INTERNATIONAL JOURNAL OF BUSINESS, 26(3), 2021 ISSN: 1083-4346

Negative Equity: House Price Declines or Equity Dilution? A Close Look at California Foreclosures During 2006-2008

Cynthia Holmes[a], Michael LaCour-Little[b], Thanh Nguyen[c]
[a]*Ted Rogers School of Management*
Ryerson University
Toronto, Canada
cynthia.holmes@ryerson.ca
[b,c]*Mihaylo College of Business and Economics*
California State University-Fullerton
Fullerton, CA, USA
mlacour-little@fullerton.edu
thanhnguyen@fullerton.edu (Contact Author)

ABSTRACT

The usual view is that households who purchased at the top of the market are those most at risk of foreclosure due to price declines. Our paper shows that the presence of house price appreciation, coupled with liberal lending practices, also leads to higher risk of having negative equity, the primary driver of foreclosure. Using public record data to study Southern California borrowers actually experiencing foreclosure during 2006 – 2008, we show that 41% of them extracted equity. The borrowers who extracted lost their homes despite having, on average, 14% initial equity and 5% home value appreciation during their ownership period. In addition, low loan-to-value, price increase, young age and high income level increase propensity to extract.

JEL Classifications: D12, D14, G21, R20

Keywords: negative equity, equity extraction, mortgage, default, foreclosure

I. INTRODUCTION

Decades of research have established that negative equity, a situation when borrowers owe more on their mortgages than their homes are worth, dramatically increases foreclosure probability (see Von Furstenburg (1969) or Campbell and Dietrich (1983) for early studies)[1]. But there is little research on how borrowers, during the period leading up to the latest foreclosure crisis, arrived to the situation of having negative equity, also referred to as being "underwater". In general, there are two possibilities explaining how borrowers become underwater: (1) the borrowers buy at the top of the market (bad timing) and experience a substantial decrease in value over their holding period; or (2) the borrowers dilute their original equity position with post-purchase subsequent borrowing through cash-out refinancing, adding junior lien debt, or some combination of the two. This paper looks at the magnitude of each of these sources of negative equity for a sample of borrowers who actually experienced foreclosure during the housing crisis of 2008[2].

Our competitive advantage is data; we have from public records the entire borrowing history for 1,216 properties contained in our sample of about 6000 foreclosures that occurred in Southern California during 2006 – 2008. In addition, we have matched public record data to mortgage records for a little less than a third of the observations. To provide some context for this time period, consider the following. In late 2006, housing prices had just begun to decline in most markets and default rates remained modest. By late 2007, housing prices had been declining for more than a year and the recession was about to commence. Moreover, market events in August 2007 had prompted many to label the situation a crisis, as subprime and alternative mortgage credit became difficult to obtain[3]. By late 2008, a series of disasters had unfolded, with defaults and foreclosures reaching record levels[4].

We examine each of the foreclosure cases in our data to determine the size of each equity position at the time of the foreclosure sale and how the borrower arrived at their particular leverage position. To preview our main results, we find that 41% of all homeowners in our sample extracted at least some equity and 87% of those extracted enough equity that their total indebtedness at the time of foreclosure exceeded the purchase price of the house. In addition, we show that the borrowers extracted equity sooner when the original loan-to-value (LTV) is lower, house price appreciation is higher, and the borrower is younger and has higher income.

Our results are important for lenders since the results contradict the usual view that house price appreciation universally reduces mortgage default risk. Rather, to the extent that house price appreciation stimulates equity extraction, it generates higher default risk over time by increasing leverage levels. We also provide a cautionary tale for homeowners deciding whether to borrow against accumulated equity. Finally, our results are important for policymakers seeking to craft measures to reduce the risk that recent events will re-occur. In our concluding section, we argue that changes to contract structures that allow senior lien holders to more effectively monitor, or price, equity-diluting behavior by borrowers are warranted[5].

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 sketches out the relationship between equity, house price movements, and debt usage. Section 4 describes data sources and methods, and Section 5 presents the results of our empirical analyses. The final section concludes with policy implications and open research questions.

II. LITERATURE REVIEW

Our research connects to the literature investigating the factors that affect the likelihood of equity extraction. This literature has documented four groups of factors. The first factor is liquidity constraints. Borrowers who experience unemployment, are younger or have lower credit scores are more likely to extract (Hurst and Staffort, 2004; Lehnert, 2004; Nothaft and Chang, 2004; Pennington-Cross and Chomsisengphet, 2007). The second factor is the mortgage interest rate. The lower the rate, whether in absolute terms or relative to rates of other consumer credit, the higher the probability of extraction (Bhutta and Keys, 2016; Pennington-Cross and Chomsisengphet, 2007). Thirdly, in order to extract equity, borrowers should have equity in the home. House price appreciation has been shown to increase the probability of originating a cash-out refinance (Nothaft and Chang, 2004)[6,7].

Finally, more recent research indicates that borrowers can take out large amounts of home equity and subsequently face higher probability of default because the law and other market participants impose little or no limit on borrowing. Kumar (2018) takes advantage of the fact that Texas is the only state limiting home-equity borrowing to 80% of the home value. The paper shows that in the border areas, Texan borrowers are less likely to default than borrowers in nearby states. Laufer (2013) estimates that if there were limits on cash-out refinance to the tune of 80% of the current house value, there would have been a 28% lower default rate in Los Angeles County during the 2008 housing crisis.

Equity extraction, as stated in Bhutta and Keys (2016), is an understudied topic due to the lack of data. Loan-level data, the most popular data used in mortgage research, is not enough. To investigate the decision to extract, researchers must compile the borrowing history of the homeowners. To do this, researchers have utilized different data sources—for example, consumer credit record data (Mian and Sufi, 2011; Bhutta and Keys, 2016). Taking a different approach, we employ the information in the title reports that record all loans that were borrowed against the property. With this data, we add to this literature strand by investigating the factors that determine the magnitude and timing of equity extraction. Similar to Kumar (2018) and Laufer (2013), our paper implies that limiting the size of cash-out refinances reduces the probability of default. In addition, we discuss other measures that can make the mortgage market safer.

Our paper also relates to the literature investigating the relationship of negative equity and mortgage default. A number of papers model a mortgage loan as an American put option where homeowners walk away, i.e. default, if the value of the mortgage exceeds the home value (Kau et al., 1992; Deng et al., 2000)[8]. Empirical work on mortgage default, however, has tended to find that borrowers do not default immediately when they are underwater (Foster and Van Order, 1984; Quigley and Van Order (1995); Foote et al., 2008; DeMarco, 2012). Accounting for this anomaly is a challenge for researchers attempting to model who defaults and who does not[9].

Other works have focused on the role of securitization, the mortgage credit expansion, the relaxation of lending standards, and the development of alternative mortgage loan contract designs to help explain the surge in recent defaults and foreclosures (Keys et al., 2010; Mian and Sufi, 2009; Pavlov and Wachter, 2004, 2006, 2011); LaCour-Little and Yang, 2010). In addition, Mian and Sufi (2010) argue that home equity borrowing precipitated the over-leveraging of U.S. households. Demyanyk and

Van Hemert (2009) argue that the rise and fall of the subprime mortgage market follows a classic lending boom-bust scenario, in which unsustainable growth leads to the collapse of the market, and empirically document a continuous decline in loan quality for six consecutive years before the current crisis.

Also relevant to our work here is Foote et al. (2012), who argue that many accounts of the foreclosure crisis, especially those that lay blame at the feet of the lending community, are at odds with one or more of twelve key facts about the mortgage market. Among these is the fact that mortgage insiders were, in general, the losers during the mortgage crisis. Who, then, were the winners? Foote et al. (2012) argue that mortgage outsiders, such as hedge fund investors who decided to bet against continued house price appreciation, were the largest winners. Based on our analysis here, we would add a very small fraction of defaulting homeowners to the list of winners, since they were able to extract large amounts of cash from their properties[10].

Our objective here is simply to carefully address the empirical question: how did borrowers facing foreclosure arrive at their equity position at the time of the foreclosure sale? As explained earlier, our results are important for lenders, homeowners, and policymakers to understand.

III. NEGATIVE EQUITY

We begin this discussion with the simple accounting identity:

$$E = MV - D \tag{1}$$

where E is equity, MV is market value, and D is total debt ($D=D_1+D_2+D_3\ldots+D_N$, where there are N liens against the collateral property). Over time, MV and D evolve, as house prices increase or decrease, and as the borrower takes on, or pays off, debt. Adding subscripts for time, we have:

$$E_t = MV_t - D_t \tag{2}$$

Clearly, $E_t < 0$ when $D_t > MV_t$. If borrowers had only one loan against their property and never refinanced, then with standard amortizing loan contracts D_t would be declining in t; however, with the ability to refinance and take cash out or add junior liens, there is no assurance that this pattern will hold. Expanding equation (2), we can represent borrower equity at any point in time as follows:

$$E_t = (MV_t - MV_0) - (D_t - D_0) + (MV_0 - D_0)$$
$$\Rightarrow \; E_t = (MV_t - MV_0) - (D_t - D_0) + E_0 \tag{3}$$

where $E_0 = MV_0 - D_0 = MV_0\,(1 - original\ LTV)$ is the equity at origination. Consequently, both the probability and magnitude of negative equity at any point in time is a function both of house price changes ($MV_t - MV_0$)—where the latter term represents the purchase price of the property, hence the difference represents capital gain or loss—and changes in total debt outstanding ($D_t - D_0$). We can represent the probability of negative equity then as:

$$\text{Prob}\ (E_t < 0) = f\ (MV_t - MV_0,\ D_t - D_0,\ \boldsymbol{X_M},\ \boldsymbol{X_P},\ \boldsymbol{X_D}) \tag{4}$$

Likewise, the magnitude of negative equity can be represented as:

$$\left| E_t \right| = f\ (MV_t - MV_0,\ D_t - D_0,\ \boldsymbol{X_M},\ \boldsymbol{X_P},\ \boldsymbol{X_D}) \tag{5}$$

In both (4) and (5), $\boldsymbol{X} = \boldsymbol{X_M}, \boldsymbol{X_P}, \boldsymbol{X_D}$ represents a vector of control variables that may affect E_0 or E_t. Conceptually, we can think of these as three types of observables: (1) market-related factors ($\boldsymbol{X_M}$) such as when the property was purchased, geographic location, and local housing cycle; (2) property-specific factors ($\boldsymbol{X_P}$) such as type, original price paid, size, maintenance, and year built; and (3) debt-usage-related factors ($\boldsymbol{X_D}$) such as original LTV, whether piggyback financing was used, whether the property has already been refinanced, and current usage of junior liens.

As shown in equation (5), negative equity depends both on the exogenous movement of house prices and borrowers' debt usage. Most popular accounts of the foreclosure crisis emphasize the former. In this paper we provide a direct test of which of these factors is more important.

In the empirical analyses that follow, we estimate the house value over its entire holding period. Concurrently, we examine actual borrowing behavior, including refinancing and junior lien borrowing. We estimate the relative magnitude of additional borrowing, the probability and the timing of any equity extraction, and see how these patterns relate to the trajectory of house prices.

IV. DATA

Our data come from three main sources. We retrieved information on foreclosing properties and their outstanding loans from website www.countyrecordsresearch.com. From CoreLogic data, we collected historical housing index and mortgage rates as well as income level and age for a fraction of the borrowers. Finally, the title reports from Ticor Title provide purchase prices and the full borrowing history from purchases to foreclosures. We describe each of the sources in detail below.

We initially obtained from www.countyrecordsresearch.com a complete list of notice of trustee sales filed during November of 2006, 2007 and 2008 in five Southern California counties[11]. Appendix A has an example of the data for one property. The information is extremely complete in some dimensions, including a listing of all recorded liens against the property, their dates, and the purchase date of the property. In addition, some basic information about the property itself is available, including address, parcel number, property use (raw land, commercial or residential use, condominium or detached single-family, number of units, square footage, lot size, and room counts), year built, and current assessed value. The data also contains the names of the borrower, lender, and trustee administering the foreclosure sale; the location and date of the sale; minimum bid; and so forth. What that data does not contain, on the other hand, is detailed information about the loan and borrower—the sort of data typically used in mortgage default research. So we do not know, for example, whether the loan was a subprime loan, the level of income documentation provided by the borrower, or whether the interest rate was fixed or variable.

We then matched the obtained data to supplementary mortgage data obtained from CoreLogic, which also provided a segmented ZIP-code-level house price index (HPI) from which we could estimate the value of the property at monthly intervals throughout the defaulting borrower's ownership period. Due to privacy issues, certain fields in the mortgage data were restricted, limiting our ability to merge Corelogic's borrowers' age and income levels to the sample. Thus we managed to collect age and income-level information for only one third of the borrowers.

Data from www.countyrecordsresearch.com include only the outstanding loans at the time of foreclosure. If a borrower took out a loan and then paid it back in full before the foreclosure, we would not see this loan on www.countyrecordsresearch.com. In order to get a full borrowing history, we obtained the title reports of the properties from Ticor Title's website. For each loan, the title report has information on the recording date (the loan initiation date) and the loan amount. Other available information includes the loan due date, lender name and type, loan type and type of financing; however, these data points are not always recorded.

Appendix B shows an example of loans being recorded (reverse chronological order) in a title report. This borrower purchased the property on 03/17/2006 for a price of $543,000. The borrower made a down payment of 30% and took out a first mortgage of $380,100. Her initial loan-to-value was 0.7. The borrower took out one additional loan on 01/23/2007 from the same lender for the amount of $100,000. On 03/20/2007 (not shown in the appendix), the borrower took out one more loan of $99,000 from Wells Fargo. The borrower then defaulted in the middle of 2008. Since data from www.countyrecordsresearch.com show that all three loans were outstanding at foreclosure, the borrower in this case did not pay off any loan during the ownership period. For other cases, if a loan is recorded in the title report but not present in the www.countyrecordsresearch.com as an outstanding loan at foreclosure, we assume the borrower has retired the loan.

Table 1 reports our sample selection process. In November of 2006, 2007 and 2008, there were 5,853 notices of trustee sales announced on www.countyrecordsresearch.com. There are three categories of properties with missing or erroneous data: those that have no trust deed reported (i.e. no outstanding loans), those that have trust deed date(s) earlier than the purchase date, and those have missing purchase dates. After we eliminated these properties, 4,867 remained. Because we could retrieve only 50 title reports per month, it would take a long time to obtain title reports for all properties. As a solution, we decided to choose a random sub-sample of 25% of properties from each cohort—2006, 2007 or 2008 foreclosing years. This random sub-sample had 1,216 properties.

Table 1
Sample Selection Process

Number of properties from www.countyrecordssearch.com	5853
Minus properties that have no trust deed (i.e. no outstanding loans)	413
Minus properties that have any trust deed earlier than the purchase date	499
Minus properties that have missing purchase date	74
Number of properties remain	4867
Randomly chosen sub-sample to download title reports from Ticor Title	1216

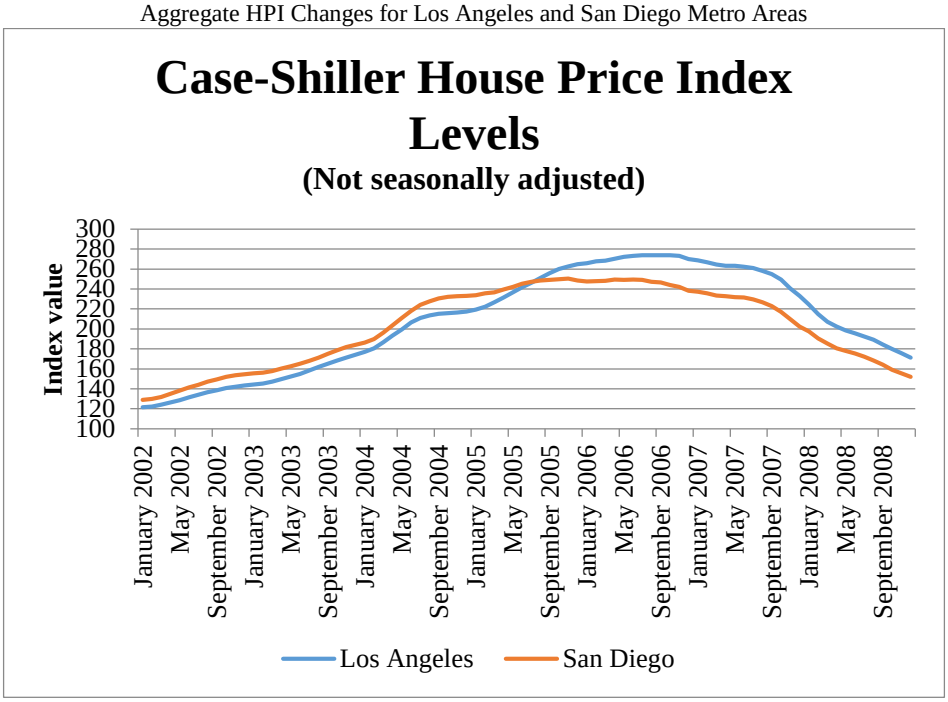
(25% from each cohorts)	
Minus properties that have no title report in Ticor Title's website	7
Minus properties that title reports don't cover purchase date (purchase date is too early)	47
Minus properties that have loan(s) reported in www.countyrecordssearch.com but not found in the title report	55
Minus properties that have original loan-to-value greater than 100%	19
Final sample	1088

Notes: Foreclosing properties are from five Southern California counties and are reported in www.countyrecordssearch.com during November of 2006, 2007 and 2008 (three cohorts based on foreclosing years). Title reports are obtained from Ticor Title for the sub-sample of 25% properties from each cohorts.

We then searched for title reports for these properties. We could not find the reports in Ticor Title's website for seven properties. For another 47 properties, we were able to obtain the reports, but the reports did not go back far enough to cover the purchase dates[12]. We further eliminated 55 properties for which www.countyrecordsresearch.com reported loans that were not in the title reports and 19 properties with original LTV higher than 1. Our final sample comprised 1,088 properties.

Next we expanded the data to a full cross-sectional time-series panel, with each property tracked over each month of borrowers' ownership. In this format, we had a total of 39,584 property-months of data. Appending the CoreLogic ZIP code HPI, we estimated the value of each property month by month. Figure 1 shows aggregate HPI movements for the Los Angeles and San Diego areas over this time period; our ZIP-level HPI measures show even greater variation. Title-report data allowed us to measure exactly when additional borrowing took place, via either refinancing or addition of junior liens. We also created a variable for each month to identify whether the house price had passed the peak level. This variable is useful in understanding whether the additional borrowing took place while house prices were still rising or when they were on the decline.

Figure 1
Aggregate HPI Changes for Los Angeles and San Diego Metro Areas



Notes: The graph shows that house prices peaked earlier in San Diego than they did in the Los Angeles Metro area (Los Angeles Metro area includes Orange and Los Angeles counties). The zip code level House Price Indices we employ show even greater variation.

V. EMPIRICAL ANALYSIS

A. Summary Statistics

Table 2 shows the distribution of the foreclosing properties by year of purchase, county and borrower income level. Large numbers of properties were purchased from 2004 to 2006. Riverside County has the highest number of properties in the sample, consistent with its standing among the counties that suffered the greatest foreclosure crisis in the nation (Woolsey, 2008). CoreLogic data provides annual income levels in 12 income ranges. We merge these ranges into three groups: low (up to $35,000), average ($35,000 – $125,000), and high income (above $125,000). As mentioned before, due to privacy reasons, out of 1088 properties we are able to match only 295 to borrowers' income level and age. Out of these 295 borrowers, 63.73% fall into the medium income category.

Table 2

Distribution of Properties by Year of Purchase, County and Borrower's Income Level

Panel A: Distribution by Year of Purchase

Year	Number of Purchases
1993	1
1994	2
1995	4
1996	2
1997	2
1998	3
1999	11
2000	10
2001	7
2002	20
2003	61
2004	186
2005	365
2006	368
2007	46
Average year of purchase	2004.8
Median year of purchase	2005

Notes: Sample contains 1088 properties. The sample includes 25% randomly chosen properties from all Southern California foreclosures during November of 2006, 2007 and 2008.

Panel B: Distribution by County

County	Percentage
Orange	5.24%
Riverside	35.85%
San Bernardino	15.9%
Los Angeles	24.17%
San Diego	18.84%
Total	100%

Notes: Sample contains 1088 properties.

Panel C: Distribution by Income Level

Income level	Percentage
Low	17.97%
Medium	63.73%
High	18.31%
Total	100%

Notes: Out of 1088 properties, only 295 can be matched to borrowers' income levels. Thus panel C shows distribution for only 295 properties. Low income means annual income of up to 35 thousand; average income is between 35 and 125 thousand; and high income is above 125 thousand.

Table 3 reports descriptive statistics for the whole sample as well as for subsamples by borrowers' income. The mean original loan-to-value, including any concurrent junior liens (original LTV), is 93%. Many borrowers in our sample were able to buy houses with very little or zero down payment. This is consistent with Table 2, where most of the purchase years are from 2004 to 2006. During this period, it was popular for borrowers to take out two mortgages—the first conforming mortgage, 80% of the price, and the second piggyback mortgage covering almost all of the rest. The average purchase price is $435,900 and the average holding period is 35.4 months.

Table 3
Summary Statistics

	Whole sample (N=1088)	Low income borrowers (N=53)	Medium income borrowers (N=188)	High income borrowers (N=54)
	Mean	Mean	Mean	Mean
Year of purchase	2004.83	2004.74	2004.62	2004.89
Original loan-to-value (includes any simultaneous 2nd mortgage)	0.93	0.96	0.93	0.93
Original purchase price (in thousands)	435.9	353.7	410.7	554.8
Original mortgage rate	6.2%	6.2%	6.1%	6.2%
Borrower's age		45.77	41.85	41.91
Ratio of maximum house value to purchase price	1.22	1.29	1.26	1.21
Length of holding period (in months)	35.4	33.1	36.1	32.5
Ratio of ending mortgage amount to original mortgage amount	1.20	1.23	1.21	1.23
Fraction of borrowers who extracted equity	0.41	0.36	0.46	0.46

Notes: Sample includes 1088 properties. Ending mortgage amount is sum of all loans outstanding at foreclosure (www.countyrecordssearch.com). Purchase price is from title reports (Ticor Title). Original mortgage amount is mortgage amount including any concurrent junior liens taken by the borrower(s) on the purchase date (Ticor Title). Maximum house value is estimated using purchase price and CoreLogic zip code House Price Index (HPI). Mortgage rate is national average mortgage rate for the purchase month.

We calculate the ratio of the ending mortgage amount (including all liens) to the original mortgage amount as our primary measure of additional borrowing. The mean value is 1.20, implying that borrowers increased their level of debt by 20%. However, note that only 41% of borrowers (446/1088) refinanced or took out home-equity loans. The mean ratio of the maximum house value during the ownership period to the purchase price is 1.22.

Looking at different income groups, it is evident that all groups bought their houses at about the same time, and the purchase prices increased with income. Ratios of maximum house value to purchase price decreased with income, consistent with the notion that the prices of lower-priced houses are more volatile. Their prices increase (fall) more during the run-up (crash). Low-income borrowers tend to be older and have higher

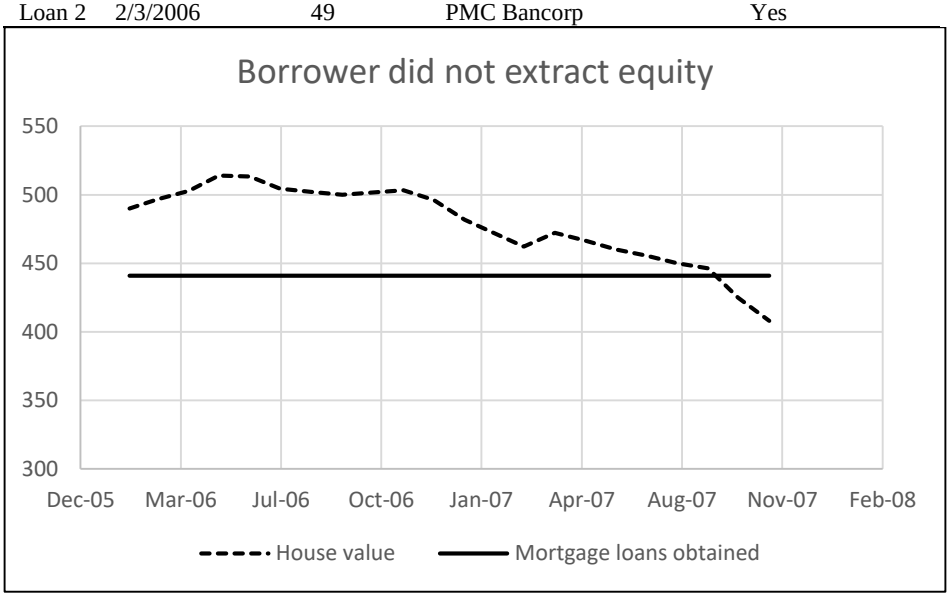
original LTV. Lower-income borrowers seem less likely to extract equity. Only 36% of them extracted compared to 46% of medium- and high-income borrowers. In the regression analysis, we will examine whether income levels affect likelihood of extraction after controlling for other relevant factors such as original LTV.

As an initial analysis, we divide the sample into two groups of borrowers. Group 1 (642 borrowers) includes those who did not extract equity (through either refinancing or home-equity loans). Group 2 (446 borrowers) includes those who extracted. Figure 2 graphs the total outstanding loan amount and house value over the ownership period of one borrower in Group 1. Since we cannot observe loan terms, the effect of amortization is not shown in the graph. House value estimates over time are based on the CoreLogic ZIP-level HPI applied to the purchase price[13].

Figure 2

Total Outstanding Loans and House Value for a Borrower Who did not Extract

	Date	Amount (thousand)	Lender	Outstanding loan at foreclosure?
Loan 1	2/3/2006	392	PMC Bancorp	Yes
Loan 2	2/3/2006	49	PMC Bancorp	Yes



Notes: The borrower did not extract home-equity during the holding period. The purchase date was 2/3/2006. Purchase price was 490 thousand.

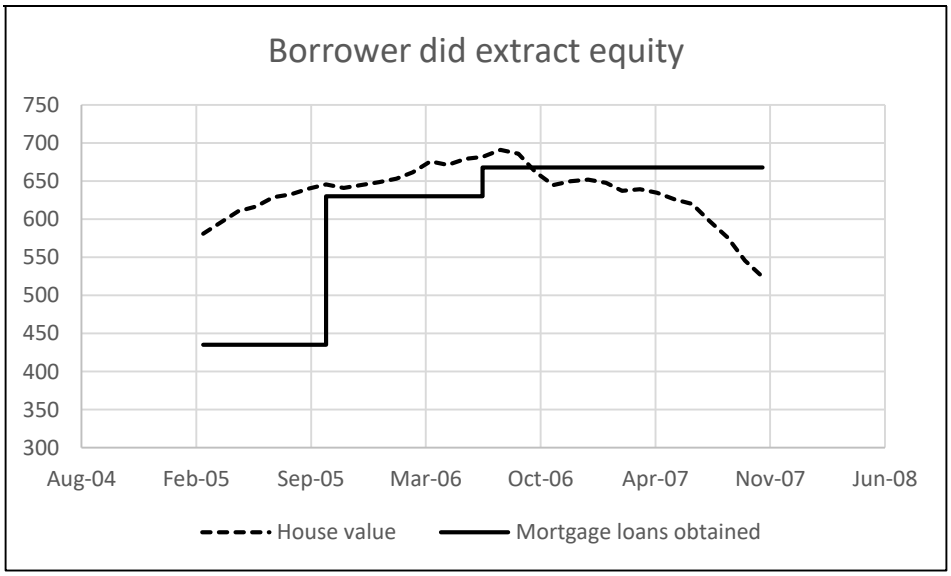
The borrower bought the house for $490,000 and took out two mortgages: a conforming mortgage covering 80% of the purchase price and a piggyback mortgage covering 10%. Thus, the original LTV was 90%. The house value initially increased slightly, but then decreased. At the foreclosure, the house value was 83% of the purchase price. The borrowers in Group 1 didn't extract equity but had their houses foreclosed. These homeowners were unlucky in the timing of their purchase. For these homeowners, the usual narrative of events outside of their control seems correct.

Figure 3 tells the story of one borrower in Group 2. The borrower bought the house in March 2005 for $581,000. At the purchase, the borrower took out only one mortgage (Loan 1) to cover 75% of purchase price. Seven months later, the borrower took out Loan 2 and Loan 3. Finally, in July 2006, the borrower took out Loan 4. The property was foreclosed in November 2007. At the foreclosure, Loans 2 and 4 were outstanding. This means the borrower repaid Loans 1 and 3.

Figure 3

Total Outstanding Loans and House Value for a Borrower Who Extracted

	Date	Amount (thousand)	Lender	Outstanding loan at foreclosure?
Loan 1	3/17/2005	435.4	Countrywide Home Loans Inc	No
Loan 2	10/21/2005	525	Wells Fargo Bank NA	Yes
Loan 3	10/21/2005	105	Wells Fargo Bank NA	No
Loan 4	7/3/2006	143	Wells Fargo Bank NA	Yes



Notes: The borrower extracted home-equity during the holding period. The purchase date was 3/17/2005. The purchase price was 581 thousand.

To graph the total outstanding loan amount over the ownership period, we assume Loans 1 and 3 were repaid at the same time the subsequent loan(s) were taken out. It is clear that Loans 2 and 3 were a refinancing transaction. The borrower borrowed $630,000 (Loan 2 plus Loan 3), repaid Loan 1, and was able to keep $194,600 in cash ($630,000 minus $435,400). Similarly, Loan 4 was taken out to retire Loan 3 and yielded the borrower another $38,000.

There are two interesting observations in Figure 3. First, the second (Loans 2 and 3) and the third time this borrower borrowed, she was able almost to max out the loan (i.e. the resulting total loan almost equals house value at the time). Second, at the foreclosure, the value of this property was about 90% of the original value—that is, higher than the original loan-to-value ratio of 75%. If no equity extraction was done, this borrower would have a capital loss but would not have been underwater. In all, 85 borrowers had similar situations. There were 174 borrowers who actually enjoyed capital gains; they would have had additional home equity if they had not extracted.

Table 4 compares the initial and ending leverage positions as well as how the borrowers arrived at their particular situation between the two groups. Borrowers in Group 1 are less lucky in the timing of their purchases. On average, they bought during 2005, closer to the price peak, compared to 2003 for Group 2. As the result, the maximum value of their properties during the ownership period was only 7% higher than the value at purchase. The number for Group 2 was 44%. The ratios of house value at foreclosure to value at purchase were 0.79 and 1.05 for the two groups[14]. The one "good" thing for Group 1 was they were able to borrow almost 100% of the purchase price. The original LTVs were 0.98 and 0.86 for the two groups. In the un-tabulated results, 88.3% of Group 1's initial mortgages include second piggyback mortgages. This number was 26.2% for Group 2.

Table 4
Comparison between Borrowers Who Did Not Extract and Who Extracted

	Borrowers who did not extract (N = 642)	Borrowers who extracted (N = 446)	Borrowers who extracted and had ending mortgage amount greater than purchase price (N = 389)
	Mean	Mean	Mean
Start of ownership:			
Year of purchase	2005.55	2003.81	2003.71
Original loan-to-value (includes any simultaneous 2nd mortgage)	0.98	0.86	0.87
End of ownership:			
Ratio of ending mortgage amount to original mortgage amount	1	1.50	1.55
Ratio of ending mortgage amount to purchase price	0.98	1.27	1.32
Ratio of ending mortgage amount to house value at foreclosure (i.e. ending loan-to-value)	1.31	1.31	1.34
During ownership:			
Holding period	26.45	48.24	49.23
Ratio of maximum house value to purchase price	1.07	1.44	1.46
Ratio of house value at foreclosure to purchase price	0.79	1.05	1.07
Number of extractions	0	1.99	2.09

Notes: The table compares borrowers who did not extract home-equity with borrowers who extracted. House value at any month during the ownership period is calculated based on the purchase price and zip code HPI. Number of extractions include number of refinancing and home-equity loans. When refinancing, a borrower could take out one, two or more mortgages. Regardless of the number of mortgages, we count refinancing as one extraction.

We then count the number of extractions for borrowers in Group 2. For example, the borrower in Figure 3 extracted twice. The first extraction (Loans 2 and 3) was a refinancing transaction and the second extraction (Loan 4) was a home-equity loan. On average, the borrowers extracted 1.99 times. In the un-tabulated results, the average number of refinancing and home-loan equity transactions was 1.03 and 0.96, respectively.

One other noteworthy variable is the ratio of the ending mortgage amount to the purchase price. This ratio is higher than 1 when the borrowers were able to extract more than their initial down payments. There are 389 such borrowers, i.e. 35.75% of the sample. These borrowers have positive net cash flow from the ownership of the property. Thus, they might have benefited from foreclosure. The last column shows they were able to increase their mortgage amount by 55% and have a ratio of ending mortgage amount to purchase price of 1.32. If these borrowers were planning to purchase houses, borrow as much as possible and then foreclose, they would end up with cash equal to 32% of the purchase price.

We, however, believe that only a very small fraction of the above borrowers actually benefited from foreclosure. First, if the extracted money was used to improve the properties, the borrowers might not end up with positive net cash flow. Second, small positive cash flow would not compensate enough for many of the other financial and emotional consequences of foreclosure.

Table 4 demonstrates two scenarios that lead to negative equity and foreclosure. The first scenario (Group 1) includes unfortunate timing of the purchase and low initial down payments. The second scenario (Group 2) starts with (ex-post) better timing of the purchase and higher initial down payments. Since the house values at foreclosure were about 5% higher than the purchase prices (please see row 8), the borrowers in Group 2 would not be underwater if they had not extracted equity. Instead, these borrowers increased the total amount of loans as house values were on the rise. As a consequence, when house values declined, their equity position turned negative.

B. Regression Analyses

We begin by analyzing the change in debt level, as measured by the ratio of final mortgage debt to original debt amount. This measure is intended to capture equity-diluting behavior by borrowers. If debt increases faster than property value, LTV will increase and thus elevate default risk over time. We want to answer the empirical question: what factors are related to equity dilution? Specifically, we estimate the following regression:

$$End\_mtg\_to\_orig_i = \alpha + \beta_1 \times Max\_val\_to\_pur\_prc_i + \beta_2 \times Orig\_LTV_i + \beta_3 \times Pur\_prc_i + \beta_4 \times Hld\_prd_i + \beta_5 \times Orig\_mtg\_rt_i + \boldsymbol{\gamma} \times \boldsymbol{D_i} \quad (6)$$

where $End\_mtg\_to\_orig_i$ is the ratio of ending mortgage amount to the original mortgage amount for borrower *i-th*; *Max_val_to_pur_prc* is the ratio of maximum house value to purchase price; *Orig_LTV* is original LTV; *Pur_prc* is purchase price; *Hld_prd* is length of holding period in months; *Orig_mtg_rt* is original mortgage rate; and ***D*** is a vector of county dummies.

Table 5 specification 1 shows, as expected, that the ratio of maximum house value to purchase price, measuring the amount of price appreciation against which borrowing might occur, has a large and highly significant positive effect on additional borrowing. In contrast, original LTV has a large and highly significant negative sign, indicating the constraining effect of high LTV. House price negatively relates to additional borrowing, but its economic effect is very small. Somewhat surprisingly, holding period is not statistically significant. We would have expected greater borrowing to occur as the time available during which to borrow grew longer.

Table 5

Regression of Ratio of Ending Mortgage Amount to the Original Mortgage Amount

	(1)	(2)
Ratio maximum house value to purchase price	0.4966***	0.8486***
	(0.001)	(0.000)
Original LTV (includes any simultaneous 2nd mtg)	-1.8133***	-1.8300***
	(0.000)	(0.000)
Original purchase price (in thousands)	-0.0002***	-0.0001
	(0.002)	(0.425)
Length of holding period in months	0.0016	-0.0071**
	(0.582)	(0.016)
Original mortgage rate on first mortgage	3.8495	-1.4683
	(0.424)	(0.759)
Borrower's age		-0.0021
		(0.244)
Indicator for low income borrower		-0.0193
		(0.690)
Indicator for average income borrower		-0.0568
		(0.115)
Indicator for Orange county	-0.0071	-0.2101*
	(0.897)	(0.052)
Indicator for Riverside county	-0.0002	-0.0595
	(0.994)	(0.163)
Indicator for SB county	-0.0311	-0.0589
	(0.387)	(0.254)
Indicator for LA county	0.0090	-0.0765*
	(0.770)	(0.095)
Constant	2.0850***	2.4203***
	(0.000)	(0.000)
Number of observations	1088	295
Adjusted R-square	61.69%	71.71%

Notes: The dependent variable is the ratio of ending mortgage amount to the original mortgage amount. The excluded county is San Diego (SD) and the excluded income indicator is high income. Borrower's age and income level are from CoreLogic data. Low income means annual income of up to 35 thousand; average income is between 35 and 125 thousand; and high income is above 125 thousand. Standard errors are heteroscedasticity-

robust. p-Values are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

In specification 2, we add borrower's age and income-level variables. The income-level indicators do not have statistically significant effects on additional borrowing. The reason might be that we lost about 70% of the sample due to missing income information. However, the coefficients indicate that higher-income households borrow more, a result consistent with the regressive nature of the mortgage tax deduction[15,16]. This finding is also somewhat contrary to the earlier common view that it is lower-income households who experienced the worst of the mortgage crisis effects[17]. However, the finding is consistent with newer research on the mortgage crisis. For example, Adelino et al. (2016) show that mortgage originations increased for borrowers across all income levels, while Ferreira and Gyourko (2015) postulate the foreclosure crisis as more of a prime, rather than a subprime, borrower issue.

Next, we turn to our panel data and estimate the following Cox proportional hazard model:

$$Log\_h_i(t) = \alpha(t) + \beta_1 \times Orig\_LTV_i + \beta_2 \times Pur\_prc_i + \beta_3 \times Mtg\_rt_t + \beta_4 \times Curr\_val\_to\_pur\_prc_{i,t} + \beta_5 \times Val\_peaked_{i,t} + \boldsymbol{\gamma} \times \boldsymbol{D_i} \quad (7)$$

where $Log\_h_i(t)$ is the log of the hazard rate (likelihood of equity extraction) for borrower *i-th* at month *t*; $\alpha(t)$ is the log of the baseline hazard function (Allison, 2010); time-invariant *Orig_LTV* and *Pur_prc* are original LTV and purchase price; time-dependent *Mtg_rt*, *Curr_val_to_pur_prc*, and *Val_peaked* are current mortgage rate, ratio of current house value to purchase price, and a dummy equals 1 if house value has peaked, respectively; and ***D*** is a vector of county dummies.

Table 6, specifications 1 and 2 present the results for the whole sample. The economic question is what factors affect the timing of the first equity extraction. We report hazard ratios (in square brackets) in addition to the coefficients and the p-values[18]. Lower original LTV is associated with higher hazard rate. For example, if the original LTV decreases by 1%, there would be a 3.6% increase in the hazard rate (hazard ratio = 0.964). When borrowers with lower LTV quickly increase leverage, there might not be any relation between initial leverage and the actual leverage one or two years into the ownership, i.e. the risk of having negative equity. This result supports the finding in Ferreira and Gyourko (2015) that initial leverage only accounts for a small variation in foreclosure outcomes. The ratio of current house value to original, on the other hand, is associated positively with the hazard rate, confirming the effect of price appreciation. If house value increases by 1%, there would be a 4.3% increase in the hazard rate (hazard ratio = 1.043).

Table 6
Cox's Proportional Hazard Regression

	(1)	(2)	(3)	(4)
Original LTV (includes any simultaneous 2nd mtg)	-3.6909***	-3.6725***	-4.7485***	-4.7317***
	(0.000)	(0.000)	(0.000)	(0.000)
	[0.964][a]	[0.964][a]	[0.954] [a]	[0.954][a]
Original purchase price (in thousands)	0.0004	0.0003	-0.0009	-0.0010
	(0.155)	(0.219)	(0.249)	(0.201)
	[1.000]	[1.000]	[0.999]	[0.999]
Mortgage rate for that month	12.3029		13.1668	
	(0.259)		(0.516)	
	[1.131][a]		[1.141][a]	
Change in mortgage rate		33.0418		-19.6663
		(0.241)		(0.721)
		[1.392][a]		[0.821][a]
Ratio of current house value to original house value	4.2157***	4.0786***	3.8063***	3.6174***
	(0.000)	(0.000)	(0.000)	(0.000)
	[1.043][a]	[1.042][a]	[1.039][a]	[1.037][a]
House value has peaked.	0.0023	0.0040	0.0741	0.0447
	(0.987)	(0.978)	(0.782)	(0.867)
	[1.002]	[1.004]	[1.077]	[1.046]
Borrower's age			-0.0298***	-0.0300***
			(0.005)	(0.005)
			[0.971]	[0.971]
Indicator for low income borrower			-0.9645*	-0.7011*
			(0.059)	(0.056)
			[0.499]	[0.496]
Indicator for average income borrower			-0.3345	-0.3458
			(0.2181)	(0.200)
			[0.716]	[0.708]
Indicator for Orange county	0.0185	0.0330	0.0976	0.0970
	(0.926)	(0.868)	(0.828)	(0.829)
	[1.019]	[1.034]	[1.102]	[1.102]
Indicator for Riverside county	0.0244	0.0313	0.1827	0.1756
	(0.856)	(0.817)	(0.531)	(0.547)
	[1.025]	[1.032]	[1.200]	[1.192]
Indicator for SB county	-0.0384	-0.0329	0.2876	0.2859
	(0.819)	(0.844)	(0.380)	(0.383)
	[0.962]	[0.968]	[1.333]	[1.331]
Indicator for LA county part A	-0.3066**	-0.2885*	-0.4360	-0.4157
	(0.041)	(0.053)	(0.204)	(0.224)
	[0.736]	[0.749]	[0.647]	[0.660]
# observations used	23137	23137	6142	6142
# of events	446	446	130	130

Notes: Cox's proportional hazards regression models time to the first equity extraction (either cash-out refinancing or home-equity loan). p-Values are reported in parentheses and hazard ratios are in square brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

[a]: Hazard ratios are calculated as exponent of the coefficients ($e^{coefficient}$) and present changes in hazard function when the covariates change by one unit. For four covariates - original LTV, mortgage rate, change in mortgage

rate, and ratio of current house value to original house value – change by one unit is unrealistic large or rare. For these covariates we calculate hazard ratios as exponent of one hundredth of coefficients ($e^{0.01 \text{ x coefficient}}$).

We do not find that mortgage rate (specification 1) or change in mortgage rate (specification 2) affect the propensity to extract[19]. This finding differs from that of Pennington-Cross and Chomsisengphet (2007), which document that a decrease in mortgage rate is associated with an increase in equity extraction. The difference might result from the fact that Pennington-Cross and Chomsisengphet (2007) use a sample consisting entirely of subprime borrowers while our sample includes borrowers with different income levels.

To test whether borrower's age and income level affect the propensity to extract, we include these variables in specifications 3 and 4. Borrower's age seem to reduce the probability of extraction. For each year increase in age, there would be a 2.9% decrease in the hazard rate (hazard ratio = 0.971). This finding is consistent with the notion that younger households tend to be more financially constrained and thus are more likely to extract (Lehnert, 2004). The indicators for low and medium income have negative coefficients, suggesting higher-income borrowers are more likely to extract after controlling for their low initial LTV.

In general, results from the Cox model are consistent with the results presented in Table 5: households with more equity (either low original LTV or house value appreciation) are more likely to borrow and borrow sooner. This pattern of debt usage put borrowers in a particularly risky position when house values began to decline in 2006. In addition, Table 6 shows that borrower characteristics such as age and income level are determinants of extraction propensity.

VI. CONCLUSION

We have shown that in Southern California, 41% of the borrowers facing foreclosure during 2006 – 2008 had extracted substantial amounts of equity through post-origination borrowing, rather than simply having their equity erode (or turn negative) as result of exogenous house price movements. While house-price appreciation has the potential to increase the equity position for borrowers, many households "cashed out", substantially increasing their overall leverage. This was facilitated, of course, by the relatively lax underwriting standards in place during much of our study period.

Some simple calculations applied to statewide figures produce remarkable results. Over the five-year period 2007 – 2011, California experienced approximately 835,000 completed foreclosures (Collins, 2012)[20]. If our data is representative of statewide averages, then 35.75% of the borrowers extracted equity and had ending mortgage amounts greater than purchase price (i.e. extracted more than initial down payment). Those borrowers invested about $17 billion in down-payment equity to acquire houses with a total value of about $130 billion. They then extracted about $62 billion in equity prior to default and foreclosure[21]. At the foreclosure sale, the properties would be worth roughly $139 billion with outstanding mortgage debt of $175 billion, implying an estimate of lender losses on the order of $36 billion. At the same time, these borrowers had no net loss at all. Their total equity investment was only about $17 billion and they extracted $62 billion.

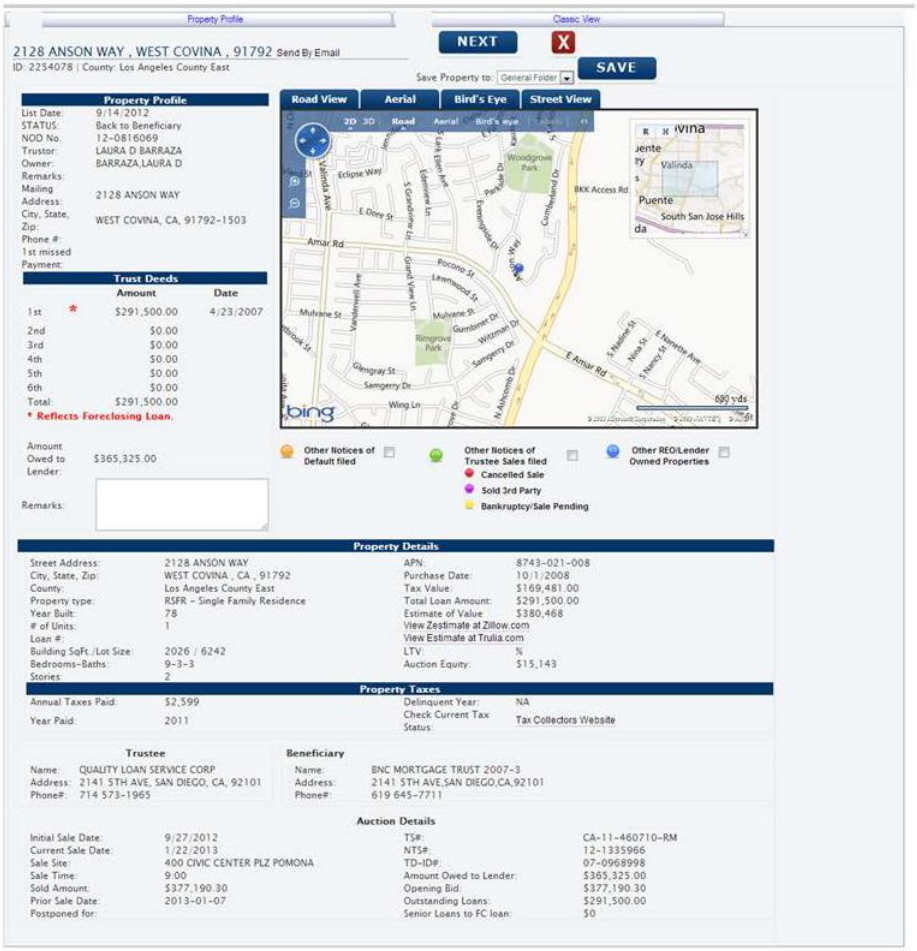
Multiple caveats are important to acknowledge. First, our estimates of the market value of the property (and, therefore, of the borrower's equity position) are entirely dependent on the ZIP-level HPI. Second, since we cannot observe loan terms, we cannot calculate amortization of principal, so our estimates of negative equity tend to be somewhat upwardly biased. Third, since we cannot observe the use of cash-out proceeds, we cannot determine to what extent these funds were reinvested in the property. Moreover, there are reasons to think that our data may not be representative of the entirety of the California market. In particular, Southern California house prices tend to be higher than those in many other areas of the state, particularly the inland Central Valley areas, where foreclosure rates have also been elevated. Finally, our data is of one market only, Southern California, so whether these patterns apply in other geographic areas we cannot say. Nevertheless, we believe it is clear from the analyses presented that the usual picture of the hapless borrower suffering financial losses as a result of foreclosure may be, at best, incomplete.

Further research is necessary to more completely address the questions we have begun to explore. Do these same patterns hold in other parts of California? Do similar patterns exist in other high-foreclosure areas, such as Nevada, Florida, Arizona, Michigan, and Ohio? Would findings change if complete information on loan terms were available? How would findings change if lenders' appraisals, rather than HPI-based values, were employed? Notwithstanding these considerations, we think our results provide a cautionary tale to mortgage market participants who believe that large initial down payments alone will be sufficient to reduce default risk. In the presence of house price appreciation coupled with liberal underwriting guidelines, borrowers can quickly dilute their initial equity position, affecting their overall risk posture substantially. Is a 75% LTV really lower-risk than an 85% LTV, if the former can readily add a 20% second boosting cumulative LTV to 95% without the consent (and possibly the knowledge) of the senior lien holder?

Limitations on subsequent borrower indebtedness, such as those routinely imposed in the commercial mortgage market, would seem an obvious tool to address this issue. However, the Alternative Mortgage Parity Act of 1982 places severe limits on the ability of a creditor to impose due-on-sale penalties (including acceleration of the note) if the transfer is not a complete sale that includes the right of occupancy. Among all of the pending regulatory issues regarding qualified residential mortgages and related topics, it may be time to reconsider restrictions on such reasonable contract provisions[22].

An alternative approach would entail contracts allowing senior lien holders to re-price the debt if borrowers engage in equity-diluting junior lien borrowing. Secondary market investors—Freddie, Fannie, or private market players—acquire loans secured by senior liens but cannot modify their credit insurance guaranty pricing despite the ability of borrowers to modify the risk profile of the loans. This is an unusual situation in insurance markets; normally, parties cannot alter their risk posture without exposing themselves to higher premiums.

Appendix A
Example of a 'Notice of Trustee Sales'



Property Profile | Classic View

2128 ANSON WAY , WEST COVINA , 91792 Send By Email
ID: 2254078 | County: Los Angeles County East

NEXT X SAVE
Save Property to: General Folder

Property Profile

List Date:	9/14/2012
STATUS:	Back to Beneficiary
NOD No.	12-0816069
Trustor:	LAURA D BARRAZA
Owner:	BARRAZA,LAURA D
Remarks:	
Mailing Address:	2128 ANSON WAY
City, State, Zip:	WEST COVINA, CA, 91792-1503
Phone #:	
1st missed Payment:	

Trust Deeds

	Amount	Date
1st *	$291,500.00	4/23/2007
2nd	$0.00	
3rd	$0.00	
4th	$0.00	
5th	$0.00	
6th	$0.00	
Total:	$291,500.00	

* Reflects Foreclosing Loan.

Amount Owed to Lender: $365,325.00

Remarks:

Road View | Aerial | Bird's Eye | Street View

Other Notices of Default filed
Other Notices of Trustee Sales filed
Cancelled Sale
Sold 3rd Party
Bankruptcy/Sale Pending
Other REO/Lender Owned Properties

Property Details

Street Address:	2128 ANSON WAY	APN:	8743-021-008
City, State, Zip:	WEST COVINA , CA , 91792	Purchase Date:	10/1/2008
County:	Los Angeles County East	Tax Value:	$169,481.00
Property type:	RSFR - Single Family Residence	Total Loan Amount:	$291,500.00
Year Built:	78	Estimate of Value	$380,468
# of Units:	1	View Zestimate at Zillow.com	
Loan #:		View Estimate at Trulia.com	
Building SqFt./Lot Size:	2026 / 6242	LTV:	%
Bedrooms-Baths:	9-3-3	Auction Equity:	$15,143
Stories:	2		

Property Taxes

Annual Taxes Paid:	$2,599	Delinquent Year:	NA
Year Paid:	2011	Check Current Tax Status:	Tax Collectors Website

Trustee		Beneficiary	
Name:	QUALITY LOAN SERVICE CORP	Name:	BNC MORTGAGE TRUST 2007-3
Address:	2141 5TH AVE, SAN DIEGO, CA, 92101	Address:	2141 5TH AVE,SAN DIEGO,CA,92101
Phone#:	714 573-1965	Phone#:	619 645-7711

Auction Details

Initial Sale Date:	9/27/2012	TS#:	CA-11-460710-RM
Current Sale Date:	1/22/2013	NTS#:	12-1335966
Sale Site:	400 CIVIC CENTER PLZ POMONA	TD-ID#:	07-0968998
Sale Time:	9:00	Amount Owed to Lender:	$365,325.00
Sold Amount:	$377,190.30	Opening Bid:	$377,190.30
Prior Sale Date:	2013-01-07	Outstanding Loans:	$291,500.00
Postponed for:		Senior Loans to FC loan:	$0

Notes: Notice of trustee sales are from www.countyrecordsresearch.com.

Appendix B

Example of Loans Recorded in Title Report

Property History **Ticor Title**

Mortgage Record - 01/23/2007

Recording Date:	01/23/2007	**Document#:**	07-0132887
Loan Amount:	$100,000.00	**Loan Type:**	Unknown
TD Due Date:		**Type of Financing:**	VAR
Lender Name:	WASHINGTON MUTUAL BANK		
Lender Type:	Bank	**Borrowers Name:**	[illegible]
Vesting:	N/A		
Legal Description:	**Lot Number:** 1 **Subdivision:** MAYFAIR **Tract Number:** 46389-14 **Unit:** 127 **City / Muni / Twp:** UNINCORPORATED		

Prior Transfer - 03/17/2006

Recording Date:	03/17/2006	**Document#:**	06-0573487
Price:	$543,000.00	**Document Type:**	Grant Deed
First TD:	$380,100.00	**Type of Sale:**	Full-Computed from Transfer Tax
First TD Doc:	06-0573488		
Lender Name:	WASHINGTON MUTUAL BANK FA		
Buyer Name:	[illegible]	**Buyer Vesting:**	N/A
Seller Name:			
Legal Description:	**Lot Number:** 1 **Subdivision:** MAYFAIR **Tract Number:** 46389-14 **Unit:** 127 **Map Ref:** MB1224 PG68-73 **City / Muni / Twp:** UNINCORPORATED		

Notes: Title reports are from Ticor Title. Records are in reverse chronological order.

ENDNOTES

1. Ferreira and Gyourko (2015) shows negative equity accounts for more than 75% of foreclosure propensity of owners-borrowers relative to all-cash owners.
2. As of Q1-2018, after a long period of house price increases since the housing crisis of 2008, there are still about 2.5 million homes or 4.7% of all mortgaged properties with negative equity. Negative equity peaked at 26% in Q4-2009 (CoreLogic, 2018).
3. In early 2007, a surge in default rates of subprime loans triggered the collapse of several large lenders with significant exposure to subprime credit and other non-traditional lending products. In the summer, two highly leveraged Bear Stearns funds with large CDO positions backed by securitized subprime collateral declared bankruptcy. These events led to a dramatic widening of credit spreads, producing a precipitous drop in the value of private-label securities with any mortgage credit risk exposure, and collapse in the overnight market for asset-backed commercial paper (Gorton, 2010).

4. Fannie Mae and Freddie Mac were both placed into conservatorship, and Washington Mutual and Lehman Brothers failed in September 2008, for example.
5. The mortgage market today is safer. However, home equity extraction is on the rise again. Attom Data, a real-estate data provider, reports the number of home equity lines of credit jumped 14% in 2018 Q1 compared to a year earlier while the dollar volume of HELOCs was up 13% (Riquier, 2018). According to a study by research firm GfK conducted in September 2018, 24 million homeowners believe borrowing against home equity is an acceptable way to cover regular bills (Griffin, 2018).
6. Pennington-Cross and Chomsisengphet (2007) classify factors that determine choice to extract equity while refinancing into three groups: borrower characteristics, housing and mortgage characteristics, and relative cost of financing.
7. Hurst and Stafford (2004), however, found LTV has no effect on probability of equity extraction.
8. From a legal perspective, post-default forfeiture of property is not explicitly granted to borrowers by lenders in the contract; it is a remedy for breach of the contract by borrowers and exercised by lenders. Moreover, mortgage debt is not truly non-recourse in many jurisdictions. In California (where our data is drawn), only the original home purchase loan is non-recourse as a matter of law; defaults on refinancing and junior lien debt may trigger deficiency judgments. After a foreclosure sale occurs, such unsecured claims are often sold to debt collectors for a few cents on the dollar.
9. McCollum and Pace (2017) shows that, given negative equity, homeowners with income stability (for example government employees) have lower rate of default.
10. 35.75% of all borrowers cash out equity in amounts greater than their initial down payments. However, we believe that only very small fraction of them actually benefit from foreclosure. First, if the extracted money was used to improve the properties, the borrowers might not end up with positive net cash flow. Second, small positive cash flow would not compensate enough for many of the other financial and emotional consequences of foreclosure.
11. The five counties are Los Angeles, Orange, Riverside, San Bernardino, and San Diego. Together they had a 2007 population of a little over 20 million people.
12. Eliminating these properties, we might bias the sample toward properties with later purchase dates. Since there are only 47 properties (out of 1216), their elimination will not affect our results.
13. Laufer (2013) estimates house value using a similar approach.
14. We also were able to employ an automated valuation model (AVM), developed by a major financial institution that prefers anonymity, to value each property as of the date of the scheduled foreclosure sales. In our analysis, we used house values based on purchase price and change in segmented ZIP-code-level HPI. The correlation between AVM and HPI-based values is 0.98.
15. Coefficient on average-income borrower is negative, meaning average-income borrowers increased total loans less than high-income borrowers did. The p-value of the coefficient is 11.5%.
16. The mortgage interest deduction is only available to taxpayers who itemize deductions; accordingly, higher-income households, who tend to own more expensive houses with larger mortgages, benefit disproportionately from the mortgage interest deduction.

17. Lower-priced houses are more volatile, increasing more during the run-up and falling more during the crash, compared to higher-priced houses. Since lower-income households typically buy lower-priced houses, this segment of the population has greater exposure to house price declines.
18. Hazard ratios are calculated as exponents of coefficients ($e^{coefficient}$) and present changes in hazard function when the covariates change by one unit (for example purchase price of 200 vs. 201 thousand). For four covariates—original LTV, mortgage rate, change in mortgage rate, and ratio of current house value to original—change by one unit is unrealistically large or rare. For these covariates we calculate hazard ratios as exponent of 0.01 of coefficients ($e^{0.01 \text{ x coefficient}}$).
19. Instead of mortgage rate or change in mortgage rate, we also used ratio of car loan rate over mortgage rate. This ratio measures the relative attractiveness of car loans compared to cash-out refinancing. Similarly, the coefficient of the ratio is not significant.
20. A completed foreclosure occurs when the property is auctioned, whether purchased by a third party or going back to the foreclosing lender. In either case, a trustee's deed is recorded, allowing a reasonably accurate count of these occurrences. In contrast, only a fraction of notices of trustee sale recordings result in actual transfers of title to the property.
21. These borrowers had initial LTV of 87% and ratio of ending mortgage to original of 155%. Average purchase price was 435.9 thousand. $130 billion total house value, for example, is calculated as the product of 835,000, 35.75%, and 435.9.
22. Following Laufer (2013), we ask: how many borrowers in our sample would not have negative equity if there were a restriction to limit borrowing to 80% of the home value? In our sample, 446 borrowers extracted equity. 217 out of these 446 would not be able to purchase houses since they have initial LTV greater than 80%. Out of the remaining 229 who had initial LTV less than or equal to 80%, 69 would not be underwater if they were not allowed to borrow more than 80% of the maximum value of their houses. In other words, 30% of these borrowers (69 divided to 229) would not default. Our calculation here is simplistic: we assume the rule limiting the loan amount to have no effect on house price and on the house-purchasing decisions of the borrowers.

REFERENCES

Adelino, M., A. Schoar and F. Severino, 2016, "Loan Originations and Defaults in the Mortgage Crisis: The Role of the Middle Class," *Review of Financial Studies*, 29(7), 1635–70.

Allison, P., 2010, *Survival Analysis Using SAS: A Practical Guide, 2nd edition*, SAS Institute Inc.

Bhutta, N., and B. J. Keys, 2016, "Interest Rates and Equity Extraction during the Housing Boom," *American Economic Review*, 106(7), 1742-74.

Campbell, T., and J. K. Dietrich, 1983, "The Determinants of Default on Conventional Residential Mortgages," *Journal of Finance*, 38(5), 1569-81.

Collins, J., Calif. Foreclosures Fall to 5-year Low, *Orange County Register*, July 23, 2012. https://www.ocregister.com/2012/07/23/calif-foreclosures-fall-to-5-year-low/. Accessed January 25, 2019.

CoreLogic, Home Equity Gains Topped $1 Trillion in the First Quarter of 2018,

CoreLogic Reports, June 07, 2018. https://www.corelogic.com/news/corelogic-reports-home-equity-gains-topped-1-trillion-in-the-first-quarter-of-2018.aspx. Accessed August 16, 2018.

DeMarco, E., Letter to Congress Summarizing FHFA's Determination on Principal Forgiveness as Loss Mitigation Tool, *Federal Housing Finance Agency*, January 20, 2012. https://www.fhfa.gov/Media/PublicAffairs/Pages/Letter-to-Congress-Summarizing-FHFAs-Determination-on-Principal-Forgiveness-as-Loss-Mitigation-tool.aspx. Accessed January 25, 2019.

Demyanyk, Y., and O. V. Hemert, 2011, "Understanding the Subprime Mortgage Crisis," *Review of Financial Studies*, 24(6), 1848-80.

Deng, Y., J. Quigley, and R. Van Order, 2000, "Mortgage Terminations, Heterogeneity and the Exercise of Mortgage Options," *Econometrica*, 68(2), 275-307.

Ferreira, F., and J. Gyourko, 2015, "A new look at the US foreclosure crisis: Panel data evidence of prime and subprime borrowers from 1997 to 2012," National Bureau of Economic Research, working paper No. w21261.

Foote, C. L., K. S. Gerardi, and P. S. Willen, 2008, "Negative Equity and Foreclosure: Theory and Evidence," Federal Reserve Bank of Boston, Public Policy Discussion Paper No. 08-03.

Foote, C. L., K. S. Gerardi, and P. S. Willen, 2012, "Why Did So Many People Make So Many Ex Post Bad Decisions? The Causes of the Foreclosure Crisis," Federal Reserve Bank of Boston, Public Policy Discussion Paper No. 12-2.

Foster, C., and R. Van Order, 1984, "An Options-Based Model of Mortgage Default," *Housing Finance Review*, 3(4), 351-72.

Gorton, G., 2010, *Slapped by the Invisible Hand: The Panic of 2007*, Oxford University Press.

Griffin, R., Cash-Strapped Americans Are Willing to Leverage Their Homes to Pay the Bills, *Bloomberg*, September 19, 2018. https://www.bloomberg.com/news/articles/2018-09-19/cash-strapped-americans-are-leveraging-their-homes-to-pay-the-bills?utm_campaign=news&utm_medium=bd&utm_source=applenews. Accessed September 19, 2018.

Hurst, E., and F. Stafford, 2004, "Home Is Where the Equity Is: Mortgage Refinancing and Household Consumption," *Journal of Money, Credit and Banking*, 36(6), 985-1014.

Kau, J. B., D. Keenan, W. Mueller, and J. Epperson, 1992, "A Generalized Valuation Model for Fixed-Rate Residential Mortgages," *Journal of Money, Credit, and Banking*, 24(3), 279-99.

Keys, B., T. Mukherjee, A. Seru, and V. Vig, 2010, "Did Securitization Lead to Lax Screening? Evidence from Sub-Prime Loans," *Quarterly Journal of Economics*, 125(1), 307-62.

Kumar, A., 2018, "Do Restrictions on Home Equity Extraction Contribute to Lower Mortgage Defaults? Evidence from a Policy Discontinuity at the Texas Border," *American Economic Journal: Economic Policy*, 10(1), 268-97.

LaCour-Little, M., and J. Yang, 2010, "Alternative Mortgage Products and the Mortgage Crisis," *Real Estate Economics*, 38(4), 687-732.

Laufer, S., 2013, "Equity extraction and mortgage default," Finance and Economics Discussion Series, Divisions of Research & Statistics and Monetary Affairs, Federal Reserve Board, Washington, D.C.

Lehnert, A., 2004, "Housing, Consumption, and Credit Constraints," Finance and Economics Discussion Series, 63, Board of Governors of the Federal Reserve System U.S.

McCollum, M., and K. Pace, 2017, "Income Stability and Mortgage Default," working paper.

Mian, A., and A. Sufi, 2009, "The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis," *Quarterly Journal of Economics*, 124(4), 1449-96.

Mian, A., and A. Sufi, 2010, "Household Leverage and the Recession of 2007 to 2009," *IMF Economic Review*, 58(1), 74-117.

Mian A., and A. Sufi, 2011, "House Prices, Home Equity-Based Borrowing, and the U.S. Household Leverage Crisis," *American Economic Review*, 101(5), 2132–56.

Nothaft, F.E. and Y. Chang, Refinance and the Accumulation of Home Equity Wealth, Freddie Mac, 2004, Working Paper No. 04-02. https://pdfs.semanticscholar.org /78a5/4033649252178946237898440cebacc1c73f.pdf. Accessed Jan 25, 2019.

Pavlov, A., and S. Wachter, 2004, "Robbing the Bank: Short-term Players and Asset Prices," *Journal of Real Estate Finance and Economics*, 28(2-3), 147-60.

Pavlov, A., and S. Wachter, 2006, "The Inevitability of Market-Wide Underpricing of Mortgage Default Risk," *Real Estate Economics*, 34(4), 479-96.

Pavlov, A., and S. Wachter, 2011, "Subprime Lending and Real Estate Prices," *Real Estate Economics*, 39(1), 1-18.

Pennington-Cross, A., and S. Chomsisengphet, 2007, "Subprime Refinancing: Equity Extraction and Mortgage Termination," *Real Estate Economics*, 35(2), 233-63.

Quigley, J., and R. Van Order, 1995, "Explicit Tests of Contingent Claims Models of Mortgage Default," *Journal of Real Estate Finance and Economics*, 11(2), 99-117.

Riquier, A., Home Equity is Surging – and That Means Homeownership May Never Be the Same, MarketWatch, June 15, 2018. https://www.marketwatch.com/ story/americans-home-equity-is-surging-and-evolving-2018-06-14. Accessed August 16, 2018.

Von Furstenburg, G., 1969, "Default Risk on FHA-Insured Home Mortgages as a Function of the Terms of Financing: A Quantitative Analysis," *Journal of Finance*, 24(3), 459-477.

Woolsey, America's Hardest-Hit Foreclosure Spots, *Forbes*, January 27, 2008. https://www.forbes.com/2008/01/27/homes-underwater-foreclosure-forbeslife-cx_mw_0128realestate.html#29f5c8c52b5f. Accessed May 03, 2019.