NBER WORKING PAPER SERIES

IS THE FHA CREATING SUSTAINABLE HOMEOWNERSHIP?

Andrew Caplin
Anna Cororaton
Joseph Tracy

Working Paper 18190
http://www.nber.org/papers/w18190

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 2012

We thank Damien Weldon and CoreLogic for providing us with access to crucial data. We also thank Diego Aragon, Gunnar Blix, Scott Frame, Charles Freeman, Ahu Gemici, Joseph Gyourko, Andy Haughwout, Steven Laufer, John Leahy, Roy Lowrance, Daniel Martin, and Ruth Wyatt for their invaluable input. Joshua Abel provided capable research assistance. The opinions expressed herein are those of the authors alone, not of New York University, the Federal Reserve Bank of New York, the Federal Reserve System, CoreLogic, or the National Bureau of Economic Research.

Is the FHA Creating Sustainable Homeownership?
Andrew Caplin, Anna Cororaton, and Joseph Tracy
NBER Working Paper No. 18190
June 2012
JEL No. H81

ABSTRACT

We produce first results on the sustainability of homeownership for recent (2007-2009) FHA-insured borrowers. More than 15 percent of these borrowers have already been 90 days or more delinquent, while less than 7 percent have completed their graduation to sustainable homeownership by finally paying off all FHA mortgages. We project that the proportion who have been 90 days or more delinquent will rise above 30 percent within five years, while fewer than 15 percent will have completed their graduation to sustainable homeownership. We show that the FHA uses an outmoded econometric model that leads it to underestimate delinquency risk to borrowers and financial risks to taxpayers. Fannie Mae and Freddie Mac use this same outmoded model. More accurate estimates would serve the cause of transparency and help policy-makers to determine these organizations' appropriate roles in the U.S. housing finance markets of the future.

Andrew Caplin
Department of Economics
New York University
19 W. 4th Street, 6th Floor
New York, NY 10012
and NBER
andrew.caplin@nyu.edu

Joseph Tracy
Executive Vice President
Federal Reserve Bank of New York
33 Liberty Street
New York, NY 10045
joseph.tracy@ny.frb.org

Anna Cororaton
Federal Reserve Bank of New York,
33 Liberty Street
New York, NY 10045
cororaton@gmail.com

I. Introduction

Following the collapse of the private mortgage market, the Federal Housing Administration (FHA) has become the only major issuer of low down-payment mortgages. In 2012 the FHA had an estimated $1 trillion dollars of insurance in force – roughly three times the 2005 level (IFE [2011], HUD [2005]). A key question is how many of these loans will produce delinquency and default as opposed to sustainable homeownership.

In this paper we use a new data set to provide first answers on sustainability for recent (2007-2009) FHA-insured borrowers. We find that more than 15 percent of these borrowers have already been 90 days or more delinquent. By way of contrast, less than 7% have completed their graduation to sustainable homeownership by finally paying off all FHA mortgages. We project that the proportion who have been 90 days or more delinquent will rise above 30 percent within five years while fewer than 15 percent will have completed their graduation to sustainable homeownership.

When homeownership is not sustainable, the human consequences can be tragic. Most borrowers who become 90 days or more delinquent will eventually lose their homes. They will also lose access to credit (see Brevoort and Cooper [2010]), may suffer health setbacks (see Currie and Tekin [2012]), and find it difficult it to move to other parts of the country to find jobs (see Ferreira et. al. [2010, 2011]).

The high delinquency rates that we identify are easy to understand. Most recent FHA loans have been for 98% of the home value (96.5% LTV plus the 1.5% fixed insurance fee). Many of the homes bought with these loans have fallen in value since first purchased. Hence many borrowers are underwater. This makes it difficult for them to exit the FHA system either by selling their homes or by refinancing with non-FHA insured mortgages. In the meantime, the continuing weakness in the real economy leaves many exposed to unemployment risk. They will likely remain locked in with the FHA for years to come, all the while remaining one bad shock away from default.

Non-sustainable lending is costly not only for borrowers, but also for taxpayers, since FHA insurance is fully backed by the U.S. government. Unfortunately the FHA has not provided an accurate risk assessment. Losses from eventual claims have been consistently underestimated in the last several Annual Reports to

Congress (Gyourko [2011]). Outmoded methodology is largely responsible for this underestimation of risk (Aragon et al. [2010], Caplin ([2010], [2011]). The FHA counts as successful any mortgage that is paid off without an insurance claim, even if this is just an internal refinance of one FHA mortgage into another. So a borrower who defaults after internally refinancing is treated by the FHA as creating one success (termination of the first mortgage) and one failure (default of the second mortgage). In fact, the borrower has nothing to show for their "success" in refinancing, and taxpayers face a large bill.[1] The situation with the GSE's (Fannie Mae and Freddie Mac) is the same. They treat as successful any agency mortgage that refinances into another agency mortgage.

The overcounting of success makes FHA's risk assessment overly optimistic. We show below that the over-counting of success is important in the recent period not only in qualitative but also in quantitative terms. Of those mortgages paid off by FHA borrowers in the 2007-2009 cohorts, more than two-thirds have been internally refinanced. These neither represent successful transitions to homeownership, nor resolutions of credit risk to the FHA.

Opening up FHA and GSE data to researchers is important if U.S. housing finance markets are to be rebuilt on more stable foundations. We obtained our data from a mortgage data and analytics provider, CoreLogic, because internal data on FHA-insured mortgages is not publicly available. We were also unable to obtain data on GSE mortgages. Hence some of the borrowers we count in our data as successfully exiting FHA may in reality have been refinanced with Fannie Mae and Freddie Mac so that the taxpayer remains exposed to the remaining credit risk. To this date, no one knows the full risks to which borrowers and taxpayers are being exposed by FHA and the GSE's.

Even without making their data publicly available, the FHA and the GSE's could readily adopt the borrower-based data structure developed herein. Doing so may lead to higher loss estimates. Yet it would

---

[1] We are not criticizing the FHA's internal refinance programs. In fact, reducing the frictions for high LTV mortgages to refinance has been shown to have important macroeconomic benefits (Caplin et. al. 1997). Rather, our criticism is with how these programs are treated in measuring FHA default rates and projected default losses.

serve the cause of transparency and help policy-makers to determine these organizations' roles in the U.S. housing finance markets of the future.

We describe the CoreLogic data in Section 2. We develop and estimate our model of borrower performance in Sections 3 and 4. We forecast default and prepayment rates in Section 5. In section 6 we show that the Actuarial Reports understate the risks that FHA-insured mortgages pose to borrowers and taxpayers alike. Section 7 concludes.

II. The FHA Sample

A. The FHA and the Borrower Experience

The Federal Housing Administration (FHA) was set up in 1934 to improve the functioning of mortgage markets. Since then it has become an important institution for implementing housing policy, providing strong support for housing affordability and homeownership. As a result of the recent financial crisis, the FHA has moved into the unprecedented position of being the low down-payment "lender of last resort." The FHA must ensure that alongside its increased market share of mortgage originations it still achieves its key goal of creating sustainable homeownership.

What little is known about recent FHA performance with regard to sustainable homeownership is contained in the FHA's mandated annual actuarial reviews and its contemporaneous reports to Congress (see for example IFE [2009, 2010, 2011]). As pointed out by Aragon et. al., one problem with the analyses in the actuarial review is that the data used does not link together FHA mortgages involved in an internal refinance. FHA mortgages that undergo an internal refinance are treated no differently than FHA mortgages that finally pay off thereby removing any further credit risk to the FHA.

The current mortgage-based approach is inappropriate for the study of sustainability. Instead, one must focus on the borrower. Specifically, one must construct the borrower experiences by linking together strings of consecutive mortgages taken out by the same borrower and secured on the same property. A borrower

experience begins with the initial exposure of the FHA fund through a purchase mortgage or a refinance from a non-FHA mortgage and ends either through prepayment outside of the FHA or through default. Internal FHA refinances carry over the credit risk from one loan to another. Linking together mortgages is especially relevant for streamline refinance loans with high LTVs because they face a high default risk.

B. Sampling Method

Using borrower experiences to measure sustainability in homeownership requires data in which contiguous FHA mortgages on the same home and with the same borrower are linked together.[2] In particular, to follow a borrower experience we need to match FHA mortgages that are the two sides of an internal FHA refinance. To execute this we specified an FHA borrower data set to CoreLogic, which made available anonymized data from two of its largest databases: (i) the mortgage servicing database containing monthly FHA mortgage performance history data from servicers, and (ii) the property record database containing property record information sourced from county assessors and recorders. Use of the latter data enables us to identify mortgages from the servicing database that are tied to the same property, enabling us to link the data. The CoreLogic servicing database includes monthly performance information for a large percent of the FHA's outstanding insured mortgage portfolio. More recent vintages have a higher coverage of FHA loans, due in part to large servicers becoming more involved in FHA servicing. This database covers more than 7.5 million FHA loans insured between 2003 and 2011. CoreLogic's property record database contains information for real estate sales and mortgage transactions covering 97 percent of the US population.[3]

---

[2] Gerardi *et al* (2007) is the only other example we are aware of in which the frame of reference is the borrower rather than the mortgage. They examine the sustainability of borrower experiences that begin with a subprime mortgage.

[3] CoreLogic's coverage is 99.9 percent (3,120 counties) of the US population for county assessor-sourced data such as tax valuations and 97 percent (1,800 counties) of the US population for title and mortgage recordings sourced from county recorders.

CoreLogic was able to identify 282,000 FHA to FHA refinance pairs. CoreLogic also provided FHA loans that were not internally refinanced – either purchase or external refinance mortgages. To construct a 5 percent representative sample for estimation, we worked backwards in time. In each year, we aligned the composition of originations across the purchase, external FHA refinance, and internal FHA refinance categories to published data on the composition of FHA originations. To standardize the sample, we only selected first-lien, owner-occupied mortgages. Starting in 2010, we randomly selected purchase and refinance loans to match the published FHA data scaled down to a 5 percent sample. For the internal FHA refinances that were randomly selected we pulled in the full chain of linked prior FHA mortgages as well. We then adjusted the required number of mortgages of each type for prior years up to but not including 2010 based on any linked mortgages that were already selected into the sample by virtue of being part of a borrower experience linked to the sampled mortgage for 2010. We then repeated the exercise for 2009 and proceeded in this manner back to 2007.[4] Our final sample is a 5 percent random sample of FHA originations from 2007 through mid-2010. These loans have performance data up to September 2011.[5]

The random sample generated from the CoreLogic linked data set closely matches published FHA data in key respects. Appendix Tables A1 to A3 provide comparisons between the published FHA data and our random sample for average FICO scores, origination loan-to-value (LTV) levels, and early delinquency rates. These show that the random sample tracks published values of key risk measures quite closely. Since the origination balance reported in the CoreLogic data incorporates any up-front mortgage premium that was financed by the borrower, we back out estimates of these origination fees from the initial loan balance in

[4] These refer to FHA fiscal years (which run from Q4 of the prior year through Q3 of the stated year) so that the last loan for any borrower must be originated no earlier than calendar year 2006 Q4. However, prior loans in a chain for any borrower can have earlier origination dates.

[5] We include in the hazard estimation all of the data including the borrower experiences that begin in 2010, but we censor all monthly observations prior to January 2007. In addition, we restrict our cohort level analysis to FHA borrowers from calendar years 2007 to 2009 for whom a longer history of performance is available.

order to make our origination LTV measures comparable to the published FHA data.[6] We track the measured LTV trends quite closely up to the third quarter of 2010. On average however, our early delinquency rates by year tend to be slightly lower than the published rates.

C. Internal Refinancing

The data from CoreLogic confirm the significance of the distinction between the borrower experience and the mortgage experience – our sample shows a high rate of internal refinancing in recent years. Our sample implies that FHA-to-FHA refinancing in 2009 has been 44 percent as large as the number of purchase originations, similar to the HUD estimate of 42 percent.

The FHA's internal streamline refinance program, in particular, has had a high take-up rate in recent years. This program is directed towards FHA borrowers with high LTVs that exceed the maximum allowed for new FHA mortgages. Without necessarily requiring a new appraisal, the program allows these borrowers to refinance into new FHA mortgages even in cases in which borrowers no longer have enough equity to meet the standard down payment amount.[7] While the FHA has put in place several requirements – for example, the new balance cannot exceed the prior balance and that the borrower must have a sufficiently clean payment history – the program allows high-LTV borrowers to lower their monthly payments without being re-underwritten. Since many of the FHA borrowers refinancing are underwater, it will be difficult for them to exit the FHA system by either selling the house or refinancing into a non-FHA mortgage. As such, these borrowers may remain at risk of default for many years.

---

[6] The upfront premium charged for the 2009 fiscal year through March 2010 was 1.75% for fully underwritten loans and 1.5% for streamline refinance loans. The premium rose to 2.25% in April 2010, for all loans. For loans originated prior to the 2009 fiscal year, the rule of thumb for fully underwritten loans from 2009-2010 (1.75%) was applied. Upfront premiums can be refunded according to the following schedule: http://portal.hud.gov/FHA-Handbooks/collections/current/print/4155-2_7.pdf. We adjust the upfront premiums subtracted from the LTV accordingly.

[7] Since no new underwriting is required for a streamline refinance, the origination loan-to-value, debt-to-income, and borrower credit score is not reported. Since no new underwriting is required for a streamline refinance, the origination loan-to-value ratios, debt-to-income ratios, and borrower credit scores are not reported.

D. Delinquency

Whether an FHA borrower experience generates a claim against the FHA is not definitively known until the borrower experience finally terminates. This claim represents the last stage of a process that begins with an initial delinquency, is followed by serious delinquency, the onset of the foreclosure process, the conclusion of the foreclosure process, and finally the sale of the property and settlement of the FHA claim.

The time between the events that precipitated the borrower's delinquency and the claim is highly variable. Table 1 illustrates these time lags for various default triggers, where the time lag is defined as the number of months in an unbroken string of delinquencies from 30-days delinquency until the onset of the specified trigger. On average it takes 3.9 months, with a standard deviation of 2.4 months, to reach the 90-days delinquency trigger from an initial delinquency. Pushing back to the beginning of a foreclosure process, the time lag increases to a mean of 9.6 months with a standard deviation of 6.0 months. Lastly, looking at the start of the REO process as the trigger, the time lag is 15.8 months with a standard deviation of 7.2 months. The increase in the variability of the gap between the initial delinquency and the trigger poses a challenge for specifying an empirical model of the default event.[8]

Our assessment of FHA performance requires estimating sustainability for FHA borrower experiences that are still ongoing. Using 90-plus day delinquency as a measure of sustainability allows us to gain early insight into what fraction of recent FHA vintages are likely to generate final claims on the FHA, even if these claims may not materialize until much later. Table 2 shows the fraction of FHA mortgages in our data that terminate in a claim conditional on the loan reaching a given stage of delinquency. The table shows that in our data, some 13 percent of loans that reach 90-days delinquency have terminated by the end of our sample, 61 percent of which have generated a claim. We can estimate the "cure" rate for each default trigger by adding the number of terminated borrower experiences that fully pay off to the number of active borrower experiences that are no longer delinquent, and then dividing by the number of borrower experiences that ever reach the default trigger. The estimated cure rate declines from 24.8 percent for the 60-plus default trigger, to

[8] The increase in the mean time lag is not as serious a problem since the time-varying control variables can be lagged appropriately.

21.2 percent for the 90-plus trigger, and down to 16.4 percent for the foreclosure start trigger. The choice of the appropriate default trigger needs to balance the aims of a low variability of time since the initial delinquency with a low cure rate. We define the default event to be the first time the mortgage reaches 90-days delinquent.

III. The Proportional Hazard Model

A. Econometric Specification

We use a standard competing-risk model to analyze the impact of borrower risk characteristics, mortgage and property characteristics, and economic factors on prepayment and default outcomes. We use a proportional hazard framework assuming independent risks. The prepayment (*p*) and default (*d*) hazard rates since origination at duration *t* are given by:

$$h^p\left(t\middle|X_t^p\right) = \exp\left(g^p(t)\right)\exp\left(X_t^p\beta^p\right) \quad (1a)$$

$$h^d\left(t\middle|X_t^d\right) = \exp\left(g^d(t)\right)\exp\left(X_t^d\beta^d\right) \quad (1b)$$

where *g(t)* is the baseline hazard function of the time since the mortgage was originated. We approximate the baseline hazard using a monthly step-function.[9] The key assumption is that the explanatory variables X_t shift the baseline hazard proportionally.[10]

As detailed above, we define the default event as the borrower experience first reaching 90-days delinquent and censor any remaining payment history on the borrower experience.[11] We use borrower experiences as the frame of reference, hence prepayment only occurs when the borrower pays off the FHA

[9] See Meyer (1990) for an early example of using step-function approximations to the baseline hazard.

[10] See Kalbfleisch and Prentice (2002) for details.

[11] That is, we do not model whether a seriously delinquent mortgage cures or the time it takes to work through the various stages of foreclosure to a final claim.

mortgage by either selling the house or refinancing into a non-FHA mortgage. We follow each borrower experience starting in the third month after its origination date up until either the borrower prepays, the default event occurs, or the sample ends.[12] Our data are at a monthly frequency.

With the estimated prepayment and default hazards we can estimate the probability that any active FHA borrower will default over a specified horizon and consequently, the probability that the borrower experience survives this horizon. Let *S* denote the estimated joint survivor function, given by:

$$S(t) = \exp\left(-\sum_{j=1}^{t}(h^p(t) + h^d(t))\right) \quad (2)$$

where *t* indexes the number of months into the forecast period and *S*(0) equals one.

For forecasting default and prepayment probabilities, we need to specify the path of the dynamic variables over the forecast horizon. The estimated probability that an active FHA borrower experience with current duration *t* will default and prepay over the next *T* months is given by:

$$Pr^D(t,T) = \sum_{j=t+1}^{T}(S(t)\, h^d(j)) \quad (3a)$$

$$Pr^P(t,T) = \sum_{j=t+1}^{T}(S(t)\, h^p(j)) \quad (3b)$$

We compute these default and prepayment projections for all active FHA borrower experiences starting at the end of our sample to generate an overall prepayment and default rate.

While the default and prepayment hazards condition on a large list of observable factors that could affect default, there may still be unobservable factors that are important for determining default rates. For example, these unobservable factors may be correlated with the "vintage" of the mortgage when it was underwritten.

[12] The third month is the first time period that the borrower is at risk of going 90 days delinquent.

We test for the presence of unobserved determinants by estimating the model allowing for a parametric distribution of the unobserved heterogeneity. The data indicate that this distribution was degenerate.[13]

B. Variables in the Specification

The CoreLogic data provide information on a variety of borrower, loan, and property risk characteristics. We supplement these with data on economic factors and state legal requirements that may impact underlying mortgage performance. For a borrower with more than one FHA mortgage, we use reported characteristics of the refinances as opposed to carrying over characteristics from the previous loan. In the case of streamline refinances however, where data are often missing, we carry over loan characteristics from the previous loan. Summary statistics of the variables in the estimation are given in Table 3. The first panel presents summary statistics of static variables for underwritten loans (not streamline refinances) whose values do not change over the life of the underlying mortgage. The second panel presents dynamic variables whose values are time-varying. For the categorical variables, the left-out group is selected to be the high-quality or relatively more common mortgage type characterized.

A borrower's current LTV likely impacts the probability of default and prepayment. We calculate this using the current mortgage balance – reflecting amortization, any accelerated payments, and inclusive of any upfront mortgage insurance premium financed by the borrower – and an estimate of the current value of the home. To estimate the house value each month, we update the appraisal value of the property using the CoreLogic metro area overall repeat-sale house price indices. Thus, the current LTV is a dynamic variable that changes to reflect both debt amortization as well as house price changes. For streamline refinances, we impute the origination LTV using the updated LTV at the end of the prior FHA mortgage. In the estimation, we include intervals for this current LTV variable beginning with an indicator for 80-84 LTV to an indicator for 120 LTV or higher. The left-out category is a current LTV below 80.

---

[13] That is, the variance of the distribution of unobserved heterogeneity was converging to zero in the estimation.

Two other important borrower-specific risk factors are the credit score and the debt-to-income ratio (DTI). For underwritten mortgages, we observe the borrower's FICO score at the origination date, so in our data FICO is a static variable that does not change over the life of a mortgage. However, it can change between mortgages for a given borrower experience if more than one underwritten mortgage is involved. For internal FHA refinances, we use the new FICO score if the loan is underwritten, while we carry over the FICO score from the prior FHA mortgage for streamline refinances. In the estimation, we include a series of indicator variables for FICO score ranges from below 580 to 680-719. The left-out category is a FICO score of 720 or higher. We include a separate indicator if the FICO score is missing and the mortgage is not a streamline refinance.

We also include the borrower's back-end DTI which is a measure of the borrower's ability to meet monthly mortgage payments. The numerator of the back-end ratio is the sum of the annual mortgage payments, property taxes, house insurance and any other annual recurring debt payments such as student loans, auto loans and minimums on credit card balances. The denominator is the borrower's annual income.[14] We include indicators for DTI intervals from 28 – 35, 36 – 43, and 44 or higher. The left-out category is a back-end DTI of less than 28. We include an indicator if the DTI is not recorded and the mortgage is not a streamline refinance.

Additional indicators are included for the type of mortgage (FRM is the left-out type), term of the loan (30-year is the left-out term), reason for the mortgage (purchase loan is the left-out reason), level of documentation (full documentation is the left out status), and property type (single family residence is the left-out property type). In addition, we control for the size of the FHA mortgage at the origination. Models of strategic default predict that the default risk increases with the mortgage balance since the costs of default are mostly fixed while its benefits tend to increase with the size of the remaining balance.[15]

---

[14] In cases where there is a co-applicant for the mortgage the sum of the two annual incomes is used.

[15] See for example Haughwout *et al* (2010).

Several local economic variables are included. To ensure that the coefficients on the LTV indicators reflect the effect of the borrower-specific equity position on observed default behavior, we include the 12-month change in local house prices to capture the effect of non borrower-specific factors. FHA mortgages with high LTVs are likely to be in local housing markets that have suffered more serious house price declines and have faced many other economic challenges as well. While we attempt to control for local dynamics, there are other stress variables not completely captured in our data. Including the change in local house prices helps isolate any of these left-out factors that are correlated with declining house prices, which in turn impact borrower behavior.

The effect of an unemployment spell on a borrower's behavior is difficult to capture since we do not observe these spells.[16] The local unemployment rate is our best proxy, although it is not highly correlated with the unobserved borrower-specific unemployment. We include the MSA unemployment rate reported by the U.S. Bureau of Labor Statistics lagged 6 months to take into account the time lag between the onset of unemployment and when the borrower reaches the 90-day delinquency status. The unemployment variable is dynamic at a monthly frequency.[17]

We capture the incentive to prepay a mortgage by including a spread variable that reflects the decline in interest rates since origination. This is calculated each month by taking the difference between the average 30-year fixed-rate mortgage interest rate at the origination month and its average value at that month, then setting it to zero if the difference is positive, i.e. interest rates have increased.[18] To the extent that there is value in the option to refinance a mortgage, the refinance incentive can reduce the likelihood of default.

---

[16] See Foote *et al* (2008) and Gerardi, Shapiro, and Willen (2007) for discussions of the "double-trigger" hypothesis that the combination of a borrower being in negative equity and then suffering an income shock leads to a higher likelihood of default and foreclosure. Aragon *et al* (2010) show that FHA borrowers who are significantly underwater are also dangerously exposed to unemployment risk. The question is how to take this into account given micro hazards do not feature the unemployment rate.

[17] For purchase mortgages, we zero out the first four observations (months 3 – 6 following origination) on the unemployment variable since the lag value is pointing to a time before the mortgage is underwritten. This is based on the premise that an unemployed borrower would not be approved for a new FHA mortgage.

[18] We use the mortgage rate reported in the Freddie Mac Primary Mortgage Market Survey.

Local contagion can affect a borrower's decision to default as well. A recent survey (Fannie Mae, [2010]) finds that borrowers who know someone who has experienced a foreclosure are more than twice as likely to seriously consider default compared to borrowers who do not.[19] We control the contagion effect by including the number of distressed sales per 10,000 households in the MSA. We calculate a three-month moving average of distress sales for each MSA using CoreLogic data. The number of households in the MSA is taken from the 2008 American Community Survey.[20]

Finally, the legal environment that governs how mortgage delinquencies are handled varies by state and we include two variables to capture this variation. First, mortgages originated in a state with a judicial foreclosure process can expect delays in completing any foreclosure, which could incentivize borrowers to strategically default.[21] An indicator for judicial foreclosure is included in the estimation. Second, mortgages are considered as recourse depending on the state, meaning the lender has the ability to pursue a defaulted borrower with a deficiency judgment. Recourse loans potentially provide more security to the lender and as a result, borrowers may be less likely to default. We also include an indicator for recourse.

A concern with loan-level data is that we only have information on first lien mortgages. If the borrower takes out second liens, then the actual combined LTV will exceed the measured LTV used in the analysis. This will bias the hazard coefficient estimates on the LTV intervals to the extent that second liens are prevalent in the data. To explore this we examined a unique panel data set which links credit files across

---

[19] A similar result is also found in Guiso *et al* (2009).

[20] http://factfinder.census.gov/servlet/DTSelectedDatasetPageServlet?_lang=en&_ts=286380818796)

[21] See for example discussions of strategic default in Foote *et al* (2008) and Haughwout *et al* (2010).

household members constructed by Equifax for the Federal Reserve Bank of New York to calculate what fraction of FHA borrowers have second liens. However, we did not find this to be a source of concern.[22]

IV. Estimation Results

We report the exponentiated hazard coefficients from the estimation in Table 4. A reported hazard above (below) one indicates a higher (lower) prepayment or default risk relative to the baseline borrower experience consisting of high-quality, fully-documented, 30-year, fixed-rate purchase mortgages with current LTV below 80, FICO score above 720, DTI below 28, and secured by a single family residence.

We begin by examining the impact of the current LTV on the default and prepayment risks. [23] The results show high LTV to be an important driver of FHA default risk, which rises monotonically with the estimated current LTV of the underlying mortgage. A borrower with an estimated current LTV between 100 and 104 is more than twice as likely to default compared to a borrower with an estimated current LTV below 80. As we raise the current LTV to 120 or higher, the relative default risk increases to over three and a half times higher than the baseline. These estimated LTV effects reflect changes in default risks holding constant the change in local house prices over the past year.

LTV is also a determinant of prepayment. Recall that prepayment in our borrower-based data involves either paying off the mortgage due to a sale of the house or refinancing to a new non-FHA mortgage. Finding the required resources to pay off a mortgage in full is particularly hard for borrowers in negative equity (LTV more than 100) who need to make up the difference between the property value and the mortgage balance in

---

[22] The Equifax data follows a 5 percent random sample of households over time by linking credit files across household members. As of December 2009, the data indicate that only 6.7 percent of FHA borrowers had some form of a second lien. In contrast, 27.6 percent of prime borrowers and 25.9 percent of non-prime borrowers hold at least one second lien. Conditional on an FHA borrower having a second lien, the average balance on the second lien is 22.4 percent of the existing combined balances across all liens. Hence not having data on second liens poses less of a problem for FHA borrower experiences. We also looked at households with an FHA mortgage and no other first lien mortgage. While it is possible that the borrower has two homes, with an FHA mortgage on one house and only a second lien on the second house, we do not expect many such cases. It is then highly likely that any existing second-liens are tied to the same property.

[23] Note however that the measured current LTV for a borrower is a noisy measure of the true current LTV.

cash.[24] Comparing a borrower with an estimated current LTV of 100 – 104 to one with an estimated LTV below 80, the prepayment rate is reduced to 64 percent of the baseline. As we raise the estimated current LTV to 120 or higher, the prepayment rate declines only slightly further to 50 percent of the baseline. A borrowers with an underwater mortgage faces a combination of a high default risk and a low prepayment rate which implies a high cumulative probability that the borrower experience will be non-sustainable.

The FHA has stressed the improvement in the FICO scores for its new originations over the past couple of years as a factor that will hold down credit losses compared to earlier vintages.[25] This improvement in FICO scores can be seen in Table A1 where the average FICO score for all new originations went from the low to mid 600s in 2007 to close to 700 in 2010. Our results confirm that the credit score at origination is a strong predictor of default. The default risk rises dramatically as the borrower's FICO score is lowered. Relative to a borrower with a FICO score above 720, the default hazard is over seven times higher for borrowers with FICO scores between 580 and 619, and over ten times higher for borrowers with FICO scores below 580.[26]

The affordability of the FHA mortgage as gauged by the borrower's back-end DTI is also a determinant of the sustainability of an FHA borrower experience. Recall that the back-end DTI captures not only the mortgage and related housing costs (such as property taxes and insurance), but also other recurring debt. As we move from a borrower with considerable budget leeway (a back-end DTI below 28) to a borrower who is more cash-flow constrained in making all required payments (a back-end DTI of 44 or higher), the relative default hazard increases by more than 50 percent.

---

[24] The effect of this "collateral constraint" on prepayments has previously been observed in other mortgage products (see Caplin *et al* (1997)). The FHA streamline refinance program is designed precisely to prevent the collateral constraint imposed by high LTVs from limiting borrowers' ability to refinance.

[25] See Secretary Donovan's written testimony before the House Committee on Financial Services, December 1, 2011.

[26] Deng and Gabriel (2006) also find that FICO scores are a strong predictor of FHA defaults using data covering from 1992 to 1996. Their results indicate a smaller effect than our findings. This may reflect that they can control for other borrower characteristics such as age, sex, race and number of dependents.

Turning to the other mortgage-specific factors, we find that borrower experiences that begin with a cash-out refinance mortgages are 28 percent more likely to default and 47 percent more likely to prepay (holding constant the current LTV and the mortgage balance). In terms of documentation, the results indicate that borrower experiences involving mortgage originations with less than full documentation are associated with lower default risks than the baseline. However, the data also indicate that borrower experiences involving mortgages with missing LTV, FICO and DTI information all have significantly higher default risks. The mortgages with these missing origination characteristics are concentrated in the low- and no-doc loans. Taken together, this indicates that mortgages that are not subject to full underwriting pose higher credit risks to the FHA. Adjustable rate mortgages are over three times more likely to prepay than FRMs. Lastly, borrower experiences with higher mortgage origination balances have higher prepayment and default risks. The higher default risk is consistent with simple models of strategic default where the incentive to strategic default is increasing in the mortgage balance controlling for the current LTV (see Haughwout *et al* (2010)).

Housing market-specific variables are meant to capture economic determinants of prepayment and default. As noted earlier, the local unemployment rate is included as a proxy for whether the borrower experiences an unemployment spell. While measurement error will attenuate the estimated impact, the data still suggest that the lagged MSA unemployment rate is significantly related to the default risk on an FHA borrower experience. Controlling for the current LTV, declining house prices over the past year are associated with rising prepayment and default risks. This could reflect a variety of other economic factors in local housing markets that are correlated with declining house prices. The data do not indicate the presence yet of a contagion effect from distress sales. With regard to the interest rate incentive to prepay, the interest rate spread is a strong predictor of prepayment for borrower experiences involving fixed-rate FHA mortgages.[27]

Finally, the legal environment governing mortgage lending which varies by state affects default risk. The data indicate that judicial foreclosure is associated with higher default risk on FHA borrower experiences,

[27] Deng and Gabriel (2006) also find this result for a sample of FHA mortgages originated between 1992 and 1996.

supporting the hypothesis that some borrowers strategically default. As noted earlier, mortgages with recourse should raise the costs of default and therefore lower the default risk on a mortgage. The data indicate, however, that default risk is 11 percent higher for borrower experiences located in states with recourse lending.

V. Forecasts

We use the estimated model to generate default and prepayment forecasts for the portfolio of active FHA borrower experiences as of the end of our estimation sample. The forecast is performed over a five-year horizon where we use updated dynamic variables based on consensus forecasts for four underlying data series – house prices, unemployment rate, 30-year fixed-rate mortgage interest rates and distressed sales ratios. In particular, the unemployment rate is projected to decrease at an increasing rate, going down by a total of 2.9 percentage points at the end of five years.[28] Mortgage rates are projected to increase by 20 basis points in each of the five years.[29] The percent of distressed sales is projected to stay at current levels for the first two years, then to return to average historical levels over the next three years.[30] Finally, average nationwide house prices are projected to decline by around 2.5 percent in the first two years then slowly appreciate in the next three.[31] For simplicity, the forecast paths of the economic variables are assumed to be the same across all metropolitan areas covered by our data. We simulate the performance of FHA borrowers from the end of our sample period in October 2011 until September 2016 according to the methodology described in Section IIIA.

---

[28] Unemployment forecast taken from Survey of Economic Projections
http://www.federalreserve.gov/monetarypolicy/files/fomcprojtabl20120125.pdf

[29] Author's assumption

[30] Author's assumptions

[31] Home price expectations data are from Macro Markets https://pulsenomics.com/Sept2011-HPE-Survey.html

One might expect the sustainability performance of a particular vintage of FHA borrowers to improve with the passage of time because this has certainly been the historical pattern based on mortgage based analysis. Unfortunately, this appears to be less apparent with recent vintages of FHA borrowers. Default rates are projected to remain high for years to come as shown in the 5-year projections given in Table 5. In particular, 31 percent of loans are expected to default within this time frame. Looking across the three vintages, the cohort of 2007 FHA borrowers is projected to perform the worst with as much as 53 percent of borrowers defaulting on their loans. While the 2009 vintage is projected to perform better, the default rate is still estimated to be around 23 percent.

In addition to the continuing high rate of default, the other striking factor is how few are projected finally to graduate to sustainable homeownership by paying off their FHA-insured mortgages in full. Across all three vintages more than twice as many borrowers are projected to become 90 or more days delinquent as are projected to fully achieve sustainable homeownership.

There is a simple reason why recent FHA borrowers may not fit the historical pattern in which after a few years default rates decrease rapidly over time. In the past, generally rising house prices and the availability of non-FHA mortgages have made it possible for borrowers to pay off their FHA mortgages in full. Neither of these routes is currently available for most FHA borrowers. There has been little or no increase in prices since these borrowers purchased their homes – in fact, we estimate that 40 percent of the active loans at the end of our sample period are in negative equity, and another 20 percent are near negative equity with an LTV of 95 to 100. Additionally, house prices are not expected to significantly increase over the next five years. As a consequence, many recent FHA borrowers are likely to remain vulnerable to economic shocks so that defaults are projected to continue at a high rate.

The bottom line is that while borrowers from 2009 are projected to perform better than those from 2007 and 2008, there is little reason to argue that sustainability issues were confined only to the 2007 and 2008 vintages of FHA borrowers.

VI. Underestimation of Risk

The FHA is designed to be a self-funded mortgage insurance program and not to need direct taxpayer support. To gauge the FHA's performance and to evaluate its financial condition, an external audit of its insurance fund is conducted each year. A key part of this audit review involves projecting future default of currently active FHA mortgages. For the past three years, default projections from the prior year have been revised upward.[32]

The recent systematic underestimation of future credit losses may be due to deficiencies in the audit analysis (Gyourko [2011). Aragon et al [2010] argued that an important flaw is the data framework used in the analysis – it is based on FHA mortgages rather than on FHA borrower experiences. In the mortgage-based view an internal refinance is treated as a successful exit as if the credit risk had been eliminated. Meanwhile, in the borrower experience view, subsequent mortgages taken out by the same borrower are tracked and the borrower's risk only leaves the FHA system when the borrower pays off the final FHA mortgage in full. This is quantitatively important since recent reductions in mortgage interest rates have dramatically increased the volume of internal refinancing from one FHA mortgage into another. In our sample where we track borrowers and their multiple mortgages, we estimate that only 6.4 percent of FHA borrowers since 2007 have successfully exited the FHA program. In contrast, if we use the mortgage data framework, the success rate is three times as high at 19.4 percent.[33] This reflects the fact that a majority of terminated mortgages have in fact immediately been refinanced back into new FHA mortgages.

The intuition that an analysis using mortgages rather than borrowers overstates successes and understates future losses has not resonated with everyone for a couple of reasons. First, it is standard academic and industry practice to perform credit risk analysis at the mortgage level. In this sense, the external audit is implementing what is considered the "best practice". Second, some have argued that there is no

---

[32] IFE 2009 (page i), 2010 (page iii) and 2011 (page iii).

[33] Around 18 percent of our borrowers have two or more FHA mortgages comprising their current borrower experience. The time in months between a mortgage origination (either a purchase mortgage or a refinance from a non-FHA mortgage) to an internal refinance peaks at around 12 months.

understatement of risk because for internal refinances the credit risk is carried forward in the data as the FHA mortgage that prepays is replaced by the new FHA mortgage. As a consequence, the credit risk is not treated in the data as if it has terminated even if mortgages are analyzed individually rather than as a linked sequence.

Our customized FHA data allow us to further investigate the implications of the data structure on projected credit losses. We already presented the hazard estimates based on analyzing the data organized by borrower experiences in Table 4. For comparison, Appendix Table A4 presents the hazard estimates based on analyzing the data organized by mortgages. It is important to highlight that the same data is used in both cases, the same variables are used to explain defaults and prepayments, and the same statistical model is used in the estimation. The only difference is how the unit of observation is defined – a borrower experience versus a mortgage.

The relative hazard coefficients between the two approaches are similar in many respects. The key difference is seen in the coefficients of the high LTV indicators in the prepayment hazards and in the baseline hazards. Data organized according to borrower experiences indicate that those with a current LTV of 120 or higher have a prepayment rate that is only 50 percent of the rate for borrowers with a current LTV of 80 or less. In contrast, data organized according to mortgages reveal a relative prepayment rate of 78 percent that of the baseline. The same pattern exists for each of the high LTV indicators which indicate that the FHA's streamline refinance program helps reduce the friction that high LTVs create for refinancing. This contrast is evidence that the FHA streamline refinance program is achieving its goal of allowing more high LTV FHA borrowers the opportunity to refinance to a lower mortgage rate.

Figures 1 and 2 contrast the default and prepayment baseline hazards between the borrower and mortgage data frameworks. The baseline default hazard curves are very similar for both data frameworks for the first two and a half years. Afterwards, the borrower baseline default hazard is above the mortgage baseline default hazard. However, the differences are more apparent for the baseline prepayment hazards. The mortgage data approach significantly raises the estimated baseline prepayment hazards relative to the

borrower-centered data approach particularly in the first two years.[34] The striking difference in the estimated baseline prepayment hazards meaningfully impacts default projections going forward by underestimating the amount of time for which the borrower will remain at risk of default. This is illustrated in Figure 3 where we show the estimated prepayment survivor functions over the five year forecast horizon for the active mortgages at the end of our sample. At any point in the forecast horizon, the survivor functions as we have constructed them indicate the fraction of the borrowers (or mortgages) that would be predicted to still be active assuming that there are no exits due to serious delinquency. Using borrower data, 92 percent of the borrowers are predicted to still be active in five years. In contrast, using mortgage data, only 47 percent of the mortgages are predicted to still be active in five years – a decline of 45 percentage points.

Table 6 provides the 5-year projections of the estimated hazard models based on the two different frameworks for the same set of mortgages that are still active at the end of our sample. To reiterate, the only difference is due to the data structure since all variables, including forecast paths of time-dependent variables, are identical. Using the data organized by borrower experiences, we estimate that 7.3 percent of the currently active borrowers will prepay over the next five years. In contrast using the data organized by mortgages, we estimate that the prepayment rate will be much higher at 47.5 percent. Switching the analysis from FHA borrowers to mortgages increases the forecasted prepayment rate by 40 percentage points due to the recent heavy use of the FHA's internal refinance programs. Similarly, using the estimates from the borrower data we project that 17.3 percent of the active mortgages at the end of our sample will reach 90 days delinquent over the five year forecast horizon. In contrast, using the estimates from the mortgage data we project that only 11.2 percent will reach 90 days delinquent.

The 2010 audit report on the FHA's mutual mortgage insurance fund indicated that the FHA linked their streamline refinances for the purpose of initializing the origination LTV on the streamline refinance. In addition, the FICO and DTI information was filled in from the prior FHA mortgage. However, mortgages

[34] While the direction of the effect on the baseline prepayment baseline hazards should be robust, the magnitude of the difference between the borrower and mortgage based hazards will depend on the degree to which the borrower data base spans periods where the internal refinancing activity has been less active than of recent.

rather than borrowers were still used as the unit of observation. Instead, mortgages that began as a streamline refinance were allowed to have separate estimated default and prepayment hazards.[35] This raises the question of how this strategy does at approximating the results one would obtain from switching to the borrower data framework. The results in Table 6 indicate that in our sample of FHA data this strategy moves the projections in the direction of those obtained by the borrower based analysis, but only partially. For example, using our borrower-based methods, we project defaults over the next five years to be more than twice as high as successful exits. Even after applying the FHA's new estimation strategy, defaults over the next five years are projected instead to be less than half as high as successful exits. The continued over-counting of successful exits results in a potentially significant underestimate of the risk to the FHA's insurance program.

VII. Concluding Remarks

We produce first results on the sustainability of homeownership for FHA borrowers between 2007 and 2009. More than 15 percent of these borrowers have already been 90 days or more delinquent, with less than half that number graduating to sustainable homeownership by paying off all FHA mortgages. We project that the proportion who have been 90 days or more delinquent will rise above 30 percent within five years. Fewer than 15 percent will have fully graduated to sustainable homeownership.

We show that accurately measuring sustainability requires a new data structure organized around borrowers rather than mortgages. The current mortgage based data structure results in future defaults being under-estimated and prepayments overestimated. This combination artificially lowers loss estimates to the FHA's insurance fund. This same data structure is used by the GSE's (Fannie Mae and Freddie Mac), which therefore understate the risks their mortgages pose to borrowers and to taxpayers.

---

[35] See Integrated Financial Engineering (2010), page A-11.

Opening up FHA and GSE data to researchers is important to help inform the debate of how the U.S. housing finance markets can rebuilt on more stable foundations. Even without making their data publicly available, the FHA and the GSE's could readily adopt the borrower-based data structure developed herein. This would serve the cause of transparency and help policy-makers to determine these organizations' roles in the U.S. housing finance markets of the future.

References:

Aragon, Diego, Andrew Caplin, Sumit Chopra, John V. Leahy, Yann LeCun, and Mario Scoffier. "Reassessing FHA Risk." NBER Working Paper No. 15802, March 2010.

Brevoort, Kenneth P. and Cheryl R. Cooper. "Foreclosure's Wake: The Credit Experience of Individuals Following Foreclosure." Finance & Economics Discussion Series 2010-59, Board of Governors of the Federal Reserve System, 2010.

Caplin, Andrew. "The FHA Reform Act of 2010." Testimony before House Committee on Financial Services, Subcommittee on Housing and Community Opportunity, March 11, 2010. http://www.house.gov/apps/list/hearing/financialsvcs_dem/caplin.pdf

Caplin, Andrew. "Perspectives on the Health of the FHA Single-Family Insurance Fund." Testimony before the House Committee on Financial Services, December 1, 2011.

Caplin, Andrew, Charles Freeman, and Joseph Tracy. "Collateral Damage: Refinancing Constraints and Regional Recessions." *Journal of Money, Credit, and Banking* 29 (November 1997): 496-516.

Currie, Janet and Erdal Tekin. "Is There a Link Between Foreclosure and Health?" Working Paper, Princeton University, March 2012.

Deng, Yongheng, and Stuart Gabriel. "Risk-Based Pricing and the Enhancement of Mortgage Credit Availability Among Underserved and Higher Credit-Risk Populations." *Journal of Money, Credit and Banking* 38 (September 2006): 1431-1460.

Fannie Mae Foundation. *The Fannie Mae National Housing Survey*, 2010.

Ferreira, Fernando, Joseph Gyourko and Joseph Tracy. "Housing Busts and Household Mobility." *Journal of Urban Economics* 68, no. 1 (2010): 34-45.

_____. "Housing Busts and Household Mobility: An Update." NBER Working Paper No. 17405, September 2011.

Foote, Christopher L., Kristopher Gerardi, and Paul S. Willen. "Negative Equity and Foreclosure: Theory and Evidence." *Journal of Urban Economics* 6, no. 2 (2008): 234-245.

Gerardi, Kristopher, Adam Hale Shapiro, and Paul S. Willen. "Subprime Outcomes: Risky Mortgages, Homeownership Experiences, and Foreclosures." Working Paper No. 07-15. Federal Reserve Bank of Boston, December, 2007.

Guiso, Luigi, Paola Sapienza, and Luigi Zingales. "Moral and Social Constraints to Strategic Default on Mortgages." Working Paper No. 15145. National Bureau of Economic Research, July, 2009.

Gyourko, Joseph. *Is FHA the Next Housing Bailout?* A Report Prepared for the American Enterprise Institute, 2011.

Haughwout, Andrew, Ebiere Okah, and Joseph Tracy. "Second Chances: Subprime Mortgage Modification and Re-Default." Staff Report No. 417. Federal Reserve Bank of New York, August, 2010.

Integrated Financial Engineering, Inc. *Actuarial Review of the Federal Housing Administration Mutual Mortgage Insurance Fund (Excluding HECMs) for Fiscal Year 2009*. Prepared for U.S. Department of Housing and Urban Development. Washington, DC, November 6, 2009.

Integrated Financial Engineering, Inc. *Actuarial Review of the Federal Housing Administration Mutual Mortgage Insurance Fund (Excluding HECMs) for Fiscal Year 2010*. Prepared for U.S. Department of Housing and Urban Development. Washington, DC, 2010.

Integrated Financial Engineering, Inc. *Actuarial Review of the Federal Housing Administration Mutual Mortgage Insurance Fund Forward Loans for Fiscal Year 2011*. Prepared for U.S. Department of Housing and Urban Development. Washington, DC, October 12, 2011.

Kalbfleisch, Jack D., and Ross L. Prentice. *The Statistical Analysis of Failure Time Data*. Wiley, 2002.

Meyer, Bruce D. "Unemployment Insurance and Unemployment Spells." *Econometrica* 58 (July 1990): 757-782.

U.S. Department of Housing and Urban Development, *Actuarial Review of the Federal Housing Administration Mutual Mortgage Insurance Fund for Fiscal Year 2005*. Washington, DC, October 14, 2005.

U.S. Department of Housing and Urban Development. *Annual Report to Congress Regarding the Financial Status of the FHA Mutual Mortgage Insurance Fund Fiscal Year 2010*. Washington, DC, November 15, 2010.

U.S. Department of Housing and Urban Development. *Written Testimony of Secretary Shaun Donovan. Hearing before the House Committee on Financial Services.* "Status of the FHA Mutual Mortgage Insurance Fund and the FY 2011 Actuarial Report." Washington, DC, December 1, 2011.

Table 1. Time from 1st Missed Payment to "Default" Trigger for Loans Ending in REO

Trigger Definition	Mean	Std Dev	25th	50th	75th	Maximum
60+	2.2	1.4	1	1	2	35
90+	3.9	2.4	2	2	5	40
Foreclosure start	9.6	6.0	5	7	12	55
REO start	15.8	7.2	10	14	20	61

Source: CoreLogic FHA Data

Table 2. Definition of "Default" and Likelihood of a Claim

	Total	Still Active		Censored	Terminated			
Trigger Definition	Reached Trigger	Last Obs Delinq	Last Obs Current	Servicing Transferred	Paid Off or REO	Pct Paid Off or REO	Pct REO	Est. "Cure" Rate
60+	42,992	25,945	8,724	3,643	4,680	10.9	58.4	24.8
90+	35,131	21,801	5,728	3,154	4,448	12.7	61.5	21.2
Foreclosure start	17,045	9,037	1,601	2,479	3,928	23.0	69.6	16.4

Notes: Percent REO is conditional on a loan being paid off. Estimated cure rate = (number paid off w/o claim + number w. last observation current) / number that reach trigger.
Source: CoreLogic FHA Data

Table 3. Summary Statistics

	a) Static Variables for Underwritten Loans			
Variable	Mean	Std Dev	Minimum	Maximum
Credit Score (FICO):	673	64	300	900
Less than 580	0.061	0.238	0	1
580 – 619	0.120	0.325	0	1
620 – 679	0.353	0.478	0	1
680 – 719	0.177	0.382	0	1
720 or higher	0.237	0.425	0	1
Missing	0.053	0.224	0	1
Debt-to-income (DTI):	40.5	9.8	10	75
Less than 28	0.072	0.259	0	1
28 – 35	0.133	0.339	0	1
36 – 43	0.193	0.394	0	1
44 of higher	0.255	0.436	0	1
Missing	0.347	0.476	0	1
Loan purpose:				
Cash out refinance	0.139	0.346	0	1
Non-cash out refinance	0.170	0.376	0	1
Unknown refinance	0.050	0.218	0	1
Purchase	0.641	0.480	0	1
Other loan-specific:				
Not full documentation	0.405	0.491	0	1
Adjustable rate	0.015	0.122	0	1
Not 30-year term	0.087	0.282	0	1
Origination balance ($10k)	17.8	9.1	1.5	77.9
State-specific				
Judicial foreclosure	0.371	0.483	0	1
Recourse	0.761	0.427	0	1
Borrower Experience	1.2	0.404	1	5

Table 3. Summary Statistics (continued)

	b) Dynamic Variables			
Variable	Mean	Std Dev	Minimum	Maximum
Loan-to-value (LTV):				
Less than 80	0.056	0.229	0	1
80 – 84	0.038	0.192	0	1
85 – 89	0.073	0.260	0	1
90 – 94	0.145	0.352	0	1
95 – 99	0.211	0.408	0	1
100 – 104	0.154	0.361	0	1
105 – 109	0.090	0.286	0	1
110 – 114	0.046	0.210	0	1
115 – 119	0.025	0.156	0	1
120 or higher	0.044	0.206	0	1
Missing	0.117	0.321	0	1
Economic determinants:				
Lag unemployment rate change	7.52	4.07	0.0	32.6
House price change, 12 month (10 percent)	−0.48	0.63	−3.9	2.4
Distress sales share (1 percent)	5.47	5.79	0	56.3
Interest rate differential (100 bp)	0.73	0.63	0	4.7
Duration at risk (months)	19	16	2	276

Notes: Summary statistics for the dynamic variables vary slightly between the prepayment and default as well as unlinked and linked data files. We report the statistics from the linked default data.

Table 4. Borrower Based Prepayment and Default Hazard Estimates:

Variable	Default	Prepayment
Loan-to-Value:		
80 – 84	1.29***	0.96**
	(0.064)	(0.061)
85 – 89	1.28***	0.65***
	(0.055)	(0.038)
90 – 94	1.53***	0.68***
	(0.058)	(0.034)
95 – 99	1.79***	0.64***
	(0.065)	(0.031)
100 – 104	2.22***	0.64***
	(0.081)	(0.032)
105 – 109	2.57***	0.60***
	(0.097)	(0.032)
110 – 114	2.85***	0.58***
	(0.115)	(0.036)
115 – 119	3.13***	0.53***
	(0.139)	(0.041)
120 or higher	3.72***	0.50***
	(0.152)	(0.035)
Missing	1.73***	0.57***
	(0.073)	(0.032)
Credit Score (FICO):		
Less than 580	10.82***	0.43***
	(0.319)	(0.023)
580 – 619	7.52***	0.59***
	(0.214)	(0.022)
620 – 679	3.91***	0.70***
	(0.106)	(0.019)
680 – 719	2.01***	0.84***
	(0.064)	(0.027)
Missing	5.28***	0.57***
	(0.180)	(0.029)
Back end Debt-to-Income (DTI):		
28 – 35	1.17***	1.05
	(0.039)	(0.054)
36 – 43	1.41***	1.10*
	(0.044)	(0.054)
44 or higher	1.59***	1.10**
	(0.049)	(0.052)
Missing	1.65***	0.97
	(0.052)	(0.047)

Table 4. Borrower Based Prepayment and Default Hazard Estimates (continued)

Variable	Default	Prepayment
Loan purpose:		
Cash-out refinance	1.28***	1.47***
	(0.024)	(0.045)
Non-cash-out refinance	1.22***	1.15***
	(0.021)	(0.034)
Unknown refinance	1.15***	1.31***
	(0.029)	(0.060)
Other loan-specific:		
Not full documentation	0.77***	1.80***
	(0.013)	(0.048)
Adjustable rate	1.06	3.16***
	(0.049)	(0.21)
Not 30-year term	1.98***	0.98
	(0.039)	(0.045)
Origination balance ($10k)	1.02***	1.04***
	(0.0007)	(0.001)
State-specific:		
Judicial foreclosure	1.09***	0.81***
	(0.015)	(0.019)
Recourse	1.11***	1.13***
	(0.020)	(0.033)
Economic determinants:		
Lag unemployment rate	1.04***	0.99**
	(0.003)	(0.005)
House price change, 12 month (10 percent)	0.94***	0.92***
	(0.011)	(0.019)
Distress sales share (1 percent)	1.00	0.99***
	(0.001)	(0.002)
Interest rate differential (1 percent)		3.09***
		(0.055)
Number of months at risk	4,171,301	4,097,331
Number of subjects	160,939	159,169

Note: The left out group is the set of high-quality FHA fully documented 30-year fixed rate purchase mortgages with current LTV below 80, FICO score above 720, DTI below 28, secured by a single family residence. Six property type indicators are included. Borrower experiences are left-censored at January 2007.

*** significant at the 1% level ** significant at the 5% level * significant at the 10% level

Table 5. Five-Year Projections

	Still Active	Default	Prepay	Ratio
Combined: 2007-2009	56.6	31.5	11.9	0.73
2007	30.6	53.2	16.1	0.77
2008	41.5	41.3	17.2	0.71
2009	67.8	23.4	8.8	0.73

Note: Vintages represent calendar years. Ratio = Default / (Default + Prepay)

Table 6. Borrower vs. Mortgage: Five-Year Projections for Active Loans

	Still Active	Default	Prepay	Ratio
Borrower Experience	75.4	17.3	7.3	0.70
Mortgage				
No interactions	41.2	11.2	47.5	0.19
Streamline refinance interactions	52.5	14.1	32.9	0.30

Note: Streamline refinance interactions allow all mortgages that begin as a streamline refinance to have separate default and prepayment hazards from mortgages that begin otherwise. Ratio = Default / (Default + Prepay).

Figure 1. Baseline Default Hazards: Mortgage vs. Borrower

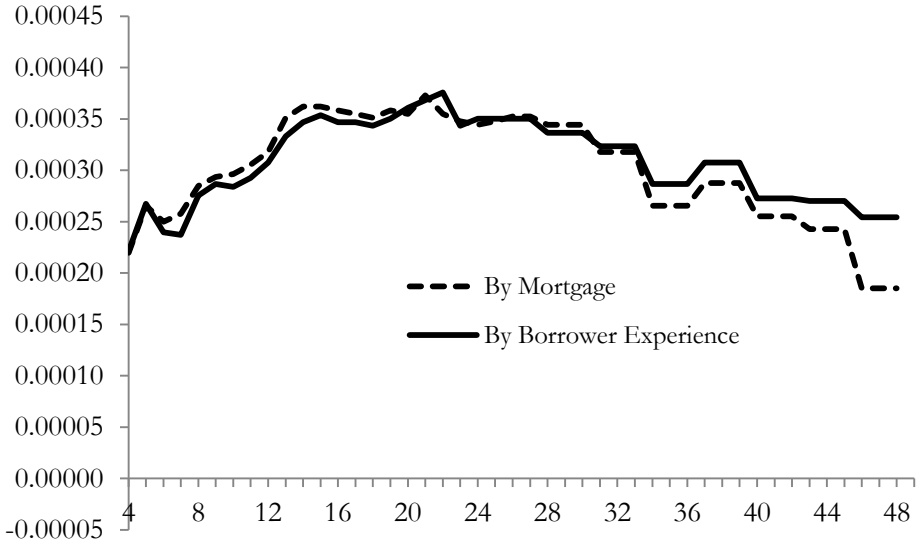


Figure 2. Baseline Prepayment Hazards: Mortgage vs. Borrower

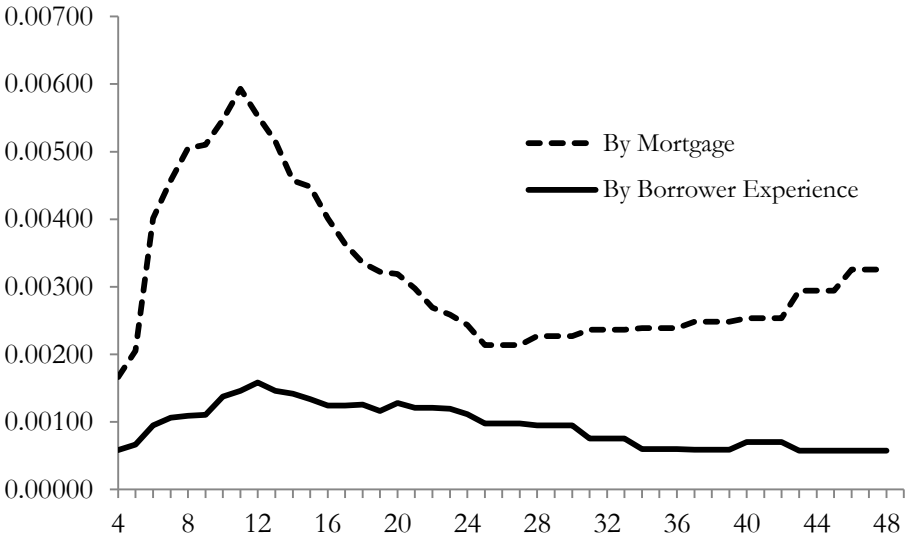
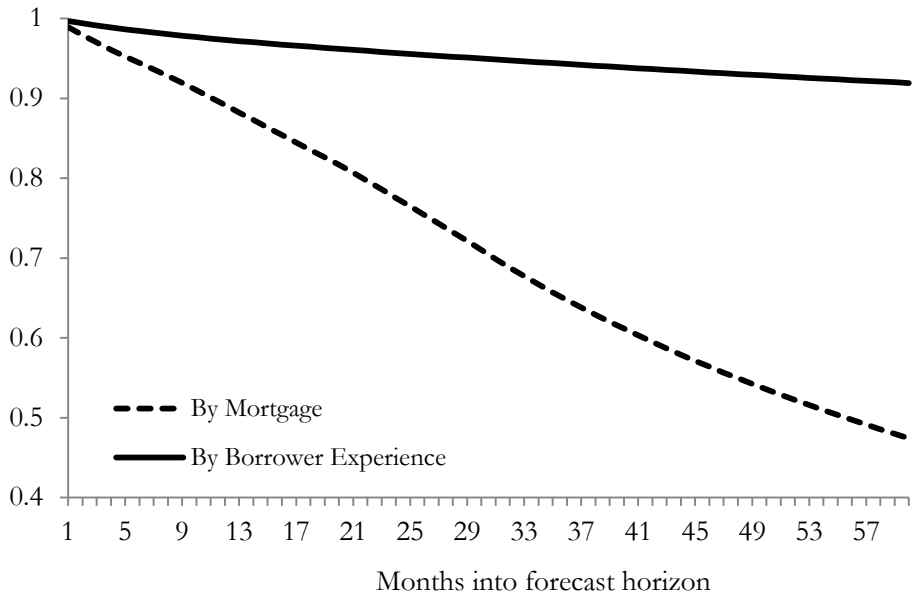


Figure 3. Survivor probabilities over the forecast horizon – borrower and mortgage



Note: The default hazards have been set to zero in constructing these survivor functions.

Table A1. Comparison between FHA Originations and CoreLogic Sample: Credit Score (FICO)

Fiscal	FY	Purchase		Conventional Refi		FHA-FHA Refi[a]		All[a]	
Year	Quarter	FHA	*CL*	FHA	CL	FHA	CL	FHA	CL
2007	1	633	639	619	620	557	625	607	634
	2	631	635	616	620	587	628	624	631
	3	628	632	613	618	613	628	623	628
	4	632	634	621	615	613	625	628	628
2008	1	631	633	620	615	612	626	625	626
	2	642	635	630	620	625	633	635	628
	3	667	655	644	637	622	643	656	648
	4	673	669	646	645	628	647	663	662
2009	1	676	673	655	652	648	649	668	666
	2	683	678	674	669	667	663	679	674
	3	696	688	689	685	676	676	691	687
	4	698	697	688	688	675	678	693	694
2010	1	697	697	692	690	681	680	694	695
	2	698	697	699	696	686	686	697	696
	3	698	698	695	699	693	689	698	698

Notes: FHA statistics are from the FHA Quarterly Reports. Fiscal years run from October of the prior year through September of the indicated year.

[a] Based on fully underwritten mortgages and exclude streamline refinances

Table A2. Comparison between FHA Originations and CoreLogic Sample: Loan-to-value (LTV)

Fiscal	FY	Purchase		Conventional Refi		FHA-FHA Refi		All	
Year	Quarter	FHA	CL	FHA	CL	FHA	CL	FHA	CL
2007	1	95.7	95.7	89.4	89.7	89.4	90.3	91.7	92.0
	2	95.6	95.4	89.2	89.7	90.0	90.6	93.4	93.4
	3	95.3	95.3	88.7	89.2	88.9	89.7	93.2	93.3
	4	95.7	95.5	89.1	89.6	89.4	90.1	93.6	93.6
2008	1	94.9	94.8	89.3	89.6	90.2	91.2	92.0	92.2
	2	95.0	94.7	89.8	90.4	90.8	91.4	92.1	92.4
	3	95.1	95.1	89.7	90.2	90.8	91.4	92.9	93.1
	4	95.2	95.2	89.4	89.8	89.8	90.5	93.1	93.3
2009	1	94.7	94.7	89.9	90.3	91.6	92.0	92.9	93.1
	2	95.1	95.0	90.9	91.2	93.0	93.7	93.1	93.2
	3	95.1	94.9	92.2	92.5	93.3	94.0	94.0	94.1
	4	95.2	94.9	90.6	90.9	91.5	92.3	93.7	93.7
2010	1	95.1	94.8	89.2	89.6	92.9	93.9	92.7	92.7
	2	95.0	94.8	89.5	89.9	90.4	91.3	93.0	93.1
	3	94.9	94.6	88.6	89.3	89.8	91.1	94.1	94.0

Notes: FHA statistics are from the FHA Quarterly Reports. Fiscal years run from October of the prior year through September of the indicated year. The FHA LTV averages exclude any financed up-front mortgage insurance premium from the loan balance. The up-front premium charged from FY09 through March 2010 was 1.75% for fully underwritten mortgages, and 1.5% for streamline refinanced mortgages. Starting in April 2010 the up-front premium was increased to 2.25% for all mortgages. Prior to FY09 the premiums varied. We adjust the CoreLogic LTV by backing out these up-front mortgage premiums.

Table A3. Comparison between FHA and CoreLogic Early Delinquency

		Purchase		Refinance		All	
Year	Quarter	FHA	CL	FHA	CL	FHA	CL
2007	1	0.6	0.4	0.8	1.3	0.7	2.2
	2	3.6	2.8	2.1	1.9	3.1	2.5
	3	3.4	2.6	3.1	2.0	3.3	2.4
	4	2.6	2.5	2.3	1.8	2.5	2.2
2008	1	2.1	2.3	3.3	1.7	2.8	2.2
	2	2.7	1.8	3.0	2.0	2.9	2.1
	3	2.3	1.5	4.0	2.1	3.1	1.8
	4	1.6	1.1	3.4	1.6	2.3	1.4
2009	1	1.2	0.9	2.2	0.9	1.6	1.3
	2	0.9	0.6	2.2	0.6	1.6	1.0
	3	0.7	0.4	2.0	0.6	1.5	0.7
	4	0.5	0.3	2.2	0.7	1.5	0.5
2010	1	0.4	0.4	0.9	0.3	0.7	0.4
	2	0.7	0.3	0.8	0.3	0.7	0.3
	3	0.7	0.5	0.7	0.3	0.7	0.5

Notes: FHA statistics are from the FHA Quarterly Reports. Fiscal years run from October of the prior year through September of the indicated year. Refinances include all fully underwriter conventional to FHA and FHA to FHA refinances. Early delinquency is defined to mean a mortgage that reaches 90-days delinquent within the first 6-months since origination.

Table A4. Mortgage Based Prepayment and Default Hazard Estimates

Variable	Default	Prepayment
Loan-to-Value:		
80 – 84	1.23***	0.93***
	(0.061)	(0.031)
85 – 89	1.21***	0.78***
	(0.053)	(0.022)
90 – 94	1.44***	0.75***
	(0.055)	(0.019)
95 – 99	1.72***	0.80***
	(0.063)	(0.019)
100 – 104	2.10***	0.86***
	(0.077)	(0.021)
105 – 109	2.44***	0.88***
	(0.093)	(0.023)
110 – 114	2.81***	0.88***
	(0.117)	(0.026)
115 – 119	3.11***	0.86***
	(0.144)	(0.030)
120 or higher	3.72***	0.78***
	(0.159)	(0.025)
Missing	1.67***	0.47***
	(0.064)	(0.013)
Credit Score (FICO):		
Less than 580	10.71***	0.85***
	(0.315)	(0.019)
580 – 619	7.41***	0.96**
	(0.211)	(0.017)
620 – 679	3.93***	0.97**
	(0.106)	(0.014)
680 – 719	2.02***	0.97
	(0.064)	(0.016)
Missing	4.71***	0.74***
	(0.162)	(0.018)
Back end Debt-to-Income (DTI):		
28 – 35	1.16***	1.18***
	(0.039)	(0.030)
36 – 43	1.39***	1.31***
	(0.044)	(0.031)
44 or higher	1.56***	1.32***
	(0.048)	(0.030)
Missing	1.68***	0.93**
	(0.052)	(0.022)

Table A4. Mortgage Based Prepayment and Default Hazard Estimates (continued)

Variable	Default	Prepayment
Loan purpose:		
Cash-out refinance	1.30***	1.38***
	(0.024)	(0.019)
Non-cash-out refinance	1.44***	0.78***
	(0.023)	(0.012)
Unknown refinance	1.28***	1.11***
	(0.031)	(0.025)
Other loan-specific:		
Not full documentation	0.84***	2.22***
	(0.014)	(0.027)
Adjustable rate	1.11**	4.42***
	(0.051)	(0.12)
Not 30-year term	1.97***	0.70***
	(0.038)	(0.018)
Origination balance ($10k)	1.02***	1.03***
	(0.0007)	(0.0005)
State-specific:		
Judicial foreclosure	1.08***	0.88***
	(0.015)	(0.010)
Recourse	1.10***	0.94***
	(0.020)	(0.013)
Economic determinants:		
Lag unemployment rate	1.03***	0.93***
	(0.003)	(0.002)
House price change, 12 month (10 percent)	0.95***	0.76***
	(0.011)	(0.007)
Distress sales share (1 percent)	1.00	1.00***
	(0.001)	(0.001)
Interest rate differential (1 percent)		2.70***
		(0.023)
Number of months at risk	4,052,279	4,014,051
Number of subjects	191,393	188,789

Note: The left out group is the set of high-quality FHA fully documented 30-year fixed rate purchase mortgages with current LTV below 80, FICO score above 720, DTI below 28, secured by a single family residence. Six property type indicators are included. Mortgages are right censored at January 2007

*** significant at the 1% level ** significant at the 5% level