. Second, owners pay a transaction cost each time they sell the house (proportional cost ϕ), which affects the value of migration. Third, owners have to comply with the

Renter	Owner
159.486	574.97

Table 3.12: Comparing the moving cost in terms of 1000s of 2012 dollars for owners and renters at $a = 0, z = z_1, Q = Q_2, P = P_2$ in the first period of life (age 20). Kennan and Walker (2011) report an average moving cost of $384,000 for a young and $312,000 for an average mover.

	Baseline	$\alpha_3 = 0$	$\phi = 0$	$\alpha_3 = \phi = 0$
Ownership rate	0.602	0.613	0.626	0.64
%Δ Migration rate	0	4.202	4.303	10.354
%Δ Migration | Own	0	30.115	21.47	67.664

Table 3.13: Decomposing owner's moving costs. Compares baseline statistics to scenarios with no additional moving cost for owners ($\alpha_3 = 0$), no financial transaction costs from selling the house ($\phi = 0$), and neither of the two ($\alpha_3 = \phi = 0$).

downpayment constraint if they wish to buy in the new region, which puts restrictions on the consumption paths of movers. Finally, ownership is correlated with larger household size ($s = 1$), which itself carries a higher moving cost (α_4).

In table 3.13 I decompose the reduced mobility of owners arising from higher utility costs α_3 and the fixed cost of selling ϕ. Ownership increases as we successively remove frictions along the first row of the table, as expected. Perhaps more surprisingly, the second row shows that the average migration rate increases by roughly the same amount if we remove the owner's moving cost α_3 or the fixed cost of selling ϕ. This does not mean that financial frictions are of equal importance for mobility than non-financial ones. As shown in the final two rows of the table, this result is driven by a change in composition, i.e. the aggregate migration rate is higher because we have more owners, who also move more. The final row shows that the increase in migration resulting from zero non-financial costs is greater than the increase from no financial transaction costs.

3.6.3 The effects on migration of a regional shock

In this section I illustrate how the model reacts to large economic shocks at the regional level. The presentation focuses on changes in migratory in and outflows to and from a region, when the regional price or income level is reduced unexpectedly at a certain point in time. The implementation of the shock is symmetric for both the case of house price and mean income, and I will use the case of the regional productivity shock to explain the details.

The regional shock consists of reducing the level of the observed mean income series by 10% in the West North Central division only (West North Central (WNC) has region index $d = 8$). The experiment is conducted under the assumption that agents did not foresee the shock and therefore are surprised in the year 2000 to find that the mapping form aggregate factors (Q, P) into (q_8, p_8) as defined in equation (3.3) does not apply anymore. In terms of their beliefs about aggregate and regional prices, they observe $\iota_{2000} \times q_{8,2000}, \iota_{2000} = 0.9$ instead of $q_{8,2000} = \mathbf{a}_8 \mathbf{F}_{2000}$, as would be predicted by the model in (3.3).[20] The shock is permanent thereafter, i.e. $\iota_{2000+\kappa} = 0.9, \kappa = 0, 1, \dots$.[21] Notice that none of the time series properties of the regional price series other than the level are changed. In particular, the growth rate and implied variance remain the same. The other regional series (house price in this instance) is held constant in each experiment, as well as both series in all other regions. Illustrations of the shocked price and income series are shown in figures 3.7 and 3.8, respectively.

Shock to average labor productivity. Reducing mean labor productivity q in a given region translates directly into lower disposable income and therefore less

[20]The surprise assumption is necessary to observe a causal effect of the price change, since otherwise the response of agents would be partially anticipating the shock. They immeditately adjust to the new mapping and behave optimally to the new sequence of prices in WNC, i.e. $\{\hat{p}_{8,t}\}_{t=2000}^{2012}$.

[21]A separate experiment with a shock that reverts back over 3 years to trend delivered similar results, just limited to a shorter timeframe.

utility. The effect of an unexpected reduction in the observed mean income level for WNC by 10% on migration outflows are shown in figure 3.9. The solid lines trace out the migration flows in the baseline scenario, while the dashed lines correspond to the shock scenario. In the right panel, showing renter emigration, we see clearly that the income reduction leads to a sustained increase in emigrants. The left panel shows owner outflows, and we also see a slight increase in emigration owners. In terms of the above discussion about moving costs and preference shocks, both results come from the fact that smaller payoff shocks are sufficient to trigger a move in the shock scenario than was the case in the baseline.

Looking at the opposite flow of migration, figure 3.10 shows the corresponding pictures for immigration from the rest of the economy into WNC. Starting with owners moving to WNC in the left panel, lower mean income makes the region is less attractive as a destination relative to other regions, thus we see a slight decrease in arrivals. The effect is much more pronounced for renters in the right hand panel. It is interesting to note the shape of the solid line tracing out the baseline inflows: As prices in the rest of the economy start to increase towards the peak in 2008, WNC, with it's relatively low level of house prices becomes more attractive to renters. The increase in renter immigration towards 2005 is large, however, it needs to be looked at together with the corresponding ouflows at the time. Over the period 1998–2012, WNC experiences average annual population growth of 1.08% in the baseline model.

Shock to house prices. The pictures in figures 3.11 and 3.12 show the changes to outflows and inflows as a result of a 30% reduction in the level of house prices in WNC in the year 2000. Starting with outflows in figure 3.11, the left panel shows that fewer owners are leaving the region than before. Owners experience a loss in net wealth, but this results in only small changes to migration behaviour. From the perspective of owners, the losses are sunk costs, and to the extent that lower current wealth makes it harder to afford a downpayment in other regions, the benefits of moving are reduced. For renters, we also see a clear reduction in ouflows. Given that rent in the region has fallen to lower levels than before, fewer renters decide to leave. It is interesting at this point to remember the result in Notowidigdo (2011), where low skilled individuals are less likely to move away from a depressed region because they want to take advantage of cheap housing. The same mechanism operates here.

Turning finally to the effects of a reduction in house prices on inflows to WNC, we see in both panels that lower prices attract slightly more owners, and significantly more renters, particularly as aggregate prices rise and therefore the cost of living in other regions increases disproportionately for renters. Both owners and renters move to the region to enjoy cheaper housing.

3.6.4 The value of Migration

In this section I investigate the value of the migration option. The experiment assumes that the situation of West North Central changes in the sense that immigration is allowed, but emigrating is prohibited. First we will discuss changes in migration flows, and the ex-ante welfare effects for residents of WNC under both scenarios. Finally, we will analyze the experience of individuals who would have moved in the baseline environment, but are now prevented from doing so.

Migration flows and are displayed in table 3.14. The top panel shows changes in immigration flows to the region for both scenarios, and the respective percentage change. Comparing the first two columns as percentage changes in column three, we see that inflows into the region fall dramatically in a world where moving away from WNC is not an option. This shows that agents outside of the region perceive WNC as a much inferior option to the baseline. In the lower panel of the table I show baseline emmigration flows for comparison. The bottom row of the table gives an estimate of average lifetime utility across both regimes, and we see that removing the option to leave the region carries a very large penalty. Across both regimes, average expected lifetime utility falls by 5.1%, which implies that individuals would demand a 4.4% increase in per period consumption in a world without the moving option before they would be indifferent to the baseline.

Figure 3.13 shows the average levels of utility conditional on age inside of WNC and in all other regions. We can see in the right panel, that reducing the value of WNC for potential immigrants affects utility only marginally. This comes from the fact that movers can easily avoid the region by moving somewhere else. For individuals inside the region, however, the changes are substantial and they vary by age. We can see that it is particularly younger individuals who suffer from the removed option to move. This makes intuitive sense, since the forgone expected gains from moving are larger if we consider a longer time horizon.

To summarize this subsection, restricting the ability to move implies large losses in welfare. This effect stems from the inability of residents to respond to changes in their economic environment over time, as well as their inability to accomodate location preference shocks.

	Baseline	No Moving	%Δ
	Immigration per period (percent of local population)		
Total	2.72%	1.76%	−35.3%
Owners	0.52%	0.37%	−28.9%
Renters	2.2%	1.4%	−36.4%
	Emigration per period (percent of local population)		
Total	1.34%	0	–
Owners	0.35%	0	–
Renters	0.99%	0	–
E[Lifetime U]	1.293	1.227	−5.1%
Welfare (c)		4.4%	

Table 3.14: Removing the migration option from residents of West North Central. The top panel shows immigration flows to West North Central as a percentage of the resident population. The same holds for the second panel shows outflows in the baseline. The final two rows show the average expected lifetime utility across scenarios, and the required consumption compensation in order to make agents indifferent.

3.7 Abolishing the Mortgage Interest Deduction

In this section I investigate the impact of abolishing the mortgage interest deduction on migration and ownership rates. In the United States, homeowners are allowed to deduct the interest paid on the mortgage for their primary residence from taxable income. This reduces the user cost of owning because it exempts one of the largest component of an owner's housing cost – mortgage interest – from taxation. This is different for renters, whose housing expenditures are not tax deductible.[22]

The mortgage interest deduction has been widely critized on grounds of equity and distortionary effects in the housing market, see for example Glaeser (2011) for an overview.[23] The common wisdom is that it distorts the housing market by subsidizing owners, thereby leading to a higher rate of ownership as would arise without the subsidy. As discussed at length above, owners are less mobile than renters, so the question investigated in this subsection is whether abolishing the mortgage interest deduction would increase mobility, and if so, by how much. The answer to this question provides some guidance on whether housing policy could serve as an effective means to enhance the efficiency of the labor market by fostering greater mobility, or not.

At this point it is important to emphasize that depending on the elasticity of housing supply in a given market, we expect to see a general equilibrium effect of

[22]The Joint Committee on Taxation estimates that tax expenditure to finance the mortgage interest deduction, which is the largest housing policy policy program in the states, was $71.7 billion in 2014 Joint Committee of Taxation (2013).

[23]It is often held that if there were an offsetting taxation of imputed rent which owner-occupiers pay to themselves in place, the negative aspects of the subsidy could be greatly reduced. Implementing such taxes is politically difficult in most circumstances, probably highlighted by the small number of nations which have adopted some form of this tax. For the case of Switzerland, see Bourassa and Hoesli (2010).

house prices in response to the policy change. The subsidy implied by the interest deduction can be viewed much like a characteristic of the house, like for instance distance to schools, or access to transportation networks. As such, it is capitalized into house price. Therefore, removing the subsidy would change long-run equilibrium prices, in the same way as moving a certain property to a location with a different set of available amenities would change its value. In order to partially accomodate this effect, I will refer to the recent paper by Sommer and Sullivan (2013), in which the authors compute the stationary general equilibrium in a model with infinitely lived, heterogeneous agents who are either renters, owner-occupiers or owner-landlords. They compute equilibrium prices and rents arising from different assumption about the tax system. They find that house prices decrease on the order of 5% when the mortgage interest deduction is abolished, with rents keeping roughly constant and the homeownership rate increasing from 65% to 71%.[24]

The experiment is implemented as follows. The model being in after tax terms, it does not feature a formal tax system which could be changed in an experiment. The role of taxes and, in general, the user cost of housing is subsumed in the implicit mortgage repayment path brought about by the final period restriction on assets, as explained in section 3.3.4. In reality the interest rate deduction reduces taxable income, thereby increasing disposable income of owners. Therefore, to simulate

[24]The mechanism is as follows: removing the subsidy lowers the equilibrium house price, since this is no longer capitalized into the value of the house; lower house prices makes housing affordable to more low wealth people who couldn't buy before, thereby increasing the ownership rate. Their model does not feature multiple labor or housing markets, and resting on the stationary equilibrium concept it does not allow for variation in house prices over time as is the case here; nevertheless, using their result to adjust the level of house prices by 5% in all locations when removing the mortgage deduction seems like a worthwhile exercise to at least approximate a potential general equilibrium effect in my model.

the removal of the deduction, I reduce disposable income of owners by an amount equivalent to their average implied tax savings. To do this I use data from Poterba and Sinai (2008), which provides estimates of the average tax savings from the interest deduction for several income and age brackets. Table 3.15 shows my version of their table.

age	$y <$ 40K	$y \in [40K, 75K]$	$y \in [75K, 125K]$	$y \in [125K, 250K]$	$y > 250K$
< 34	250	720	2220	4400	8650
35-50	260	880	1810	4400	7130

Table 3.15: Average annual tax savings in dollars implied by the mortgage interest rate deduction for owners at various age and income groups. Data from Poterba and Sinai (2008) adjusted to 2012 dollars.

To provide some guidance, it is useful to start with a simple calculation to gauge the likely effect of the policy change on migration rates under the assumption that the conditional choice probabilities (i.e. whether to move or not) in the model do not change. This is equivalent to saying that there is a pure composition effect, but no effect on behaviour. To simplify the example, let's assume that the baseline ownership rate is $\pi_o = 0.63$, and that the annual migration rates for owners and renters are given by $m_o = 0.7\%$ and $m_r = 2\%$ respectively. This would give rise to a baseline unconditional migration rate of $\pi_o m_o + (1 - \pi_o) m_r = 1.81\%$. Assuming that the conditional choice probabilities which give rise to m_o and m_r do not change due to the policy change, and assume, for example, that removing the subsidy increases the ownership rate by 1% such that $\pi'_o = 0.64$. In that case we would expect to see a new migration rate of $\pi'_o m_o + (1 - \pi'_o) m_r = 1.68\%$, implying a decrease in the migration rate of 0.013 percentage points (or a 35% reduction of the rate).

The choice probabilities do change after the policy is implemented. In fact, it is easy to show that the only case under which the relative moving probabilities would remain constant is the one where the relative lifetime utilities in each region would change by exactly the same amount. This is not very likely to happen. Remember that the value in any location is determined by the utility derived from owning (enters utility directly), by the level of house prices, and by the level of consumption. Given a vector of house prices and incomes in the baseline environment, we can determine the relative differences in utilities and the corresponding probabilities of moving. Removing the mortgage deduction affects the price vector. Furthermore, by redistributing tax receipts we increase disposable income of a set of the population that was not able to buy before – not in their current region, and possibly not in another region. The overall effect on the migration rate will therefore be composed of a composition effect (shifting individuals from renter to owner status or vice versa), and an effect that arises from changes in behaviour, influenced by different price levels, different price to rent ratios, and redistribution of tax receipts from previous owners to the entire population.

The results are listed in table 3.16, and the columns under the subheading *Remove Deduction* show the results of the experiment with and without the GE correction. Both cases redistribute the taxes saved by removing the deduction on a per capita, per period basis. In other words, for total tax revenue X, and N individuals observed for T periods, each individual receives $X/(TN)$ additional dollars per period. This scheme approximates a reduction in income taxes financed by the removal of the mortgage deduction.

In the column without the GE correction, we see that ownership decreases by roughly 0.8%. This is a result of some marginal buyers being unable to satisfy the downpayment without the deduction. The migration rate increase only marginally despite this, because the change in composition towards more renters is offset to some degree by harder access to ownership in all regions without the benefits of the deduction. This reduces the incentives to move for some households who would have bought in different regions before. In terms of welfare effects, agents are close to indifferent between this policy and the baseline.[25]

The final column shows the results with the GE correction, which lowers house prices by 5% in all regions, while keeping rents at a constant level. Keeping rents constant is achieved by changing the price to rent ratios κ_d in proportion to the reduction in prices. We find that ownership increases by about 1.3% as a result of lower house prices. The reverse mechanism to the previous paragraph is at work, implying that more people can buy, in this case despite the removal of the subsidy to owners. The change in composition towards more owners combined with access to housing in more regions produces a net effect on migration that is slightly positive at 0.115% of the baseline rate. The welfare implications for this experiment are larger than in the previous case and amount to 2.4% of per period consumption over the lifecycle.

In concluding this section, it is instructive to note the importance of the general equilibrium effect in this case. Under the assumption of constant prices, the effect of removing the deduction is that ownership is reduced and that migration slightly

[25] As a metric of welfare I compute the implicit consumption tax δ which would make agents indifferent in terms of expected lifetime utility between the baseline and policy regimes, as detailed in appendix B.1.

increases. Removing the deduction means fewer low wealth housholds can buy housing, which reduces welfare, and this offsets any gains made form slightly more migration. Taking the price change and the implications for the price to rent ratio into account, however, shows that ownership would increase. This would affect the migration rate only marginally, but have a significant impact on welfare.

3.8 Conclusion

The main result of this paper is to show that despite average migration rates being low, the option value associated with the possibility to leave a location in a world with regional shocks to house prices and labor income is large. Removing the option to leave a certain region in the model implies an associated reduction in expected lifetime utility of 5.1%, or 4.4% of per period consumption. To arrive at this result, I construct a lifecycle model which includes homeownership as a choice variable next to savings and location choices, which I then fit to SIPP data and use to make counterfactual experiments. Considering homeownership is motivated by the fact that well over 60% of the US population are owners, and the observation that owners exhibit vastly different migratory behaviour than renters. The model places particular emphasis on a close representation of the observed house price and income series, both of which exhibit strong correlation of regional shocks.

In a policy experiment where I remove the mortgage interest deduction for owners, I find that accounting for a likely general equilibrium effect is crucial for the resulting effects. Assuming that house prices would not change as a result of removing the deduction implies that migration rates would increase slightly, mainly due to a shift in composition towards more renters. Correcting prices with an external estimate of the likely GE effect (a 5% reduction as reported in Sommer and Sullivan (2013)) results in a different conclusion: lower prices after the removal of the deduction allow more people to buy, resulting in an increase of ownership. The net effect on migration is only marginally positive, however, since part of the shift in composition towards more owners is offset by changes in migration behaviour brought about by lower prices in all regions and redistribution of income to the poor. The welfare implications depend greatly on whether or not prices are adjusted, with average welfare gains 1% in the former, and of the order of 2.4% of period consumption in the latter case.

In its current state, the model is silent with regards to location amenities. Dissentangling the effects of price changes on the consumer's budget constraint from its effects on local amenities, and therefore utility, is clearly important to understand migration decisions better. I view the current implementation as a first step in this direction, and more work is necessary to incorporate amenities.

	Baseline	Remove Deduction	
		w/o GE	w GE
Ownership Rate	0.631	0.625	0.639
Migration Rate	0.01282	0.01285	0.01284
%Δ Ownership	0	−0.882%	1.36%
%Δ Migration	0	0.247%	0.115%
Welfare	0	1%	2.4%

Table 3.16: Abolishing the mortgage interest deduction. Depending on whether or not a GE correction to house prices is applied (house prices are 5% reduced), the migration rate increases slightly. Cheaper housing everywhere and higher disposable income from redistribution enables more previously liquidity constraint households to buy – in their home region, but crucially also in other regions. This leads to a very small increase in the migration rate.

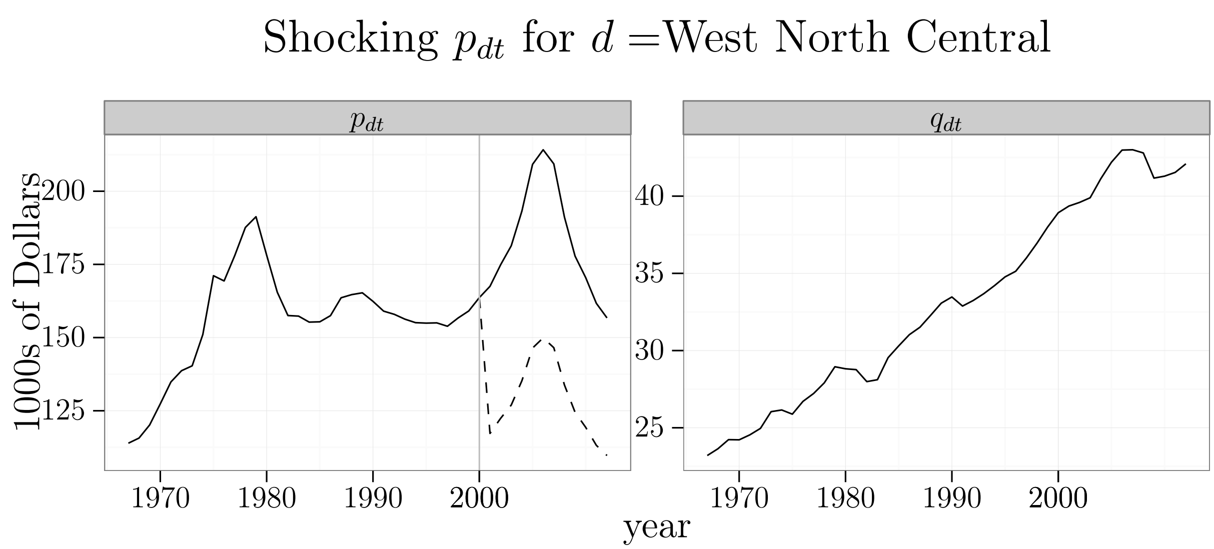

Figure 3.7: Shocking the house price series for West North Central from 2000 onwards. The shock multiplies the data series with the factor $\iota = 0.7$, i.e reduces the level by 30%. The dashed line in the right panel is the path of house prices after the shock.

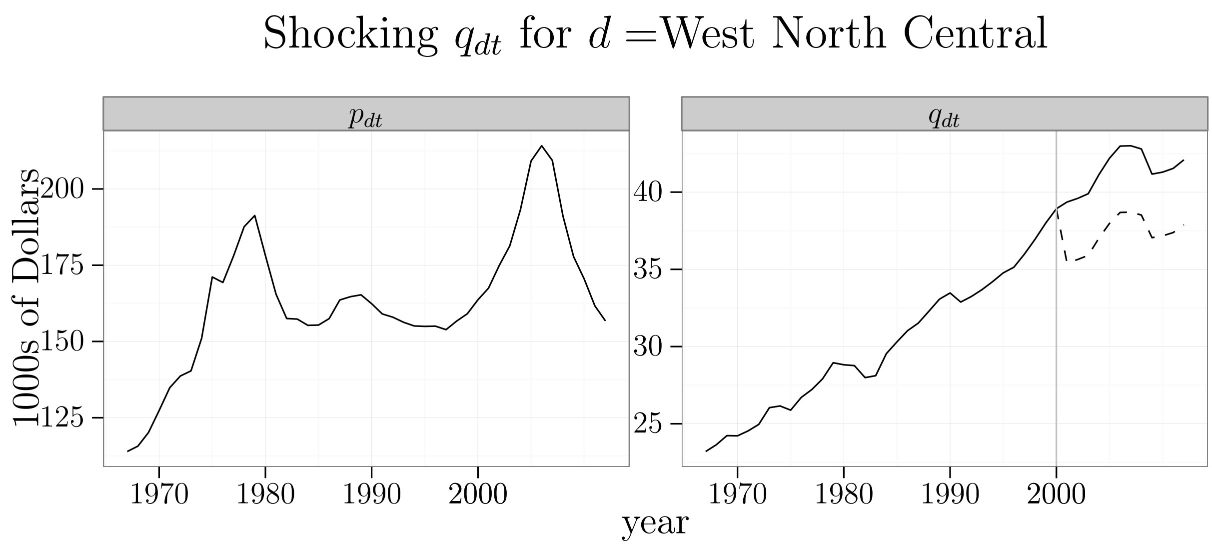

Figure 3.8: Shocking the level of average labor productivity in region West North Central by 10% in 2000.

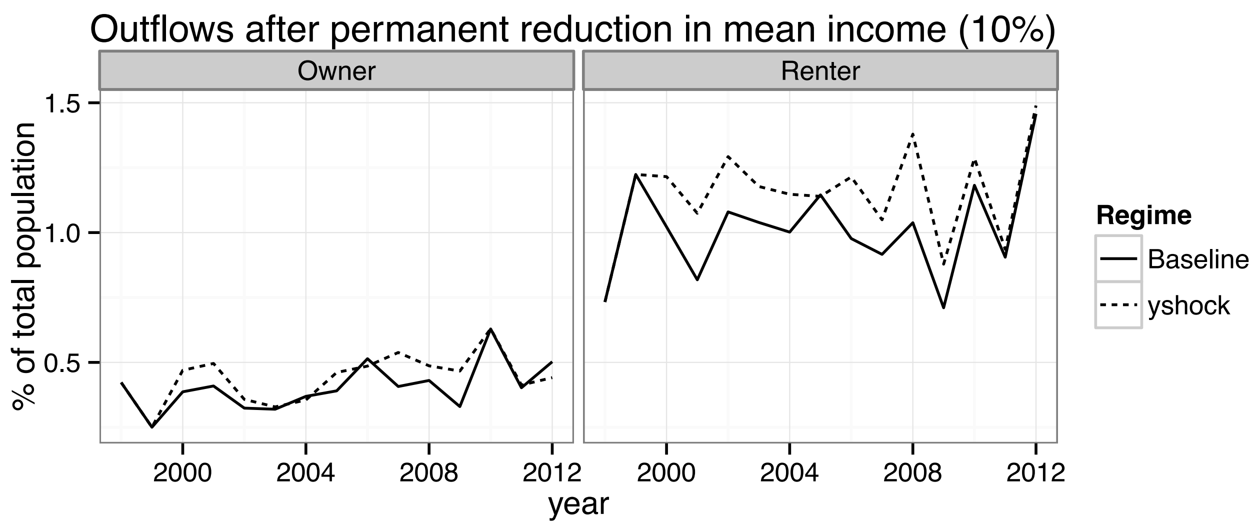

Figure 3.9: The effect of a permanent 10% reduction in productivity q in 2000 in the WNC region only. The experiment holds the regional price series in WNC and price and incomes in all other regions fixed at their observed values.

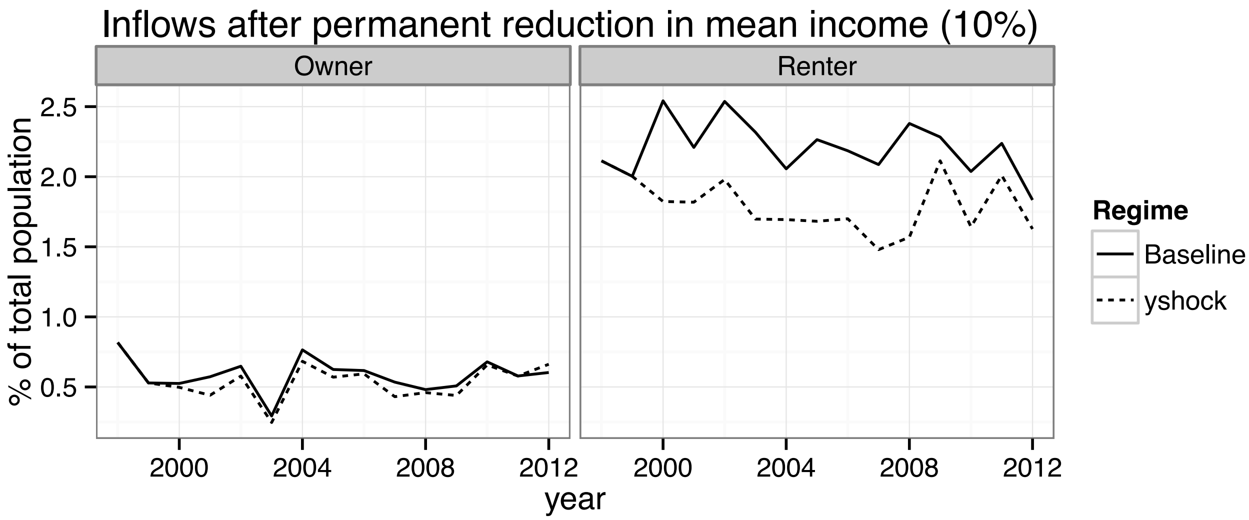

Figure 3.10: Changes in inflow patterns to WNC after the mean productivity level is permanently reduced by 10% in 2000.

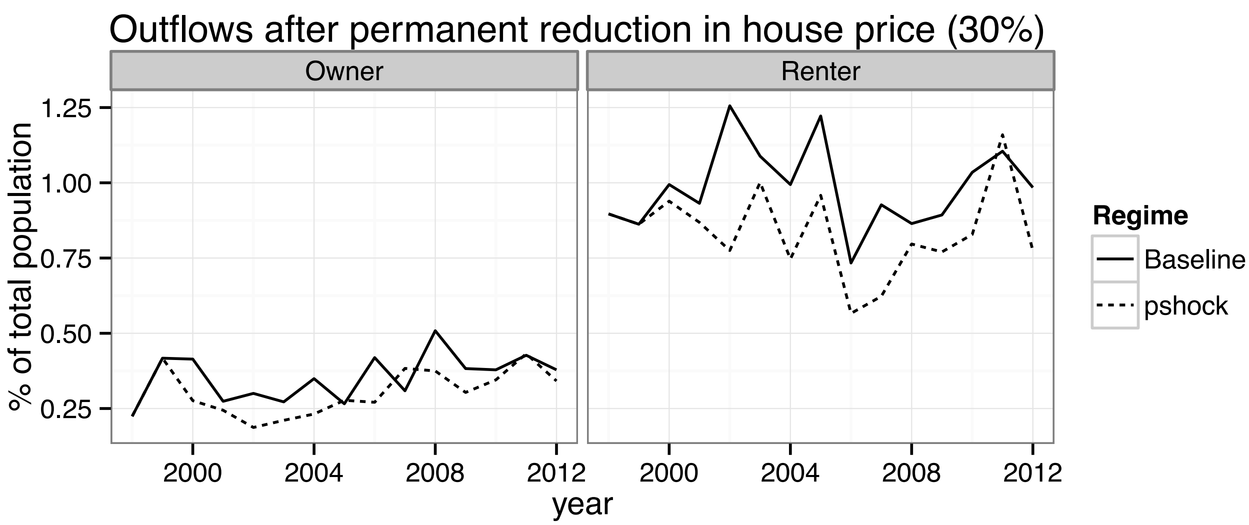

Figure 3.11: The effect of a 30% decrease of the house price level in 2000 in the West North Central Division on migratory outflows from the region.

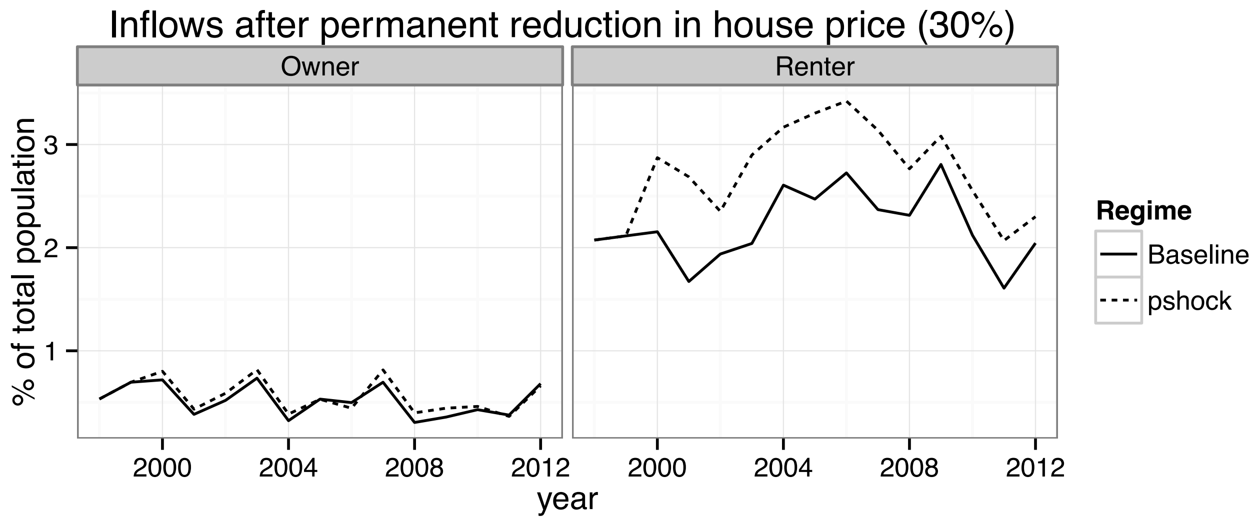

Figure 3.12: The effect of a 30% decrease of the house price level in 2000 in the West North Central Division on migratory inflows to the region.

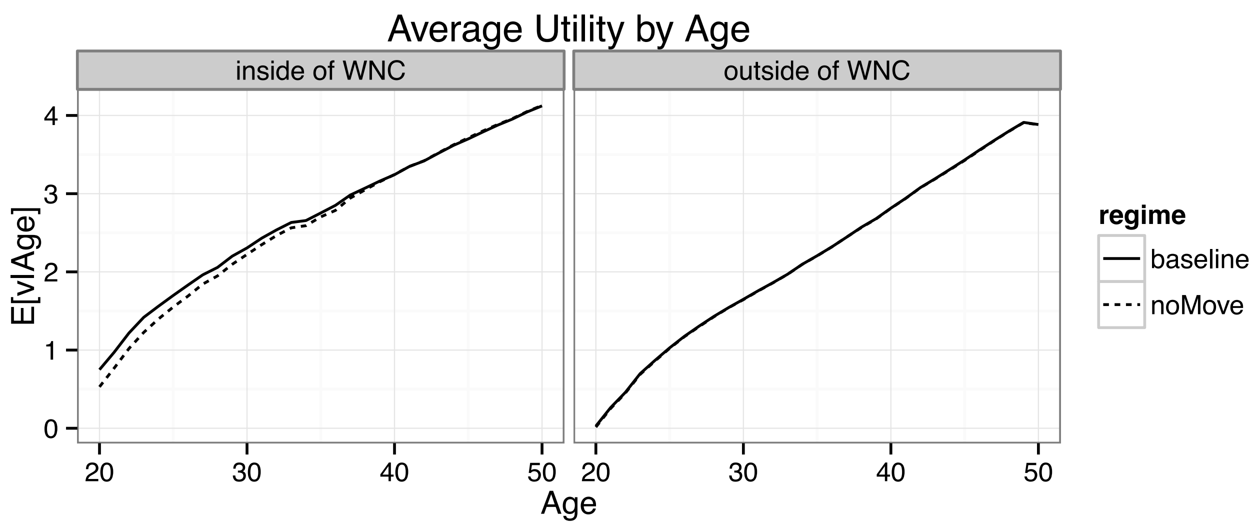

Figure 3.13: Removing the option to leave WNC. This plot shows average utility levels conditional on age, for the population residing in WNC, and the population residing elsewhere.

Appendix A

Appendix to Bankruptcy and Default

State	Deficiency	Home.Exemption	medinc	hex.fraction	sd.delta.p	group
NC	No	18500.00	45607.13	0.41	3.18	1
WA	No	40000.00	59951.18	0.67	7.38	1
AK	No	54000.00	63456.71	0.85	7.70	2
CA	No	50000.00	58509.89	0.85	10.26	2
MT	No	100000.00	43752.43	2.29	5.70	2
ND	No	80000.00	51275.34	1.56	6.25	2
AZ	No	150000.00	49907.10	3.01	8.96	3
MN	No	200000.00	59445.86	3.36	5.16	3
AL	Yes	5000.00	43445.55	0.12	3.06	4
GA	Yes	10000.00	49418.75	0.20	3.79	4
IL	Yes	7500.00	54433.88	0.14	4.91	4
IN	Yes	7500.00	48301.03	0.16	3.62	4
KY	Yes	5000.00	42728.06	0.12	3.03	4
MD	Yes	0.00	68697.79	0.00	6.56	4
OH	Yes	5000.00	49214.44	0.10	3.66	4
TN	Yes	5000.00	43074.65	0.12	3.16	4
VA	Yes	5000.00	62967.78	0.08	5.37	4
WY	Yes	10000.00	53708.11	0.19	6.90	4
AR	Yes	17425.00	41227.34	0.42	3.73	5
CO	Yes	45000.00	61377.39	0.73	5.58	5
DE	Yes	50000.00	56565.67	0.88	5.76	5

HI	Yes	17425.00	64089.82	0.27	10.51	5
LA	Yes	25000.00	42654.21	0.59	5.51	5
ME	Yes	35000.00	50249.51	0.70	6.27	5
MI	Yes	17425.00	51084.04	0.34	5.79	5
MO	Yes	15000.00	48774.10	0.31	3.74	5
NE	Yes	12500.00	53861.02	0.23	3.29	5
NJ	Yes	17425.00	68284.69	0.26	7.62	5
NM	Yes	30000.00	45115.96	0.66	5.35	5
OR	Yes	25000.00	52448.20	0.48	7.25	5
PA	Yes	17425.00	51987.45	0.34	4.24	5
SC	Yes	17425.00	44104.29	0.40	3.12	5
SD	Yes	30000.00	49528.12	0.61	3.62	5
UT	Yes	20000.00	60398.63	0.33	6.44	5
WI	Yes	40000.00	53704.30	0.74	4.35	5
WV	Yes	25000.00	42656.15	0.59	4.35	5
CT	Yes	75000.00	67675.40	1.11	8.04	6
ID	Yes	104471.00	50053.53	2.09	5.83	6
MA	Yes	100000.00	63015.52	1.59	8.03	6
MS	Yes	75000.00	38908.97	1.93	3.24	6
NH	Yes	100000.00	68438.14	1.46	8.01	6
NV	Yes	550000.00	54782.10	10.04	10.06	6
NY	Yes	50000.00	52655.17	0.95	6.79	6
RI	Yes	200000.00	55399.59	3.61	8.63	6
VT	Yes	75000.00	55026.47	1.36	5.56	6
FL	Yes	∞	47917.01		7.97	7
IA	No	∞	52378.80		3.85	7
KS	Yes	∞	48913.09		3.33	7
OK	Yes	∞	46108.99		5.60	7
TX	Yes	∞	48876.19		4.83	7

Table A.1: Grouping of US states by legal environment concerning bankruptcy and mortgage default. Columns 2 and 3 are taken from Mitman (2011).

Appendix B

Appendix to Migration and Homerownership

B.1 Welfare Measure

Denoting the expected lifetime utility from the baseline and policy regimes under consumption tax δ by U and $\hat{U}(\delta)$ respectively, the equalizing consumption tax δ^* solves

$$\begin{aligned} U - \hat{U}(\delta^*) &= 0 \\ U &= \frac{1}{TN}\sum_{i=1}^{N}\sum_{t=1}^{T}\beta^{t-1}u(c_{it}) \\ \hat{U}(\delta) &= \frac{1}{TN}\sum_{i=1}^{N}\sum_{t=1}^{T}\beta^{t-1}u(\delta c_{it}) \end{aligned}$$

where N is the number of simulated individuals and $u(c)$ stands, with some abuse of notation, for the stream of utility from equation (3.5) as implied by optimal behaviour. Accordingly, a value $\delta^* > 1$ implies that agents would be indifferent between any proposed policy change if consumption were scaled up in every period, i.e. they would demand a subsidy. In the opposite case of $\delta^* < 1$ they would be happy to give up a fixed proportion $\delta^*$of period consumption if they were given the opportunity to participate in the policy.

B.2 Initial Conditions and Cohort Setup

The SIPP estimation sample runs from 1998 through 2012. The data moments the model is supposed to replicate are weighted averages over this period, where the weights are the SIPP sampling weights. When reconstructing an artificial sample from the model simulation, care must be taken to replicate the shocks experienced by each cohort in the data leading up to the point where they are observed.

The data is subset to the ages allowed for in the model, i.e. 20–50. I compute data moments, for example the average homeownership rate in region d, or the average total wealth of age group 40–45 in d, as averages over the entire sample period:

$$\begin{aligned} \text{mean\_own\_data}_d &= \frac{1}{15}\sum_{t=1998}^{2012}\left(\frac{1}{N_{dt}}\sum_{i\in d,t}^{N_{dt}}\omega_{it}\mathbf{1}\left[h_{it}=1\right]\right) \\ \text{mean\_wealth\_data\_40\_45}_d &= \frac{1}{15}\sum_{t=1998}^{2012}\left(\frac{1}{N_{dt,j\in[40,45]}}\sum_{i\in d,t,j\in[40,45]}^{N_{dt,j\in[40,45]}}\omega_{it}w_{ijt}\right) \end{aligned}$$

where N_{dt} is the number of people in d at date t, and ω_{it} is a person's crossectional weight, and $i \in d, t$ stands for i is in d at date t. Similarly, $i \in d, t, j \in [40, 45]$ stands for i is in d at date t and age j in [40,45].

This means that for the second data moment, for example, 40 year-olds from 1998 contributed as well as 40 year-olds from the 2012 cohort. Needless to say, those cohorts faced a different sequence of house price shocks leading up the point of observation. For individuals "born" before the first data period, i.e. 1998, I construct regional house price and regional income series going back until 1968. Simulating individuals from the 1968 cohort for a full lifetime of J=30 years until the reach age 50 brings them into the year 1998, where they form the group of 50 year-olds in that particular year. This sort of staggered simulation is carried out until the final cohort is born in 2012 at age 20. No simulation needs to take place for any individual alive at years after 2012.

B.3 Estimation of G_{move}

In a first step I estimate the marginal distributions of z_{idt} and z_{ikt+1} for all movers. These are the cross-sectional distributions of residuals u_{it} and u_{it+1} from the regression in expression (B.1), which is estimated for all movers. The move takes place in period t, such that by assumption, u_{it} is the residual wage in origin location d, and u_{it+1} is the residual wage in the new location k.

$$\ln y_{idt} = \beta_0 + \beta_1 \text{college}_{it} + \delta p(\text{age}_{it}) + \beta_2 \text{numkids}_{it} + \beta_3 \text{sex}_{it} + \beta_4 \text{metro}_{it} + \gamma_d + u_{it} \quad \text{(B.1)}$$

Here $p(\text{age})$ is a third order polynomial in age, metro is an indicator for metropolitan status and γ_d is a Division fixed effect. Then I convert the residuals into their respective rank in the empirical distributions of before and after move residuals. Denoting the standardized values by $(\hat{u}_{it}, \hat{u}_{it+1})$, the next step involves fitting the a normal copula via maximum likelihood to this data. The results are shown in table B.1, and they indicate a correlation between $\hat{u}_{it}$ and $\hat{u}_{it+1}$ of 0.59. This estimate together with the marginal distibutions of u_{it} and u_{it+1} are used in the structural model, where I use the current value of z, evaluated in the marginal distribution of u_{it} for a mover together with the copula estimate $\hat{G}_{\text{move}}$ to draw the next value of z'.

B.4 Map

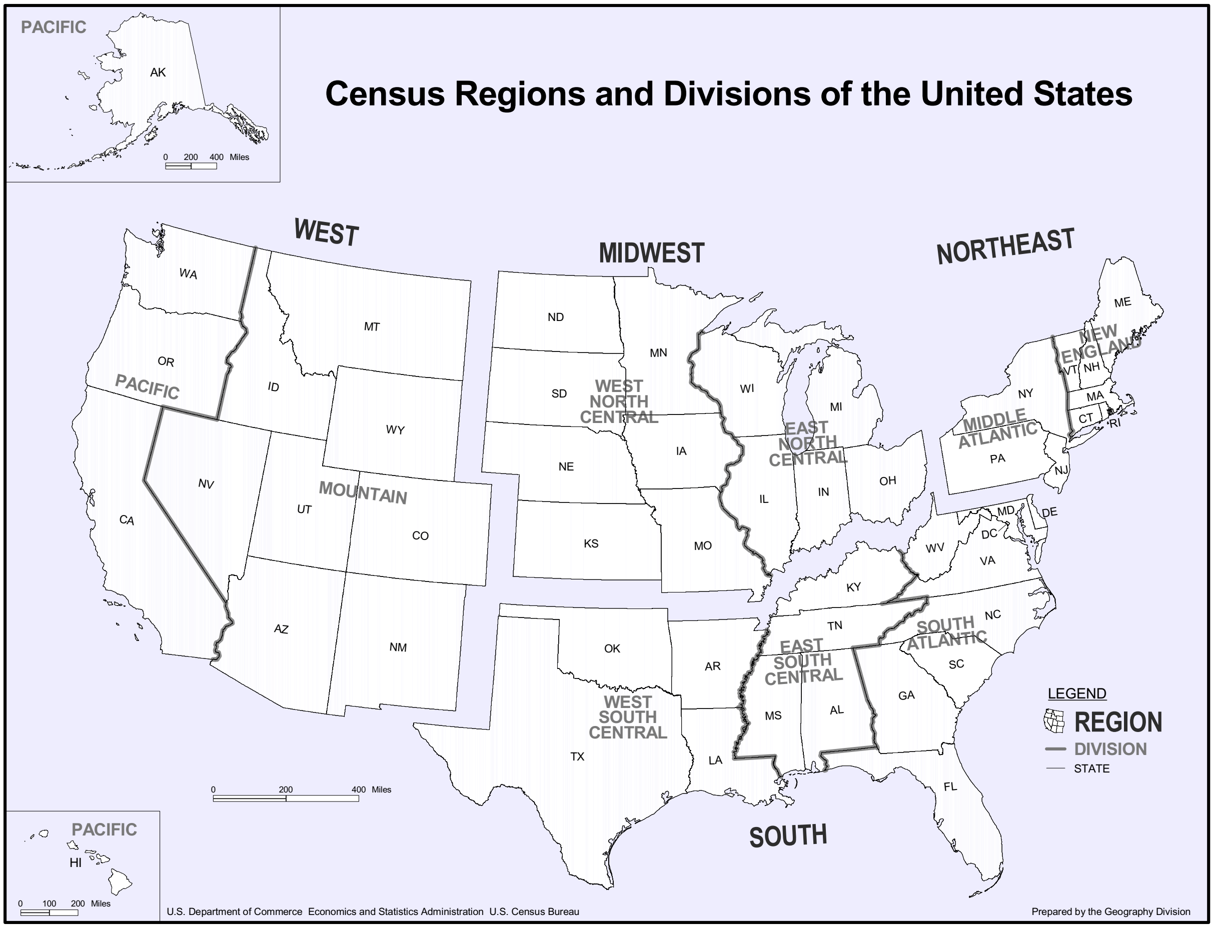

Figure B.1: Census Division Map, taken from https://www.census.gov/geo/maps-data/maps/pdfs/reference/us_regdiv.pdf. The Divisions are from left to right Pacific, Moutain, West North Central, West South Central, East North Central, East South Central, New England, Middle Atlantic and South Atlantic.

B.5 Additional tables and figures

	ρ	S.E.
$G_{\text{move}}(z_t, z_{t+1})$	0.59762	0.01795

Table B.1: Normal Copula estimates for the rank of wage residuals u_{it} and u_{it+1} for individuals who move in period t.

Figure B.2: Age profiles as predicted by the empirical implementation of individual labor income, equation (3.22), for three different levels of regional mean productivity q. Notice that in the model as well as in the data it is never the case that all regions have the same level of average income.

	East North Central		East South Central		Middle Atlantic		Mountain	
	q_{dt}	p_{dt}	q_{dt}	p_{dt}	q_{dt}	p_{dt}	q_{dt}	p_{dt}
$\mathbf{a_{0d}}$	12.30***	61.10***	3.74***	88.19***	8.42***	−34.84**	8.38***	5.89
	(0.72)	(10.51)	(0.60)	(7.15)	(0.64)	(12.00)	(0.67)	(10.85)
Q_t	0.62***	−0.84	0.70***	−1.53***	1.00***	2.87***	0.56***	−1.23*
	(0.03)	(0.49)	(0.03)	(0.34)	(0.03)	(0.56)	(0.03)	(0.51)
P_t	0.01	0.70***	0.01	0.61***	−0.01*	0.75***	0.03***	1.20***
	(0.01)	(0.10)	(0.01)	(0.07)	(0.01)	(0.12)	(0.01)	(0.10)
R^2	0.97	0.74	0.98	0.73	0.99	0.92	0.98	0.89
Adj. R^2	0.97	0.72	0.98	0.72	0.99	0.91	0.97	0.89
Num. obs.	92	92	92	92	92	92	92	92

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

	New England		Pacific		South Atlantic		West N Central		West S Cen	
	q_{dt}	p_{dt}	q_{dt}	p_{dt}	q_{dt}	p_{dt}	q_{dt}	p_{dt}	q_{dt}	
$\mathbf{a_{0d}}$	3.77***	−114.58***	13.32***	−214.09***	6.54***	39.23***	7.75***	62.46***	5.46***	106.
	(0.64)	(20.60)	(0.56)	(17.11)	(0.64)	(5.32)	(0.71)	(7.80)	(0.93)	(12.
Q_t	1.18***	4.54***	0.55***	3.08***	0.75***	−1.47***	0.72***	−1.69***	0.63***	−3.
	(0.03)	(0.97)	(0.03)	(0.81)	(0.03)	(0.25)	(0.03)	(0.37)	(0.04)	(0.
P_t	−0.01*	1.05***	0.03***	1.91***	0.01	1.14***	0.01	0.78***	0.02*	0.
	(0.01)	(0.20)	(0.01)	(0.16)	(0.01)	(0.05)	(0.01)	(0.07)	(0.01)	(0.
R^2	0.99	0.89	0.98	0.95	0.98	0.97	0.98	0.81	0.96	0.
Adj. R^2	0.99	0.89	0.98	0.95	0.98	0.96	0.98	0.80	0.96	0.
Num. obs.	92	92	92	92	92	92	92	92	92	92

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table B.2: Aggregate to Regional price mappings. This table shows the estimated coefficients from equation (3.3), which relates the aggregate factors (Q_t, P_t) to regional income and house price (q_{dt}, p_{dt}).

	$\log y_{it}$
Intercept	-0.684^{***}
	(0.135)
age	0.211^{***}
	(0.006)
age^2	-0.004^{***}
	(0.000)
age^3	0.000^{***}
	(0.000)
East North Central	0.273^{***}
	(0.029)
East South Central	0.214^{***}
	(0.030)
Middle Atlantic	0.273^{***}
	(0.028)
Mountain	0.276^{***}
	(0.029)
New England	0.294^{***}
	(0.027)
Pacific	0.287^{***}
	(0.028)
South Atlantic	0.265^{***}
	(0.029)
West North Central	0.280^{***}
	(0.029)
West South Central	0.248^{***}
	(0.030)
R^2	0.043
Adj. R^2	0.043
Num. obs.	288952
RMSE	0.904

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table B.3: Regional Mean Income to Individual level income mapping. This is the empirical implementation of equation (3.1), as explained in section 3.5.1. The estimated equation is $\log y_{idt} = \beta_0 + \eta_d \log \overline{y}_{dt} + \beta_1 \text{age}_{it} + \beta_2 \text{age}^2_{it} + \beta_3 \text{age}^3_{it} + u_{it}$ and the coefficients η are denoted with the Division names.

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Note on co-authored work

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- Chapter 1, "Recourse and Residential Mortgage Market: The case of Nevada" is joint work with Wenli Li, and each author contributed equally to the paper.
- Chapter 2, "Consumer Bankruptcy and Mortgage Default" is joint with Costas Meghir and Wenli Li, and each author contributed equally to the paper.
- Chapter 3, "Regional Shocks, Migration and Homeownership" is single authored by Florian Oswald.