Residential Mortgage Default and Consumer Bankruptcy: Theory and Empirical Evidence*

Wenli Li, Philadelphia Federal Reserve
and Michelle J. White, UC San Diego and NBER

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1. Introduction

In this paper, we examine homeowners' decisions both to default on their mortgages and to file for bankruptcy. The mortgage default decision and the bankruptcy decision have both been intensively studied, but important interactions between the two decisions have been ignored. Researchers studying the mortgage default decision have tested models of whether homeowners actually default when they gain financially from doing so and, more recently, they have also examined whether liquidity constraints play a role in the mortgage default decision. Researchers studying the bankruptcy decision have also tested models of whether households file when they gain financially from doing so and have also examined whether households file because they experience negative shocks such as job loss or health problems. But the two decisions have been treated as though they were independent. In addition, most researchers have assumed—for lack of data—that mortgage default decisions depend only on the level of mortgage debt, while bankruptcy decisions depend only on the level of unsecured debt.

Homeowners' decisions to default on their mortgages and to file for bankruptcy are related in several ways. Homeowners in financial distress who wish to save their homes can file for bankruptcy and have some or all of their unsecured debts discharged, thus making it easier for them to make their mortgage payments. If they are in arrears on mortgage payments but wish to save their homes, then they can use Chapter 13 to spread repayment of the arrears over five years. Homeowners who plan to give up their homes also have an incentive to file for bankruptcy, since bankruptcy can be used to delay foreclosure and, post foreclosure, deficiency judgments can be discharged in bankruptcy. Conversely homeowners with high home equity and/or high income have an incentive to avoid bankruptcy even if they are financially distressed, since they may be forced to repay unsecured debt from the proceeds of selling their homes in bankruptcy or from their future incomes.

In this paper, we construct a model that predicts whether homeowners' default on their mortgages and/or file for bankruptcy, where the model takes account of many ways in which the two decisions are related. We test the model by estimating a multi-probit model that explains whether homeowners default on their mortgages, file for bankruptcy, or do neither. We use a new panel dataset of homeowners with mortgages that includes

information both on mortgage debt and all other types of household debt. This dataset allows us to test how credit card and other unsecured debt affects homeowners' decisions to default on their mortgages and how mortgage and other secured debt affects their decisions to file for bankruptcy. Our paper is innovative in testing a structural model, in simultaneously explaining both default and bankruptcy, and in estimating cross effects, i.e., how unsecured debt affects the default decision and secured debt affects the bankruptcy decision.

In this draft we report preliminary results, based on samples of fixed rate mortgages that are both prime and subprime. In the future, we also plan to examine samples of homeowners with prime and subprime adjustable rate mortgages.

We find that when homeowners are predicted to gain from defaulting on their mortgages but not filing for bankruptcy, their probabilities of doing so rise by 2% for those with prime mortgages and 34% for those with subprime mortgages. When homeowners are predicted to gain from filing for bankruptcy but not defaulting, their probability of filing rises by 52% for those with prime mortgages and 29% for those with subprime mortgages. We also find that there are cross-effects, so that when homeowners are predicted to gain from bankruptcy but not default, their probability of doing the opposite—i.e., defaulting on their mortgages but not filing for bankruptcy—falls significantly for those with both prime and subprime mortgages. Also when homeowners are predicted to gain from default but not from bankruptcy, their probability of doing the opposite falls by 26% for those with prime mortgages. We also find that when homeowners are predicted to gain from both default and bankruptcy, their probability of default rises, but their probability of bankruptcy does not change significantly.

Literature

Since the mortgage crisis began in 2007, a large literature has emerged explaining homeowners' decisions to default on their mortgages. See, for example, Demyanuk and von Hemet (2008), Jiang, Nelson, and Vytlacil (2009), Gerardi, Shapiro and Willen (2007), Bajart, Chu and Park (2008), Mayer, Pence and Sherlund (2008), Keys,

Mukherjee, Seru and Vig (2010), and Li, White and Zhu (2010).[1] There is also a literature explaining households' decisions to file for bankruptcy, see Fay, Hurst and White (2002) and Gross and Souleles (2002). The two literatures have remained separate mainly because, until recently, no data were available that gave information at the household level on both mortgage and non-mortgage debt.

Two recent papers are most closely related to ours. The first, by Elul et al (2010) uses a combined dataset to examine how both credit card debt and mortgage debt affect homeowners' decisions to default on their mortgages. They examine only the mortgage default decision, but they find that homeowners' decisions to default on their mortgages depend on both types of debt. The other paper, by Cohen-Cole and Morse (2009), estimates a model that explains whether homeowners default on their mortgages or on their credit card debts, conditional on default. They find that, rather than always protecting their mortgages at the expenses of their credit cards, homeowners often preserve liquidity by defaulting on their mortgages in order to retain their access to credit cards. A drawback of their model, however, is that they only examine households that default on one or the other type of debt, thus ignoring information provided by those who do not default at all. Our model considers both decisions.

Model

Our primary goal in this paper is to examine how households' decisions to default on their mortgages and file for bankruptcy are related. Rather than simply enter levels of mortgage debt and credit card debt in our regressions, we instead construct variables that measure whether households gain financially from defaulting on their mortgages and whether they gain financially from filing for bankruptcy. For many homeowners, the two decisions are inter-related. In this section, we discuss how homeowners gain financially from defaulting on their mortgages and filing for bankruptcy.[2]

Consider first homeowners' gain from filing for bankruptcy. Homeowners' gain from filing depends on whether they file under Chapter 7 or Chapter 13 and also depends on

[1] These papers, with the exception of Li et al (2010), examine only subprime mortgages. None had information on second mortgages or non-mortgage debt.
[2] For more detailed discussion, see White and Zhu (2010).

whether they file before versus after the 2005 bankruptcy reform. Prior to the 2005 reform, homeowners could file under Chapter 7 and have their unsecured debts—including credit card debts, installment loans, and medical bills—discharged in bankruptcy. They were not obliged to repay unsecured debt from future income and most homeowners were also not obliged to repay from assets. But the terms of mortgage loans could not (and still cannot) be changed in bankruptcy. Suppose the discounted present value of future interest and principle payments on unsecured debt is denoted P'. Also suppose the cost of filing for bankruptcy is denoted C_b, where C_b includes court costs, lawyers' fees and the cost of reduced access to credit after bankruptcy. Homeowners' gain from filing for bankruptcy under Chapter 7 prior to 2005 was $P' - C_b$. As discussed in White and Zhu (2010), many homeowners in financial distress gained from filing for bankruptcy under Chapter 7, because having their unsecured debt discharged helped them pay their mortgages and keep their homes.

Homeowners can also file for bankruptcy under Chapter 13. Under Chapter 13, homeowners propose a repayment plan to repay mortgage arrears over five years. Prior to 2005, they were not obliged to repay any of their unsecured debt in Chapter 13. Assuming that they repay their mortgage arrears (plus interest) and make all the normal mortgage payments during the five year period, they keep their homes and the terms of the original mortgage contract are reinstated. Chapter 13 thus helps homeowners by allowing them to keep their homes even if they owe substantial amounts on their mortgages, by allowing them to spread out repayment of the arrears.

The 2005 bankruptcy reform changed bankruptcy law by instituting a "means test" that forces some homeowners to file under Chapter 13 if they file for bankruptcy at all and requires that they use some of their future income to repay unsecured debt. Because the means test is complicated, we use an approximation of the actual procedure. Homeowners whose income is below the median income level in their states are still allowed to file under Chapter 7, so that their gain from filing for bankruptcy remains the same. But homeowners whose income is above the state median income level are required to file under Chapter 13 if they file for bankruptcy at all. Under Chapter 13, these homeowners are obliged to use the difference between their actual income level and the state median income level for five years to repay debt in bankruptcy. Suppose *Y*

denotes income and X_y is the income exemption in bankruptcy, which we assume equals the state median income level. Then homeowners in bankruptcy are obliged to use $\max[5(Y - X_y),0]$ of their future income to repay debt. Also suppose M_5' denotes the discounted present value of payments on secured loans over the next five years, including normal mortgage payments, car loan payments, and arrears on mortgage and car loans. Because secured debts have priority over unsecured debts in bankruptcy, homeowners' obligation to repay unsecured debt in Chapter 13 bankruptcy is $\max[5(Y - X_y) - M_5',0]$. Homeowners' financial gain from filing for bankruptcy under Chapter 13 after 2005 is therefore $P' - C_b - \max[5(Y - X_y) - M_5',0]$. (Note that some homeowners are also obliged to repay debt from assets in bankruptcy—see below.)[3]

Now turn to homeowners' gain from defaulting on their mortgages. The cost of owning a home equals $M_T' - V$, where V is the value of the house and M_T' is the discounted present value of all mortgage payments from the present until the end of the mortgage contract at year *T*. Homeowners' cost of renting alternative housing if they default is denoted R_T', which equals the discounted present value of the future cost of renting a house from the present until year *T*. Homeowners are better off defaulting on their mortgages and giving up their homes if the cost of owning exceeds the cost of renting, or if $M_T' - V > R_T'$. In terms of house value, the condition for homeowners to be better off defaulting is $V < M_T' - R_T$.

When homeowners default on their mortgages, lenders foreclose and sell the house. If the house sells for less than the current mortgage principle (including arrears and penalties), then there is a deficiency. In some states, mortgage lenders have the right to sue borrowers to collect the deficiency. The deficiency judgment, denoted *DJ*, equals the value of the house *V* minus the current mortgage principle, denoted MP, minus the cost of selling the house in foreclosure, denoted C_f, or $DJ = MP - V - C_f$. For homeowners in states that allow deficiency judgments, the condition for homeowners to gain from

[3] This simplifies the actual means test in bankruptcy, which requires filers having income above the state median level to go through a procedure to calculate an individualized income exemption and, using the income exemption, to calculate the obligation to repay. We use the state median income level as a proxy for the income exemption, because income above this level triggers the means test.

defaulting on their mortgages becomes $M'_T - V + DJ > R'_T$. However, deficiency judgments are unsecured debts, so that (former) homeowners can have them discharged by filing for bankruptcy. In this situation, their gain from filing for bankruptcy increases to $P' + DJ - C_b - \max[5(Y - X_y) - M'_5, 0]$. The discharge of deficiency judgments in bankruptcy is another way in which homeowners' gains from filing for bankruptcy and from defaulting on their mortgages are related.

Now suppose the value of the house is higher, so that the cost of owning is less than the cost of renting, or $M'_T - V < R'_T$, or $V > M'_T - R'_T$. Homeowners in this situation gain from avoiding default on their mortgages and keeping their homes. However they may nonetheless default if they are liquidity-constrained. We assume that homeowners are liquidity-constrained if they cannot afford to pay their mortgages even if they use up to 50% of their incomes and also borrow up to the credit limits on their existing credit cards. Suppose available credit on existing credit cards is denoted *AC*. The cost of paying the mortgage and mortgage arrears in bankruptcy is M'_5 over five years and the cost of filing for bankruptcy is C_b. Assuming that both of these costs are spread over 5 years as part of a Chapter 13 repayment plan, homeowners are assumed to be forced to default because of liquidity constraints if $.5Y + AC < (M'_5 + C_b)/5$.

Now suppose the value of the house is sufficiently high that homeowners are obliged to use give up their homes and use part of their home equity to repay unsecured debt in bankruptcy. These homeowners prefer to avoid defaulting on their mortgages, because the cost of owning is less than the cost of renting. But they might nonetheless default on their mortgages because they are liquidity-constrained. If they do so, then their homes are sold in foreclosure and the proceeds of sale, *V*, are used first to pay foreclosure costs, denoted C_f, and then to repay the mortgage (first, then second) in full. Then homeowners are entitled to receive up to the amount of the homestead exemption in their states. States' homestead exemptions, denoted X_h, range from zero in Delaware and Maryland to unlimited in Texas, Florida and several other states. After homeowners receive the full amount of the homestead exemption, anything remaining must be used to repay unsecured debt. The amount of home equity that homeowners are

obliged to use to repay in bankruptcy is therefore $NEHE = \max[V - MP - C_f - X_h, 0]$, where $NEHE$ denotes non-exempt home equity.[4] If homeowners have non-exempt home equity, then their gain from filing for bankruptcy falls to $P' - C_b - NEHE$. If they have both non-exempt home equity and non-exempt income, then their obligation to repay debt in bankruptcy equals the maximum of their non-exempt home equity and their non-exempt income over five years. For these homeowners, the financial gain from filing for bankruptcy becomes $P' - C_b - \max[5(Y - X_y), NEHE]$.[5]

Thus homeowners' decisions to default on their mortgages and to file for bankruptcy interact in several ways, because discharge of unsecured debt in bankruptcy reduces the cost of paying the mortgage and therefore helps homeowners avoid default, but discharge of deficiency judgments in bankruptcy makes it less expensive for them to give up their homes in some states. Also, the obligation to repay unsecured debt from home equity and—since bankruptcy reform—from future income discourages homeowners from filing for bankruptcy if they have high incomes or high assets.

Figure 1 shows homeowners' incentives to file for bankruptcy and to default on their mortgages as a function of their incomes *Y* and the value of their homes *V*. pD/B denotes homeowners who are predicted both to default and file for bankruptcy, pD/NB denotes those who are predicted to default only, pND/B denotes those who are predicted to file for bankruptcy only, and pND/NB denotes those who are predicted to do neither. The horizontal dashed line in the figure denotes the level of home value where homeowners are indifferent between defaulting versus not defaulting on their mortgages, or where $V = M'_T - R'_T$. The height of the line varies across homeowners—it shifts upward when the cost of paying the mortgage is higher and the cost of rental housing is lower, and vice versa. The broken vertical line shown in black denotes the income level where homeowners are indifferent between filing versus not filing for bankruptcy. This line

[4] The mortgage principle includes mortgage arrears, if any. We assume that homeowners have no non-exempt assets other than home equity. This is because retirement accounts are generally exempt in bankruptcy and homeowners can often convert non-exempt financial assets into exempt assets by using the funds to partially repay their mortgages. See White (1998) for discussion.

[5] Note that if homeowners have non-exempt home equity, then they cannot have deficiency judgments.

shifts to the right when homeowners have more unsecured debt, since filing for bankruptcy is worthwhile at higher income levels.[6]

The region labeled pD/Ba is where homeowners are predicted to default on their mortgages and file for bankruptcy because home value and income are both low. The region labeled pD/NB is where homeowners are predicted to default because home value is low, but not file for bankruptcy because income is high. The sideways L-shaped region labeled pND/NB occurs where both income and home value are high, so that homeowners are predicted to avoid both default and bankruptcy. The top left corner of this region consists of homeowners who have high house value but low income. They are predicted to avoid both default and bankruptcy because, in bankruptcy, they would be required to sell their homes and repay their unsecured debts from non-exempt home equity. The region labeled pD/Bb is where homeowners are liquidity-constrained. They would prefer to avoid defaulting on their mortgages because home value is above the dashed line, but they are forced to default because low income prevents them from making their mortgage payments. Finally there are two regions labeled pND/B in the middle of the figure where homeowners file for bankruptcy but do not default. Homeowners in this region gain from filing for bankruptcy under Chapter 13, because an extra dollar of unsecured debt is discharged for each extra dollar of secured debt and this subsidy pushes the bankruptcy/no bankruptcy dividing line to the right. Homeowners in the region pND/Bb above the dashed line are predicted to avoid default regardless of whether they file for bankruptcy or not, but those in region pND/Ba below the dashed line would otherwise default. Those in the pND/Ba region keep their homes only because of the subsidy to homeowning in bankruptcy. The pND/Ba region exists only for homeowners having high levels of unsecured debt.[7]

Data and summary statistics

[6] Prior to the 2005 bankruptcy reform, homeowners were predicted to file for bankruptcy even at very high income levels because there was no means test.

[7] See White and Zhu (2010) for an estimate of the fraction of homeowners who keep their homes because of the bankruptcy subsidy.

Our data are derived from three separate sources. The first is the LPS dataset, which consists of a large sample of prime and subprime mortgages. It contains information concerning homeowners' financial characteristics, the property, and the mortgage at the time of origination, plus updates on whether homeowners paid in full and whether they file for bankruptcy each month. The second is a large sample of individuals from Equifax, which includes information on all types of credit accounts, including credit cards, installment loans, car loans, student loans, and first and second mortgages. For each loan, quarterly updates are provided concerning the loan principle, the terms of the loan, credit limits where applicable, and whether the loan was paid in full. Although the Equifax sample includes both homeowners and non-homeowners, we consider only homeowners with prime, fixed rate mortgages. Finally the third dataset is HMDA, which gives information concerning all mortgage originations in the U.S. We merge both the Equifax and the LPS data with HMDA and, through the HMDA match, with each other. The match is done by linking first mortgages based on the zipcode of the house, the date of origination of the mortgage, the type of mortgage, and the size of the mortgage principle. The merged dataset consists of individuals with mortgages that originated in any of the years 2004, 2005 or 2006. These individuals and their loans are followed each quarter until the mortgage is paid off, refinanced, transferred to a different servicer, the homeowner defaults or files for bankruptcy or does both in a particular quarter, or our sample ends in the fourth quarter of 2009.[8]

Our sample for this paper consists of approximately 239,000 prime, fixed rate mortgages and 17,000 subprime, fixed rate mortgages. For the two samples, we have approximately 1.8 million and 106,000 quarterly observations, respectively. In the future, we also plan to examine prime and subprime adjustable rate mortgages.[9]

Information on the quarter in which homeowners defaulted on their mortgages or filed for bankruptcy is taken from LPS; we define mortgage default to occur when the

[8] We drop mortgages in areas that were affected by Hurricanes Katrina and Rita, since many homeowners in these areas delayed paying their mortgages and their delinquencies were recorded as defaults in our data.
[9] Adjustable rate mortgages are more difficult to analyze because the interest rate generally is fixed during the first two years (the "teaser" rate) and then shifts to a variable rate that equals an index rate plus a markup.

mortgage first becomes delinquent for at least 90 days.[10] The HMDA dataset provides information on homeowners' income, race, sex, and marital status at the time of the mortgage application. The Equifax dataset provides quarterly information on the size of each loan, whether the loan was paid in full, and homeowners' financial characteristics, including FICO score, debt-to-income ratio, and mortgage loan-to-house value ratio each quarter. We also add a number of legal variables and macroeconomic variables—discussed below.[11]

For each homeowner in each quarter, we calculate the predicted default and bankruptcy variables pD/B, pND/B, pD/NB, and pND/NB. These variables are calculated according to the discussion in the previous section. The calculations take account of whether each observation occurs before versus after the 2005 bankruptcy reform, since homeowners' gain from filing for bankruptcy changed at the time of the reform. These calculations use homeowners' income, debt, and house value each quarter. Since we only observe income at the time of mortgage origination, we update it using the rate of change in per capita income in the homeowner's state since the date of mortgage origination. Similarly, house value is also observed only at the time of mortgage origination, so we update it using the rate of change in the housing price index in the metropolitan area since the date of mortgage origination. Debt levels are updated each quarter based on actual data. (See the appendix for more details on methods of calculation and assumed parameter values.) Because we take account of changes in house value, the calculations also allow for the effect of the mortgage crisis.

We use the notation aD/B, aD/NB, aND/B and aND/NB to denote whether homeowners actually default on their mortgages and/or file for bankruptcy each quarter. aD/B equals one if homeowners both default and file for bankruptcy in the same quarter, aD/NB equals one if they default but do not file for bankruptcy in a particular quarter, aND/B equals one if they do not default but file for bankruptcy in a particular quarter, and aND/NB equals one if they do neither in a particular quarter. We drop homeowners

[10] We use 90 days of delinquency to define mortgage default, because homeowners often repay arrears when their delinquency periods are shorter. We want our default variable to capture homeowners who intend to give up their homes.

[11] Our observations are of individuals rather than households. The full amount of first mortgage loans is assigned to the individual. But if non-mortgage or second mortgage loans are joint obligations of a husband and wife, then only half of each loan is assigned to the individual.

from the sample once they default or file for bankruptcy, so that these variables capture which event comes first (unless homeowners do both in the same quarter).

We have two additional variables that depend on levels of both secured and unsecured debt and are expected to affect both the mortgage default and bankruptcy decisions. One is a measure of whether homeowners are liquidity-constrained, which equals one if they must use at least half of their monthly income plus any unused borrowing capacity on their credit cards to make their combined payments on all types of debt. The liquidity constraint measure is our closest variable to capturing whether homeowners have experienced adverse events that reduce their ability-to-pay or increase their debt levels. The other is homeowners' risk score lagged one quarter, which is a prediction of their likelihood of defaulting on any type of debt payment within the next two years. (Higher risk scores are predicted to be negatively related to default and bankruptcy.) Both measures are updated each quarter.

Table 1 shows summary statistics for variables used to calculate the predicted default and bankruptcy decisions and table 2 shows the predicted versus actual values of the D/B variables. Note that homeowners are predicted both to default and to file for bankruptcy much more often than they actually do so. 2.6% and 2.8% of homeowners with prime and subprime mortgages, respectively, are predicted to default and file for bankruptcy each quarter, but the probabilities that they actually do so are only 0.024% and 0.125%, respectively. Similarly 3.4% of both samples are predicted to default but not file for bankruptcy each quarter, while only 0.5% and 2.4% of prime and subprime mortgage-holders actually do so. More homeowners are also predicted to file for bankruptcy but not default than actually do so. The predicted probabilities are 0.1% and 0.35% for prime and subprime mortgage-holders, respectively, compared to actual probabilities of 0.01% and 0.17%, respectively. These figures reflect the fact that many households do not actually file or default when they would gain financially from doing so.[12]

In figure 2, we report separate time trends for mortgage defaults and bankruptcy homeowners with prime and subprime mortgages. The probability of homeowners

[12] This mirrors the results in White (1998), who showed using data from the 1980's and 1990's that many more households would gain from filing for bankruptcy than actually file. The mortgage default literature also shows that homeowners often do not default when they would gain financially from doing so. See, for example, Gerardi, Shapiro and Willen (2007), who show that many homeowners in Massachusetts during the early 2000's did not default even when they had negative equity.

defaulting but not filing for bankruptcy, aD/NB, rose sharply starting at the beginning of the financial crisis in 2006/7 and peaked in 2009 at 1.6% per quarter for prime mortgages and nearly 9% for subprime mortgages. In contrast, the number of actual bankruptcy filings, aND/B, and the number of homeowners that simultaneously defaulted and filed for bankruptcy, aD/B, rose much less. These time trends suggest that homeowners are likely to default on their mortgages first, even if they file for bankruptcy later on. [13]

Specification and Results

We estimate a multi-probit model explaining homeowners' decisions to default on their mortgages and file for bankruptcy. The dependent variables are aND/B and aD/NB, with aND/NB as the omitted category. (We drop aD/B as a separate category, since it is very rare.) The main independent variables are the predictions pD/B, pND/B, and pD/NB, with pND/NB as the omitted category. We predict that aND/B will be positively related to pND/B and aD/NB will be positively related to pD/NB—these are the own effects. Similarly we predict that aD/NB will be negatively related to pND/B and aND/B will be negatively related to pD/NB—these are the cross effects. Also because homeowners tend to default first and file for bankruptcy later, aD/NB is predicted to be positively related to pD/B and aND/B is predicted to be negatively related to pD/B—these are the sequence effects.

Table 3 gives summary statistics for the control variables used in the multi-probit estimation. Controls include the homeowner's age and age squared, the age and age squared of the mortgage, the age and age squared of the homeowners' oldest credit card account, if the homeowner is female, is black and is married, whether full documentation, low documentation, or no documentation of income and assets was provided when applying for the mortgage (the omitted category is partial documentation), whether the property is single-family, whether it is a second home or an investment property (the omitted category is a primary residence), whether the mortgage is a jumbo, whether the mortgage was for refinance (versus purchase), whether the mortgage was securitized, and whether the mortgage was originated by the lender itself, by an agent who sells groups of

[13] Li and White (2009) show that 80% of homeowners who default on their mortgages eventually file for bankruptcy as well, but the filings occur over a two year period following default.

mortgages to the lender, or by a correspondent agent (the omitted category is origination by an independent agent). We also include the liquidity constraint dummy and the homeowner's lagged risk score, as well as the lagged 90-day mortgage default rate and bankruptcy filing rate in the state. State and quarter fixed effects are also included.[14]

Table 4 gives the results. Examining the control variables first, we are particularly interested in the variables that affect both the mortgage default and bankruptcy decisions. Being liquidity-constrained is positively related to whether homeowners default and negatively related to whether they file for bankruptcy (the latter relationship is significant only in the prime mortgage sample). Interpreting the results as semi-elasticities, homeowners who are liquidity-constrained are 10% and 29% more likely to default if they have prime and subprime mortgages, respectively, but 72% and 12% less likely to file for bankruptcy if they have prime and subprime mortgages. Homeowners' risk scores also affect their probabilities of both default and bankruptcy, with higher risk scores being associated with lower probabilities of both. If homeowners' risk scores rise by 10 points, their probabilities of default fall by 0.15% and 0.6% and their probabilities of bankruptcy fall by 1.1% and 0.5%, for homeowners with prime and subprime mortgages, respectively. All of these results are statistically significant. The other variables that affect both decisions are the lagged state aggregate default and bankruptcy filing rates. Homeowners are significantly more likely both to default and file for bankruptcy when either the lagged state aggregate bankruptcy rate or the lagged state aggregate mortgage default rate rise. These relationships are highly significant for homeowners with both types of mortgages.

Now turn to loan age. The probability of mortgage default rises and then falls with mortgage age—a relationship that has been discussed by Demyanyk and van Hemet (2010) and Jiang et al (2009) for subprime mortgages. We find that rising mortgage age has a similar rising and then falling relationship with whether homeowners file for bankruptcy, although it is only marginally significant subprime mortgage-holders. On the bankruptcy side, the age of credit card accounts has been found to be an important predictor of bankruptcy, with the probability of bankruptcy rising as credit card accounts

[14] Our choice of control variables is guided by availability and the previous literature. See Demyanyk and van Hemet (2010) for discussion of the role of mortgage age in default decisions and Keys et al (2010) for discussion of the role of securitization.

age (see Gross and Souleles, 2004). We find the same positive and significant relationship between credit card age and bankruptcy filings. This relationship is statistically significant for both types of mortgages. In addition, we find a negative and significant relationship between the probability of mortgage default and the age of the oldest credit card account, which is strongly significant for both types of mortgages. The negative relationship between account age and whether homeowners file for bankruptcy may occur because homeowners with older credit card accounts are more likely to use bankruptcy to avoid mortgage default and keep their homes.

Turning to the own, cross, and sequencing effects, table 5 gives the results in terms of semi-elasticities, or percentage changes in homeowners' probabilities of defaulting or filing for bankruptcy when our prediction changes from no default/no bankruptcy to any other state. For example, the percentage change in the probability that homeowners actually default when we predict that they do so—the own effect—is $(\Delta(aD/NB)/(aD/NB))/(pD/NB))$ and the percentage change in the actual probability that homeowners default when they are predicted to file for bankruptcy—the cross effect—is $(\Delta(aD/NB)/(aD/NB))/(pND/B))$. The percentage change in the probability that homeowners default first when they are predicted both to default and file for bankruptcy—the sequence effect—is $(\Delta(aD/NB)/(aD/NB))/(pD/B))$.

Our main results are that all of the own, cross, and sequence effects have the predicted signs and are statistically significant in explaining both default and bankruptcy decisions for prime mortgage-holders and in explaining the default decisions of subprime mortgage-holders. The own effects imply that when homeowners are predicted to default, their actual probabilities of defaulting rise by 2% and 34% if they have prime and subprime mortgages, respectively; while the actual probabilities of filing for bankruptcy rise by 52% for homeowners with prime mortgages if they are predicted to file. These effects are significant at at least the 5% level. The cross effects imply that when homeowners are predicted to file for bankruptcy, they are 7% less likely to default if they have prime mortgages and 45% less likely to default if they have subprime mortgages. Similarly, when homeowners are predicted to default, they are 26% less likely to file for bankruptcy if they have prime mortgages. The sequencing effects imply that when

homeowners are predicted to both default and file for bankruptcy, they are 3% more likely to default if they have prime mortgages and 23% more likely to default if they have subprime mortgages. These results are statistically significant at the 5% level or higher. But their probabilities of filing for bankruptcy do not change significantly. Our results are weakest in explaining bankruptcy decisions by subprime mortgage-holders, where neither the own, cross or sequence effects are significant. This may be because our subprime mortgage sample is small or because the number of bankruptcy filings was particularly low in the years 2006-2008 following bankruptcy reform.

Conclusions and notes on future work

This paper is the first to simultaneously examine homeowners' mortgage default and bankruptcy decisions. We first set up a model that predicts whether homeowners gain financially from defaulting, filing for bankruptcy, doing both, or doing neither. The model takes account of the many ways in which mortgage default and bankruptcy decisions interact. Then we test the importance of our predictions—along with other variables—in determining whether homeowners actually default on their mortgages and/or file for bankruptcy. We test the model on separate samples of prime and subprime fixed-rate mortgages.

The major results are that homeowners are significantly more likely to default and file for bankruptcy when they are predicted to gain financially from doing so. Actual default rates rise by 2% for homeowners with prime mortgages and 34% for homeowners with subprime mortgages when homeowners are predicted to gain from defaulting. Actual bankruptcy rates rise by 52% for homeowners with prime mortgages when homeowners are predicted to gain from filing. Homeowners are also less likely to default when they are predicted to gain from filing for bankruptcy and vice versa. The cross effect of gaining from bankruptcy on the probability of mortgage default is -7% for those with prime mortgages and -45% for those with subprime mortgages; while the cross effect of gaining from default on the probability of filing for bankruptcy is -26% for those with prime mortgages. Finally, the sequence effects show that when homeowners are predicted to gain from both default and bankruptcy, their actual probabilities of default

rise by 3% and 23% if they have prime and subprime mortgages, respectively, and their actual probability of bankruptcy falls by 78% if they have prime mortgages. All of these results are statistically significant.

We are still working on the analysis. We plan next to analyze samples of prime and subprime adjustable rate mortgages. Because most subprime mortgages are ARMs, we expect that our sample of subprime ARMs will be much larger than our sample of subprime FRMs. We also plan to run our models separately for the periods before versus after the start of the financial crisis.

Figure 1:

Homeowners' incentives to default on their mortgages and file for bankruptcy

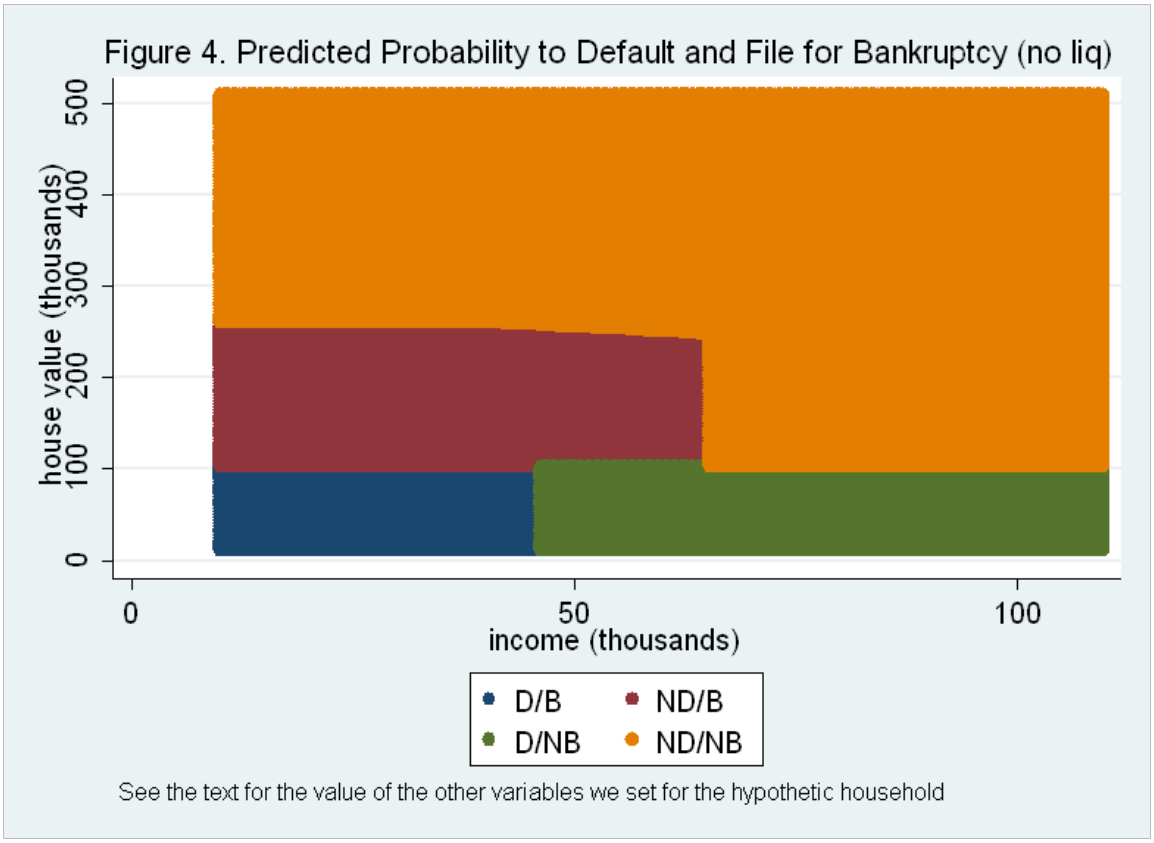
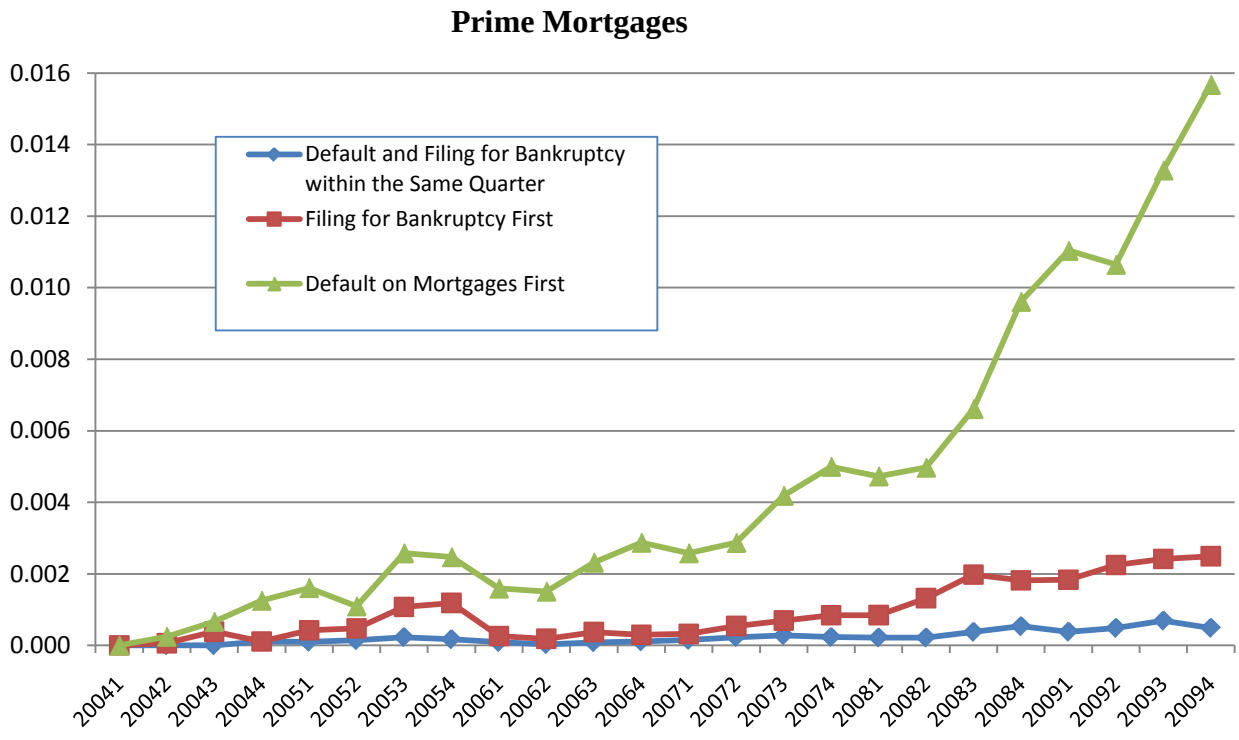


Figure 2: Mortgage Default (90+ days) and Bankruptcy Filings, 2004-2009



Subprime Mortgages

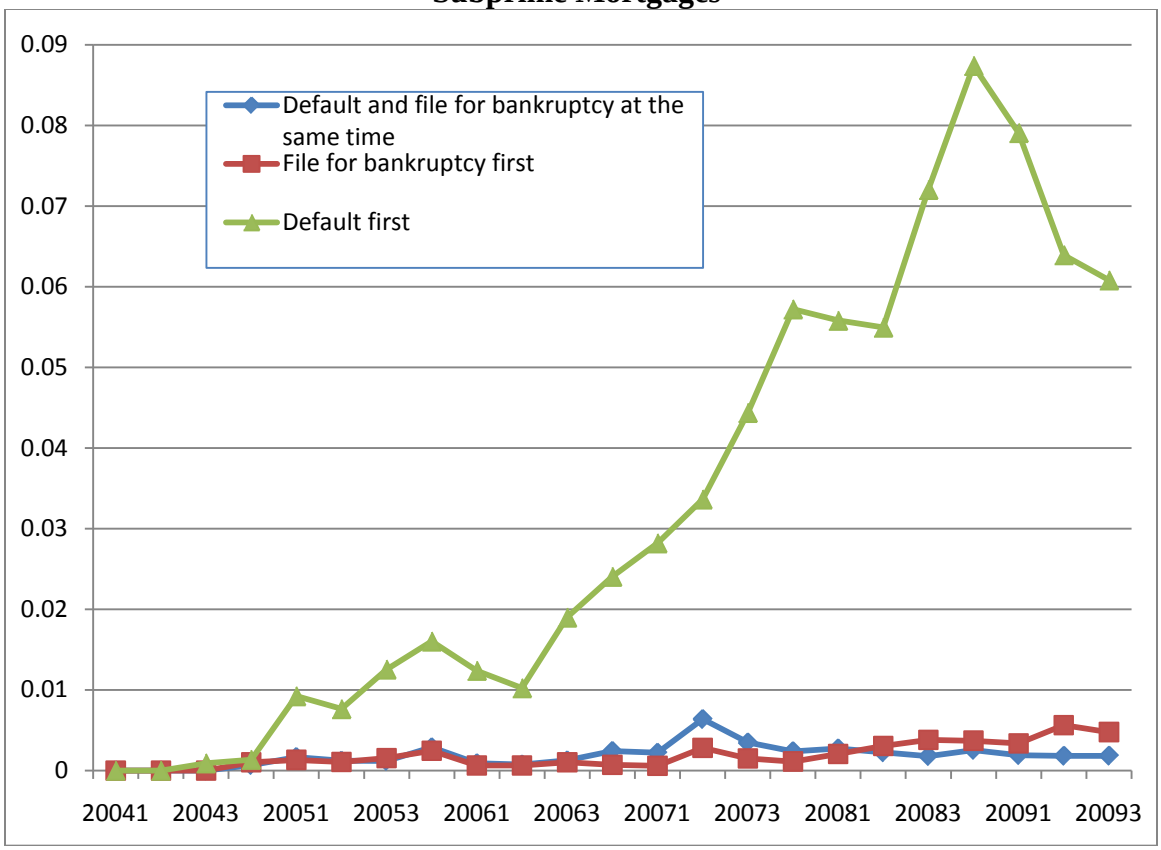


Table 1: Summary Statistics of Variables Used to Predict Default and Bankruptcy

	Prime Sample			Subprime Sample		
	Mean	Median	S.E.	Mean	Median	S.E.
Income ($)	90,937	71,447	102,028	75,250		67,064
House value ($)	302,998	232,607	402,468	244,500		181,200
Mortgage balance ($)	197,453	145,184	221,059	184,500		202,700
Mortgage arrears ($)	7,208	5,268	18,173	7,200		11.800
Remaining terms of mortgage contract (yrs)	24.48	27.50	6.65	328		66.6
Current mortgage rate (%)	5.95	5.87	0.61	7.37		1.18
Balance of other secured debt ($)	12,277	3,694	23,389	10,500		21,900
Balance of revolving debt ($)	17,968	4,347	45,801	11,400		31,000
Past due of revolving debt ($)	170	0	2,843	473		2,618
Credit limit of revolving debt ($)	52,973	31,307	75,909	23,900		48,800

Table 2:
Predicted versus Actual Probabilities of Homeowners' Defaulting on Their Mortgages and Filing for Bankruptcy

	Prime Sample		Subprime Sample	
	Predicted	Actual	Predicted	Actual
Default and bankruptcy (D/B)	0.0261	0.000242	0.0277	0.00125
Default, no bankruptcy (D/NB)	0.0340	0.00493	0.0337	0.0239
No default, bankruptcy (ND/B)	0.00115	0.000982	0.00352	0.00167
No default, no bankruptcy (ND/NB)	0.938	0.9938	0.934	0.973

Note: Mortgage default is defined as mortgages being 90 days or more delinquent, using data from LPS. Probabilities are quarterly.

Table 3: Summary Statistics

	Prime Sample			Subprime Sample		
Variable	Mean	Median	S.E.	Mean	Median	S.E.
Homeowner's age (years)	46.7	46.0	12.6	48.1	47	12.1
Age of the mortgage (quarters)	8.44	8	5.77	5.79	5	4.81
Age of the oldest credit card account (months)	68.5		33.2	62.7	56	30.9
If female-headed household	.269		.444	.334	0	.471
If African-American	.0671		.250	.138	0	.345
If married	0.562	1	0.496	.460	0	.498
Lagged risk score: [300,850]	727	748	83.5	637	639	90.4
If full documentation for mortgage	0.360	0	0.480	.606	1	.488
If low documentation for mortgage	0.0596	0	.237			
If no documentation for mortgage				.00169	0	.0411
If mortgage securitized	0.128	0	0.334	.757	1	.429
If investment property	0.0280	0	0.165	.0217	0	.145
If refinance (versus purchase)	0.497	0	0.500	.782	1	.412
If jumbo loan	0.053	0	0.225	.0686	0	.252
If single family home	0.819	1	0.385	.853	1	.354
If mortgage originated by lender	0.437	0	0.496	.374	0	.483
If mortgage purchased wholesale	0.159	0	0.366	.116	0	.320
If mortgage purchased from correspondent	0.199	0	0.399	.102	0	.302
Lagged state 90-day mortgage default rate	0.0147		0.0115	.0133	.0111	.0101
Lagged state bankruptcy filing rate	0.126		0.0803	.120	.0968	.0807
Number of observations	1,553,000			123,000		

Table 4. Results of Multi-Probit Regressions
Explaining Mortgage Default and Bankruptcy Filings:

Marginal Effects

	Prime Sample		**Subprime Sample**	
	aD/NB	aND/B	aD/NB	aND/B
pND/B	-.00236*** (0.000714)	.000599*** (.000229)	-0.015** (0.00733)	0.00103 (.000997)
pD/NB	.000804*** (0.000270)	-.000295* (.000169)	0.0115*** (0.00237)	0.00234 (0.000702)
pD/B	.000955*** (.000296)	.0000896 (.000178)	0.00782*** (.00270)	0.000758 (.000761)
If liquidity-constrained	.00331*** (.000124)	-.000825*** (.0000682)	.00970*** (.00101)	-.000422 (.000265)
Lagged risk score	-.0000525*** (7.38e-7)	-.0000131*** (3.74e-7)	-.000208*** (6.36e-6)	-1.61e-5*** (1.73e-6)
Age of the borrower (in years)	-.000117*** (0.0000309)	.0000126 (.0000138)	-.000121 (.000270)	1.20e-6 (.00008)
Age squared	1.05e-6*** (3.18e-07)	-1.36e-8 (1.34e-7)	2.30e-7 (2.64e-6)	2.97e-8 (7.50e-7)
Age of the mortgage (quarters)	.000313*** (0.0000518)	.000127*** (.0000255)	-.000526 (0.000432)	.000205* (.000121)
Age of the mortgage squared	-.0000279*** (2.09e-06)	-5.75e-6*** (9.77e-7)	-6.17e-5*** (2.42e-5)	-7.64e-6 (6.00e-6)
Age of the oldest credit card account (months)	-.000044*** (6.57e-6)	.000019*** (3.23e-6)	-.000154*** (0.0000586)	.0000763*** (.0000206)
Age of the oldest credit card account squared	2.06e-7*** (3.92e-8)	-8.49e-8*** (1.88e-8)	5.35e-7 (3.67e-7)	-4.61e-7*** (1.31e-7)
If female head of household	-.000656*** (.00013)	.0000484 (.0000584)	-.00200** (.00103)	-.000439 (.000284)
If African-American	.000512*** (.000185)	-.000341*** (.0000944)	-.00165 (.00142)	.000249 (.000342)
If married	-.00102*** (.000121)	.00022*** (.0000543)	-.00170* (.000990)	.000847*** (.000262)
If full documentation provided	-.000698*** (0.000225)	.000271** (.000114)	.00440* (.00255)	-.000783 (.000617)
If low documentation provided	-.000553* (.000296)	.000212 (.000145)		
If no documentation provided			-.00461 (.0124)	.00175 (.00222)

If mortgage securitized	+.00203*** (0.000177)	.000332*** (.000112)	.00726*** (.00133)	-.000481* (.000300)
If investment property (vs primary residence)	-.00262*** (.000433)	-.000988*** (.000226)	.00242 (.00357)	-0.000208* (0.00103)
If second home (vs primary residence)	-.00343*** (.000822)	-.000950** (.000410)		
If refinance (versus purchase)	-.000575*** (0.000130)	+.000187*** (.0000577)	-.00579*** (0.00127)	0.000534 (0.000349)
If jumbo mortgage	.00131*** (.000298)	-.000338* (.000191)	.0102*** (.00191)	-.000276 (0.000721)
If property is single family	-.0000355 (.000154)	0.0000413 (.0000755)	-0.00168 (.00134)	0.0000632 (0.000428)
If mortgage originated by lender	-.000875*** (.000149)	-.0000563 (.0000699)	-.00435*** (.00120)	-.000899** (.000347)
If mortgage purchased wholesale	-.0000816 (.000179)	.0000272 (.0000825)	-.00756*** (.00168)	.000173 (.000380)
If mortgage purchased from correspondent	-.0000749 (.000176)	.0000424 (.0000823)	.00268 (.00174)	.0000176 (.000179)
Lagged state 90-day mortgage default rate	.00127*** (.0000941)	.000213*** (.0000497)	.00634*** (.000591)	.000238 (.000179)
Lagged state bankruptcy rate	.00621** (.00247)	.00227** (.00106)	.00506*** (.00474)	.0141*** (.00474)
State dummies?	Yes	Yes	Yes	Yes
Time dummies?	Yes	Yes	Yes	Yes

Note: Mortgage default is defined as 90 days and more in delinquency. The base outcome is no default, no bankruptcy. We omit the category aD/B because it is very rare for homeowners to both default and file for bankruptcy in the same quarter. *** indicates 1% significance; ** indicates 5% significance; and * indicates 10% significance.

Table 5:
Results for Own, Cross, Sequence and Liquidity Effects

Semi-Elasticity Form

	Prime sample		**Subprime sample**	
	Mortgage default but no bankruptcy	Bankruptcy but no mortgage default	Mortgage default but no bankruptcy	Bankruptcy but no mortgage default
Own effect	2.3%***	52%**	34%***	29%
Cross effect	-6.9%***	-26%*	-45%**	6.6%
Sequence effect	2.8%***	-78%	23%***	22%
Liquidity effect	9.7%***	72%***	29%***	-12%

Notes: Own effects are percentage increase in the probability of defaulting only (filing for bankruptcy only) when the homeowner is predicted to default only (file for bankruptcy only). Cross effects are percentage increase in the probability of defaulting only when the homeowner is predicted to file for bankruptcy only and the percentage increase in the probability of filing for bankruptcy only when the homeowner is predicted to default only. Sequence effects are percentage increases in the probability of defaulting only (filing for bankruptcy only) when the homeowner is predicted to do both. Liquidity effects are percentage increases in the probability of defaulting only (filing for bankruptcy only) when the homeowner is liquidity-constrained. Marginal effects are given in table 3. Triple, double, and single asterisks indicate significance at the 1%, 5%, and 10% levels, respectively.

Appendix A: Data Construction

Our data come from three sources: the mortgage loan-level data from the LPS Applied Analytics Inc. (formerly known as McDash), the mortgage applications data collected under HMDA (Home Mortgage Disclosure Act), and the individual-level credit use data from the FRBNY (Federal Reserve Bank of New York) Consumer Credit Panel, which are taken from Equifax. We supplement the main data with house price indices at the MSA, non-MSA, and the state level from FHFA (Federal Housing Finance Authority), and per-capita state income from the Bureau of Economic Analysis. Both of the latter datasets are at quarterly frequency.

The LPS data are provided by servicers of mortgage loans and include nine of the top 10 mortgage servicers in the U.S. The data include information obtained at origination such as the appraised value of the house, balance of the mortgage, terms of the mortgage contract (interest rates, maturity, documentation type, property type, lien type, loan type, purpose of the loan, etc.) and property location (zip code). They also include information on mortgage performance, current interest rate, remaining balance, investor type, and bankruptcy filings, all updated monthly. Starting in 2004, the LPS data cover about 70 percent of the mortgage market in the U.S.

Under HMDA, mortgage lending institutions with assets above a certain threshold are required to report basic information on every mortgage application that they receive. This information includes characteristics of the applicant (income, race, sex, presence of co-applicant); characteristics of the loan (size, type, purpose, and whether the property is owner-occupied); the census tract in which the property is located; and whether the application was approved.

The FRBNY Consumer Credit Panel is a new longitudinal (quarterly) database from Equifax, one of top three credit bureaus. The dataset consists of a random subsample of credit users and contains comprehensive information on each type of debt held by individual borrowers, including balance, payment, credit limit, and if delinquent. In addition, the dataset includes loan-level information on borrowers' mortgages, including origination date, loan amount, loan type, and location of the property (address).

The panel is a 5 percent random sample of Equifax' credit records. See Lee and Klaauw (2010) for more details.

We restrict our analysis to first-lien fixed-rate mortgages originated in 2004, 2005, and 2006. Mortgages were first matched between LPS and HMDA based on the zip code of the property, the date when the mortgage originated (within 5 days), the origination amount (within $500), the purpose of the loan (purchase, refinance or other), the type of loan (conventional, VA guaranteed, FHA guaranteed or other), occupancy type (owner-occupied or non-owner-occupied), and lien status (first-lien or other). The LPS data is then linked to the FRBNY Consumer Credit Panel through characteristics of first mortgages, origination date (same month and year), initial balance (within $500), and zip code. The final dataset consists of individuals whose mortgages matched in all three datasets. Table A.1 reports the matching statistics. Note that the three-way match rate is necessarily low because the FRBNY data is (only) a 5% random sample of individuals' credit records.

Finally, we convert the LPS data from monthly to quarterly by taking the average values of the continuous variables over the three months within the each quarter. We assume that individuals are in default or bankruptcy if LPS reports that they are either state in any month during the quarter.

Table A.1
Match Rates for LPS, HMDA, and FRBNY Consumer Credit Panel

Year	LPS-HMDA Match	LPS-FRBNY Consumer Credit Panel	Three-way match
2004	47.07%	5.05%	2.95%
2005	40.91%	7.23%	3.86%
2006	35.46%	6.77%	3.19%

Note: The low match rates between LPS and the FRBNY Consumer Credit Panel reflects the fact that the latter is a 5 percent random sample of records from Equifax.

Appendix B: Variable Definitions

Mortgage Default -- We use two definitions of default: when a mortgage is 90 days or more delinquent for the first time and when a mortgage is in foreclosure, under liquidation, or in REO (real estate owned) proceedings. These definitions correspond to the LPS variables MBA_STAT =9 and MBS_STAT = F, L, or R, respectively. .

Consumer Bankruptcy – We consider the borrower as filing for bankruptcy when the LPS bankruptcy flag turns to one for the first time.

House Value – Each quarter, we increase/decrease the appraised value of the house observed at the date of mortgage origination (the LPS variable appraisal_amt) by the proportional change in the FHFA house price index for the relevant metropolitan area (MSA) since the mortgage originated. If the house is not in a metropolitan area, we use the house price index for non-metropolitan areas in the state. For states that are entirely in metropolitan areas (District of Columbia, New Jersey, and Rhode Island), we use the state-level house price index.

Income – We observe income at the time of mortgage origination, from HMDA. We then increase/decrease income levels each quarter by the rate at which the state per capital income level has changed over the same period.

Mortgage Debt Outstanding – We obtain the total outstanding mortgage balance each quarter from FRBNY Consumer Credit Panel (cma_attr3165). This includes both first and second mortgages.

Other Secured Debt Outstanding – We define other secured debt outstanding as the sum of auto loan balances (cma_attr3160) and student loan balances (cma_attr3166), both taken from the FRBNY Consumer Credit Panel.

Unsecured Debt Outstanding – We define unsecured debt outstanding as the amount of revolving debt that is past due, according to the Credit Panel (cma_attr3246). Compared to the debt balance, this definition has the advantage of netting out transaction volume on revolving accounts. Separating these two is important for our purposes, since we do not observe the borrowers' non-housing financial asset.

Household Demographic Characteristics (from HMDA)[15]

Age – Age of the mortgage applicant.

Sex – A dummy variable indicates whether the applicant is female.

Black – A dummy variable that captures whether the applicant is black.

Married/Presence of co-applicant – A dummy variable that takes a value of 1 if there is a co-applicant for the mortgage and zero otherwise. The presence of a co-applicant typically indicates that the applicant is married.

Other Mortgage Loan Characteristics (from LPS Except for the Risk Score)

Age of the mortgage loan – Calculated as months since time of mortgage origination (close_dt).

Jumbo – Whether the loan is a jumbo at the time of origination (jumbo_flg=1).

Prop_sgf – Whether the mortgage is for a single family housing (prop_type=1).

Investor_private – Whether the mortgage loan is privately securitized (investor_type=1).

Dum_refi – Whether the mortgage is for refinance purpose (purpose_type_mcdash=2, 3, or 5).

House_second – Whether the property is a second or vacation house (occupancy_type=2).

House_invest – Whether the property is an investment property (occupancy_type=3).

Doc_full – Whether the borrower has full document at origination (document_type=1).

[15] Due to our agreement with LPS, we do not report any summary statistics or econometric analysis with regard to borrower demographics.

Risk score – Credit score from the FRBNY Consumer Credit Panel, updated quarterly.

Variables Related to Foreclosure and Bankruptcy Laws

Recourse – Whether the state has recourse. The variable is taken from Ghrent and Kudlyak (2010).

Homestead exemption – The bankruptcy homestead exemption levels by state are from Elias (2006 and earlier editions). In the case when there is co-applicant, we treat the borrower as married and adjust the homestead exemptions according to the requirements of the state. See Li, White, and Zhu (2010) for more discussion.

Median state income – We use the state median income for a household of three from the U.S. Trustee Program at the Department of Justice (www.justice.gov/ust/eo/bapcpa/meanstesting.htm).

Other Calibrated Variables

Bankruptcy cost – The filing cost is assumed to be $2000 (which is somewhat on the high end of a Chapter 7 bankruptcy filing cost but low end of a Chapter 13 bankruptcy filing cost). In the case of a Chapter 13 filing (the borrower fails the income means test after the 2005 bankruptcy reform), we add the additional cost of 10 percent of the payment under the Chapter 13 repayment plan. This includes the repayment of the arrearage of mortgage and other secured debt, the extra payment (derived as the borrower's actual income subtracted the state median income and the payment for arrearage for secured debt) that goes to unsecured creditor over a five-year period. The 10 percent corresponds to the trustee fees.

Foreclosure cost – It is assumed to be 30 percent of the house value. See Carroll and Li (2010).

The present value of the mortgage – For fixed rate mortgages, the stream of monthly mortgage payments, which are known from our data and remain fixed for the entire mortgage term, are discounted to the present using an annual discount rate of 3 percent, where 3 percent is the average riskfree rate in the US since WWII.

For adjustable rate mortgages, we know the monthly mortgage payment for the introductory period—usually 2 years. At the end of the initial period, we assume for simplicity that the mortgage converts to a fixed rate rather than an adjustable rate mortgage. The interest rate for the remaining term of the mortgage is assumed to be the 10-year Treasury bond rate prevailing at the end of the introductory period, plus a borrower-specific risk premium. The borrower-specific risk premium is estimated using the following procedure. First we estimate a regression explaining the difference between the interest rate on subprime fixed rate mortgages and the 10 year Treasury bond rate. The explanatory variables are the borrowers' characteristics. Then we use coefficients of the regression and the individual borrower's error term to estimate a risk premium for each borrower. We assume that the resulting interest rate holds for as long as the mortgage remains in our dataset. The monthly mortgage payments are discounted to the present at a discount rate of 3%. (This general approach is based on Bajari et al, 2008.)

The present value of the rental cost -- This equals the discounted present value of the cost of renting housing of the same size as the current house over the remaining years of the mortgage contract. Calculated by assuming that anual rental expenditure equals 6 percent of current value of the house and that rent payments increase at a rate of 3.38 percent per year (the growth rates of rental shelter component of Consumer Price Index and discounted to the present assuming a discount rate of 3 percent per year.

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