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Interest Rates and Equity Extraction during the Housing Boom

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Interest Rates and Equity Extraction During the Housing Boom*

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Abstract

Monetary policy is perhaps the most important tool the government has to quickly affect the trajectory of the economy. This paper estimates the impact of policy-driven short-term mortgage rates on home equity based borrowing. Using credit record panel data from 1999–2010, we show that the likelihood of equity extraction peaked in 2003 when mortgage rates hit historic lows, and estimate that a 100 basis point rate decline leads to a 25 percent rise in extraction. Exploiting geographic variation in house price fluctuations, we find this rate effect is half the magnitude of the house price effect. Additionally, differential responses by age and credit score provide new evidence of financial frictions. Finally, equity extraction increases default risk, most strikingly for those extracting in 2006 when both interest rates and house prices were peaking. Conditional on many factors including credit score, zip code house price changes and county fixed effects, those who extracted in 2006 were 90 percent more likely to become delinquent on a mortgage than non-extractors over the next four years.

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I Introduction

To what extent can monetary policy influence the economy, and which sectors of the economy respond to such policy shocks? A large literature examines these questions, and for good reason: Monetary policy is perhaps the most important tool the government has to quickly affect the trajectory of the economy. Research in this area is ongoing in part because of significant institutional and technological changes to the financial system that may have altered the transmission of monetary policy to the real economy (Boivin et al. 2010). For example, during the recent housing boom, homeowners had unprecedented access to borrow against the equity in their homes.

This paper is the first to study the recent impact of policy-driven short-term mortgage rates on home equity based borrowing, or "equity extraction." Equity extraction is an understudied topic despite its potential importance to the macroeconomy and for understanding the sharp growth in household debt during the 2000s (Dynan and Kohn 2007).[1] Well over 60 percent of households own their home, and the home represents most households' largest asset and their primary source of collateral for borrowing, either for personal or business reasons. According to one study, over one-quarter of small business owners borrow against residential property to help finance their business (NFIB 2012). As we will show, extraction of home equity was a significant source of homeowner liquidity in the first half of the 2000s. By our measure, home equity extraction totaled over $1 trillion from 2002-2005, not including the use of funds to move into more expensive homes or buy second homes. Furthermore, our results support the 2004 testimony of former Federal Reserve chairman Alan Greenspan that, "The lowest home mortgage rates in decades were a major contributor to... a large extraction of cash from home equity," and contrast with the view that households are unresponsive to monetary policy (see, e.g. Christiano, Eichenbaum and Evans 1996).

To study equity extraction, we use a large, nationally representative borrower-level panel dataset based on consumer credit records maintained by Equifax, which provides details on the liability side of individuals' balance sheets at a high frequency. Figure 1 presents our estimate of the fraction of

[1] In contrast, there is an extensive literature on wealth-maximizing refinance decisions focusing on the spread between a homeowner's mortgage rate and the prevailing market rate (see, e.g. Agarwal et al. 2013, Bennett et al. 2000), as opposed to the focus in this paper on equity extraction decisions, which may or may not involve a refinancing.

homeowners who extract equity over time, defined as instances where borrowers increase their *total* mortgage debt (i.e. including junior liens) by at least five percent, alongside the path of the Federal Funds rate and the short-term mortgage rate. Consistent with the view that monetary policy can spur homeowners to borrow against their home, the likelihood of extracting equity peaked in 2003 as interest rates reached historic lows. While it is well known that there was a refinance boom in 2003, Figure 1 reveals a less well-known fact that there was also a boom in equity extraction.

Of course, other factors confound the interpretation that a drop in rates sparked extraction. The Federal Reserve eased in the early 2000s to help combat a weak economy characterized by rising unemployment that peaked in 2003. As Bernanke and Gertler (1995) note, credit demand has a countercyclical component as households try to smooth through cyclical fluctuations in income (see also Hurst and Stafford 2004). In addition, home prices rose significantly in the late 1990s and early 2000s, which is likely to have contributed to equity extraction as found in previous work (Mian and Sufi 2011, Disney and Gathergood 2011). In contrast, the sharp downturn in home prices since 2007 may help explain the lack of equity extraction in recent years despite another episode of policy easing and low mortgage rates.

In order to isolate the effect of interest rates, we exploit the substantial geographic variation in economic and housing conditions across local economies during the recent boom and bust. As Ferreira and Gyourko (2012) document, and as Figure 2 shows, there was a striking amount of variation in the timing and magnitude of house price changes over this period. Thus, although interest rates are set nationally, variation in the timing of business cycles across local markets implies that interest rates will differ for a given set of economic and housing conditions. To see this more clearly, Figure 3 shows that although Boston and Seattle reached the same peak in house prices, Boston's housing market did so two years before Seattle's. Consequently, residents of Boston and Seattle experienced different interest rate environments following similar amounts of post-1997 home price appreciation. Furthermore, when interest rates hit lows in 2003, in contrast to places like Boston, some cities like Cleveland had experienced very little home price growth. In sum, disaggregated data allow us to precisely separate the effect of interest rates from other economic factors that influence equity extraction.[2]

[2] A widely held view seems to be that the housing boom was a single national phenomenon driven largely by low interest rates, and thus one might question the idea of disentangling the effect of interest rates from house prices on

After controlling for zip code level house price growth, as well as county-level trends in wage growth and employment, we find that a 100 basis point (bps) drop in short-term mortgage rates leads, on average, to a three percentage point rise in the likelihood of extraction, or 25 percent relative to the average extraction rate over time of 12 percent. This estimate is only slightly larger if we instrument for the mortgage rate with the Fed Funds rate — which provides an exogenous source of variation in lenders' cost of funds conditional on unemployment and wage growth — to address simultaneity bias concerns.

The estimated total interest rate effect (that is, the effect on both the extensive and intensive margins) is a little over half as large as the estimated total effect of home price growth. As we explain in Section III, we do not instrument for house price growth using supply elasticities as in Saiz (2010), but instead rely on several controls for economic and credit conditions to address the issue that such factors can affect both home prices and borrowing or consumption (Attanasio et al. 2009).[3]

We also identify a significant interaction effect. Namely, house price growth amplifies the effect of interest rates, and vice versa.[4] That said, our estimates suggest that even when there has been little or no recent house price growth, a 100 bps drop in rates leads to a two percentage point rise in extraction.

Our baseline specification controls for time-varying credit conditions with a novel measure constructed from the credit record data, specifically the fraction of "marginal" credit applicants who obtained a new account. Previous measures of credit access have relied on nationwide survey responses from lenders (such as the Federal Reserve's Senior Loan Officer Opinion Survey, or SLOOS), or self-reported measures from the Survey of Consumer Finances on being denied credit or receiving less credit than requested. In contrast, our measure of credit availability, based on the share of marginal credit applicants in a region who obtain a new account in the next quarter,

equity extraction. However, the dramatic heterogeneity documented in Figure 2 casts doubt on this view, and the findings in Ferreira and Gyourko (2012) suggest instead that local income growth played a major role in triggering house price booms at various points in time. Although a theoretical link between interest rates and house prices through user cost is clear (see, e.g. Himmelberg, Mayer, and Sinai 2005), other factors must be at play in order to understand the dispersion in both timing and magnitude of local housing booms.

[3] Although we do not instrument for house prices, which in theory biases our estimate upward, we find an extraction response to home price growth of only about $0.07 per dollar rise in home value, compared to about $0.25 in Mian and Sufi (2011). Recent estimates of the response of consumption to home price growth vary, but in general are less than $0.10 per dollar (see, e.g., Bostic et al. 2009, Carroll et al. 2010, Case et al. 2011).

[4] See Aoki et al. (2004) for a model of how house prices and monetary policy interact.

captures credit supply with a direct empirical and high-frequency approach.

An additional benefit of using borrower-level data is that we can carefully address potentially confounding changes in borrower characteristics over time. In fact, our baseline result is robust to including individual measures of liquidity such as ex-ante credit card utilization rates (e.g. Elul et al. 2010), and other characteristics such as borrower age and credit score. Thus, potential changes in the composition of homeowners over time do not appear to be driving our findings. The baseline result is also qualitatively unchanged when we control for whether individuals have a home equity line of credit prior to the extraction decision, which helps capture changes over time in the ease of accessing home equity (Muellbauer 2007). Finally, the baseline result is robust to controlling for past extractions, so the drop-off in extraction in 2004, for example, does not simply stem from the high likelihood of extraction in 2003.

The credit record data allows us to explore heterogeneity in the extraction response to changes in interest rates and house prices. Similar to Mian and Sufi (2011), we find that younger homeowners' extraction decisions are more sensitive to house price growth than older homeowners. Although this finding is suggestive of credit constraints since standard models predict the housing wealth effect to be larger among older homeowners (see e.g. Campbell and Cocco 2007), the lack of data on the extent to which older homeowners consume out of liquid assets instead of borrowing complicates such an interpretation. However, we also find that *within* age group, homeowners with mid- to low- credit scores are more sensitive to house price gains *and* less sensitive to interest rates, which provides new and more compelling evidence for binding collateral constraints that might propagate cyclical fluctuations (e.g. Kiyotaki and Moore 1997, Iaocoviello 2005).

Finally, we explore the longer-term implications of equity extraction for homeowner leverage and risk. In order for equity extractions to have substantive real effects, it must be the case that extractors were not simply swapping more expensive uncollateralized debt for cheaper collateralized debt. Using an event-study framework, we find that extractors generally use only a small portion of home equity funds to repay more expensive debt. For the median extractor who increases his mortgage debt by about $25,000, his uncollateralized consumer debts can be expected to decline by about $2,800 during the year of extraction.[5] Overall, the analysis indicates that extracting home

[5]To be sure, consumer debt loads are relatively small compared to typical mortgage extraction amounts. While the median extraction amount is about $25,000, the median amount of uncollateralized debt (not including student

equity leaves homeowners substantially more indebted for at least several years thereafter.

The risk created by equity extraction depends on borrowers' change in leverage, which depends on how extractors use borrowed funds. For example, extractors could use the funds to invest in liquid assets, mitigating the rise in leverage, and diversifying their portfolio. However, we find that in any given year, and conditional on county fixed effects and an extensive array of borrower credit characteristics, those extracting equity are more likely to experience mortgage delinquency over the next four years than non-extractors. Differential delinquency rates are observed even in years well before the housing bust, but the most severe delinquency rate differential occurred among those extracting at the peak of the housing boom: All else equal, extractors in 2006 were about 90 percent more likely than non-extractors to become delinquent on mortgage debt over the next four years.[6] Extractors in 2006 were also almost 40 percent more likely to be delinquent on *non*–mortgage debt in the next four years than non-extractors. This suggests an important role for income shocks combining with negative equity to drive mortgage defaults (so-called "double-trigger" defaults), in contrast to "ruthless" defaults where homeowners simply walk away from their homes in response to negative equity and would therefore default only on mortgage debt (see, e.g., Bhutta et al. 2010, Foote et al. 2008).

The next section outlines a theoretical framework for the equity extraction decision. Section III describes our data sources and empirical approach. Section IV presents our findings, and Section V concludes with some broad policy implications related to the impact of equity extraction and leverage on the crisis.

II Conceptual Framework

In this section, we describe a framework for thinking about the household equity extraction decision. An optimizing homeowner who maximizes over multiple periods may want to increase his collateralized borrowing for four potential reasons. First, a decrease in the interest rate, all else equal, lowers the price of credit and makes borrowing more desirable. Second, an increase in the value of collateral (housing wealth) can both increase the value of consumption smoothing across

debt) among extractors is about $5,000.

[6]Our results are strongly consistent with contemporaneous work by Laufer (2013), whose structural analysis suggests that equity extraction was a crucial determinant of foreclosures in Los Angeles County.

periods because of a wealth effect, and also relax a credit constraint that makes desired borrowing feasible. Third, a widening in the difference between current and future income, which could reflect either a negative shock to current income or a positive shock to expected future income, may encourage borrowing in the current period. Finally, a relaxation in credit standards allows households to borrow more at a given income level or house value.[7]

To be more concrete, consider a homeowner with separable log utility who is choosing how much to consume over two periods (within a longer lifecycle), with the ability to tap into home equity to smooth consumption. The homeowner receives income in both periods (y_1, y_2), owns a home with value V, and can extract equity E up to a collateral constraint of aV $(0 \leq a \leq 1)$, at the prevailing mortgage rate, r.[8] Thus the homeowner solves the following constrained optimization problem:

$$\max u(c_1, c_2) = \max\{ln(c_1) + \beta ln(c_2)\}$$

subject to

(1) $c_1 = y_1 + E$

(2) $c_2 = y_2 - E(1 + r) + \omega V$

(3) $E < aV$

where β is the discount rate between periods and ω represents the desire to consume out of housing wealth (with $0 \leq \omega \leq 1$). In particular, for young people, who may continue to consume similar housing for a long time, ω should be close to zero, while for older people who might downsize in the near future, ω is likely to be well above zero.[9]

Plugging in the equations for c_1 and c_2 and solving for the optimal level of equity extraction,

[7] Households may also wish to extract equity in order to purchase assets for diversification purposes, or to increase the value of their home through repairs. Among respondents to the Survey of Consumers in early 2002 who extracted equity through cash-out refinancing, 43% say they put some of the extracted funds toward home improvements, and 13% say they invested some funds in the stock market or other financial investment (see Table 6 of Canner, et al. 2002). For simplicity, we do not include these possibilities in our framework; instead one could think of E as equity extraction net of investments.

[8] The collateral constraint and interest rate in this simple framework are viewed as exogenous from the homeowner's perspective. The collateral constraint can be motivated by the fact that y_2 is unobserved by the lender. In Geanakoplos (2009), a varies over time in response to house price trends, amplifying boom and bust cycles.

[9] Adding this housing wealth effect parameter is a straightforward (albeit ad hoc) way to incorporate a well-known source of heterogeneity into our simplified framework.

E^*, when the collateral constraint does not bind:

$$E^* = \frac{\omega V + y_2 - \beta(1+r)y_1}{(1+r)(1+\beta)}$$

And if $E^* > aV$, then the collateral constraint binds and extraction will be limited to aV.

This simple framework provides key predictions that will be helpful in guiding and interpreting our empirical analysis. First, a positive shock to home values V both increases the demand for credit and relaxes the collateral constraint. The derivative of E^* with respect to a change in home values (not constrained by the collateral limit) is:

$$\frac{\partial E^*}{\partial V} = \frac{\omega}{(1+r)(1+\beta)} \tag{1}$$

This consumption response will be stronger for individuals with higher ω, i.e. older homeowners, and with lower β, i.e. more impatient homeowners.[10] Second, for homeowners with high future income (such as young people), E^* will be large and the collateral constraint will be more likely to bind.[11] Third, a negative shock to interest rates will increase E^*. The derivative of E^* with respect to r is:

$$\frac{\partial E^*}{\partial r} = \frac{-(\omega V + y_2)}{(1+r)^2(1+\beta)} \tag{2}$$

However, homeowners who are already at the collateralized leverage constraint, aV, will be unable to respond to this shock. In addition, individuals with a larger housing wealth consumption parameter ω or smaller discount rate β will respond more to a decline in interest rates. We quantify homeowners' extraction responses to these drivers in Section IV, but first describe our data and methodological approach.

[10] Using data from the UK, Campbell and Cocco (2007) find heterogeneous extraction responses to house price gains along the age distribution, with older consumers being more responsive.

[11] Note that there is no uncertainty in our framework, particularly with regard to income or house prices. As in Chen, et al. (2012), if we allowed for house price uncertainty, households may choose to pre-emptively extract equity if they anticipate house price declines (and thus a more binding collateral constraint).

III Data and Methodology

We use data from the Federal Reserve Bank of New York's Consumer Credit Panel (CCP), a nationally representative 5 percent sample of all individuals with a credit record and a valid Social Security number. The CCP tracks the same individuals over time at a quarterly frequency, and the sampling approach is designed to generate the same entry and exit behavior as present in the population, with young individuals and immigrants entering the sample and deceased individuals and emigrants leaving the sample each quarter at the same rate as in the U.S. population, such that each quarterly snapshot continues to be nationally representative.[12]

The CCP provides data on individuals' debt holdings, payment history, credit scores and geographic location down to the census block, with all items refreshed quarterly.[13] Importantly, because the data are an individual-level panel, and because they provide detailed information on all debt holdings, we can track the total mortgage debt of a given borrower from quarter to quarter and thus observe the precise timing of equity extractions, regardless of whether a borrower extracts equity through a cash-out refinancing, home equity loan, or home equity line of credit (HELOC).

Using the geographic location of mortgage borrowers, we merge in several time-varying measures of local economic conditions (e.g. county unemployment rate), as well as house price indices (HPIs) at the zip code level from CoreLogic. These HPIs are monthly, repeat-sales indices, and are available for over 6,000 zip codes, covering roughly 60 percent of the national population.[14] Information on house prices at such a disaggregated level is of first-order importance for obtaining precise estimates of the relationship between house price appreciation and equity extraction given the considerable within-MSA heterogeneity in house price dynamics (Dorsey et al. 2010; Ferreira and Gyourko 2012; Glaeser et al. 2013).

[12]For more information on the CCP, see Lee and van der Klaauw (2010). It is important to note that all individuals in the data are anonymous: names, street addresses and social security numbers have been suppressed. Individuals are distinguished and can be linked over time through a unique, anonymous consumer identification number assigned by Equifax.

[13]Credit scores for each individual are based on the Equifax 3.0 model, which is similar conceptually and numerically to the FICO score. The Equifax score ranges from 280 to 850, with higher scores associated with a lower expected likelihood of default. See `https://help.equifax.com/app/answers/detail/a_id/244/noIntercept/1` for more information.

[14]The zip code coverage of the dataset depends on factors such as state sales price disclosure laws, the corporate history of CoreLogic, and the thickness of the zip code's real estate market. Figure 6 shows that the time series patterns of the aggregate dollar amount of extraction for the full sample as well as the sample with coverage in the CoreLogic data are nearly identical, suggesting bias arising from coverage issues is fairly minor.

To make the dataset more manageable we draw a 5 percent sample from the CCP data, implying a 0.25 percent sample of the population, with observations from 1999q1 through 2011q1. At the beginning of each year, we identify "typical" homeowners eligible to extract equity during the year: people with a mortgage (excluding those with less than $5,000 of mortgage debt) who do not move during the year (their census block location remains constant), and who do not appear to be real estate investors (that is, those who we can reasonably infer to have just one mortgaged property at the beginning and end of a year).[15] We do not directly observe whether someone owns their residence, but rather assume ownership given that the consumer has a mortgage. According to data from the Survey of Consumer Finances, 70 percent of homeowners in 2004 and 2007 had a mortgage (Bucks et al. 2009).

We identify equity extractions in the data as instances when a borrower's outstanding mortgage debt increases by more than 5% over a one year period, with a minimum increase of $1000. This increase in outstanding mortgage debt can come from a cash-out refinancing, taking on a second lien or home equity loan, or drawing on a HELOC. We identify the method of extraction — for the first time, to our knowledge — using trade line information on each mortgage held.[16] Thus, if a borrower's total mortgage debt rises from $100,000 to $110,000, we can distinguish whether that occurred on a first-lien closed-end mortgage, a home equity line of credit, a junior-lien closed-end mortgage, or some combination.[17]

Our primary analysis involves regressing an indicator variable for extraction on interest rates, recent local house price appreciation, credit conditions, and local economic conditions, with baseline

[15] In our data, we must assume that the property address coincides with a borrower's mailing address. For those with multiple mortgaged properties, this assumption is clearly inaccurate, and including these borrowers in the sample would introduce considerable noise in estimating price growth of properties that a borrower owns. We also do not observe whether two mortgages are secured by the same or different properties and thus must infer investor status. A borrower is classified as an investor if (1) he has exactly two closed-end mortgages where the smaller loan is at least one-third the size of the larger, (2) he has three or more closed-end mortgages with positive balances, or (3) he has two closed-end mortgages with positive balances and at least one home equity line of credit.

[16] Previous analysis has relied on loan-level rather than individual-level data, see Agarwal et al. (2006) and Agarwal et al. (2011).

[17] Lien status is not reported by lenders, but can be inferred from the number and relative sizes of the mortgages on file.

regressions of the form:

$$extract_{itzc} = \alpha + \beta_1(rate_t) + \beta_2(HPIgrowth_{tz}) + \beta_3(creditconditions_t) + \beta_4(securitizationrate_t) + \beta_5(unemp_{tc}) + \beta_6(empgrowth_{tc}) + \beta_7(wagegrowth_{tc}) + e_{itzc}$$

for person i in zip code z and county c during year t.[18] In the above equation, $rate$ is the average annual interest rate on a 1-year adjustable rate mortgage (ARM), and $HPIgrowth$ represents the average annual house price growth rate over the past 3 years. The coefficients on these two variables are of primary interest, in addition to their interaction, which we include in subsequent specifications. Indeed, we do not claim that households' responses to house price growth and interest rates are strictly mutually exclusive, and we find evidence for an important interactive component to the two channels on the extraction decision.

We focus on rates for one-year (30 year amortization) ARMs, in particular annual averages of initial offer rates from Freddie Mac's Primary Mortgage Market Survey (PMMS), a weekly survey of mortgage lenders. Monetary policy typically influences short-term mortgage rates much more directly than longer-term mortgage rates, and thus we are interested in the potential effect of changes in short-term rates on extraction. Ex-ante, equity extraction activity could respond to shorter-term rates because rates for home equity lines and home equity loans are priced off of the shorter end of the yield curve. In addition, ARMs tend to be popular among those who take cash-out when refinancing (Canner, et al. 2002). Ultimately, whether short-term rates, and by implication monetary policy, affect equity extraction is an empirical question at the heart of this paper.

Unfortunately, we cannot measure directly the amount of equity (home value minus home-secured debt) individuals have in their home at any point in time. Instead, we use recent house price growth in one's zip code as a proxy, along with controls for year of mortgage origination in some specifications, with the idea that those living in areas where house prices have grown (or contracted) most significantly will have the most (or least) amount of equity.

As discussed in the introduction, a key element of our identifying variation is that some housing

[18] In Section IV.D., we simultaneously examine both the intensive and extensive margins of extraction.

markets experienced low interest rates after their price booms, while others experienced higher interest rates (see Figure 3). Our focus on house price dynamics at a finer level than the MSA is motivated by studies like Ferreira and Gyourko (2012), who document extensive heterogeneity in the timing of house price booms at both the across-MSA and within-MSA level (see also Mian and Sufi 2009). Although local markets, defined here at the zip code level, can have similar magnitudes of house price changes, the variation in the timing of their booms helps us to separately identify the determinants of home equity extraction.

One natural caveat to this approach is that we treat house price dynamics, conditional on several controls for local economic conditions, as exogenous from the perspective of existing homeowners. We do not employ the popular MSA-level measure of housing supply elasticity (Saiz 2010) as an instrument for house price growth for two primary reasons. First, this instrument does not vary over time or within MSA. Second, our data covers the housing bust period, for which supply elasticity is not a good instrument since negative housing demand shocks cause house price declines in both elastic and inelastic areas due to the durability of housing.[19] Instead, we control for other economic fundamentals at the county level that might drive both house prices and borrowing. Specifically, the variable *empgrowth* is the average annual employment growth over the past 3 years; *wagegrowth* is the average annual growth in the average wage per worker over the past 3 years; and *unemp* is the average unemployment rate during the year. These three variables, computed from data from the Bureau of Labor Statistics, help capture economic conditions that might affect extraction decisions and also be correlated with interest rates or house price changes. Notably, these three variables "explain" just over 40 percent of the variation in our local house price growth variable. Thus, our extraction regressions will identify the house price effect from the unexplained portion of the variation in house price appreciation.

To account for variation in lending conditions over time, we create a proxy measure, *creditconditions*, generated from the CCP data as the fraction of marginal credit applicants who applied for and were able to obtain credit during the year. Specifically, our measure of credit conditions approximates the approval rate on any type of credit that would be the basis for a credit inquiry by a consumer. We estimate this variable as the share of borrowers with credit scores between 550 and 600 and at

[19] It is also noteworthy that Davidoff(forthcoming) presents results casting some doubt on the power of supply elasticities as an instrument for house price growth during the recent housing cycle.

least one credit inquiry during the year who opened at least one new credit account during the year. This measure is a substantial improvement over previous measures of credit availability, which have relied on bank-level surveys of "loosening" or "tightening" standards and are not easily quantified. In contrast, our measure provides a simple summary measure of credit availability: For example, 57 percent of marginal consumers actively searching for credit opened a new account in 2006, a share that declined sharply to just 40 percent by 2009. We also include a measure of the private securitization rate over the period, calculated from Inside Mortgage Finance, to capture another important dimension of credit conditions during the housing boom (see Keys, et al. 2010).

In subsequent specifications we add individual-level controls, such as credit score, age, credit card utilization rate and the year of origination of their current primary mortgage from the CCP data, as well as zip code fixed effects. These variables help control for compositional changes of the mortgage borrowing population over time that may have affected the likelihood of equity extraction.

IV Results

IV.A Summary Statistics

The characteristics of our sample are described in Tables 1 and 2. Column 1 of Table 1 shows the number of potential equity extractors each year — those with at least $5,000 of mortgage debt at the start of the year, excluding movers and investors as discussed earlier — and columns 2 and 3 show the number and share who extracted equity each year.[20] Over 12 percent of homeowners extracted equity on average between 1999 and 2010, but in 2003 nearly 20 percent did so. Comparing columns 4 and 6, extractors tend to have similar credit scores as homeowners at large, with the biggest differences in 2006 and 2009 (in opposite directions).

Column 8 shows that extractors typically increase their mortgage debt by a significant amount — usually around 20 percent or more. As such, monthly payments on mortgage debt (column 9) for the median extractor increase substantially, especially in years when interest rates are relatively high (e.g. 2000 and 2006). Column 10 indicates that about two-thirds of extractors in a given year

[20] The sample size changes from year to year in large part because of changes in the number of people with a mortgage. The sample in 2001 is somewhat attenuated relative to what might be expected because geographic location was unavailable for a relatively large number of mortgage borrowers that year.

extract in other observed years, and column 11 suggests that extracting in two consecutive years is not uncommon (peaking in 2006 when house prices in general were at their apex).

Finally, the last four columns decompose equity extractions — for the first time, to our knowledge — into possible methods.[21] Over the course of the decade, the popularity of different methods of extraction varied, with cash-out refinancing being the most common method during the low interest rate years, but falling off sharply from 2004 to 2007 as interest rates rose. In 2006–2007, home equity lines of credit (HELOC) were the most prevalent means of equity extraction. When interest rates rose, a HELOC or junior lien may have been used in lieu of a cash-out refinance to avoid resetting one's entire mortgage balance to a higher rate.

Table 2 presents summary statistics for the right-hand-side variables of the regression discussed in the previous section. The mean one-year ARM rate experienced over time across all individuals in the sample is about 4.9 percent, with a standard deviation of 0.95 percent. The average annualized three-year house price growth rate is about 4.2 percent, with a sizable standard deviation of 8.7 percent.

IV.B Patterns of Equity Extraction over Time

As mentioned earlier, Figure 1 shows that the likelihood of home equity extraction reached its peak when interest rates bottomed. During 2001–2004, short-term interest rates plummeted as the Federal Reserve responded to the dot-com bust and ensuing recession. The one-year ARM rate fell below 4 percent for the first time on record in 2003. Simultaneously, the extraction rate series rises and peaks in 2003, with nearly 20 percent of sample homeowners extracting equity in that year.

Figure 1 also provides an alternative definition of extraction. Our preferred extraction measure is a 5 percent or larger increase in balances (the solid line), as this is similar to the definition of cash-out refinance that Freddie Mac uses. A more stringent definition — a 10 percent increase in mortgage balances — shows a nearly identical time series pattern.

The broader macroeconomic patterns over the period 1999 to 2010 are shown in Figure 4. The top-left and middle-left panels replicate the time-series patterns shown in Figure 1. Extraction rates

[21] As described in the previous section, the method of extraction has to be inferred from patterns in the mortgage balances and number of home-related lines of debt.

fell after 2003 even though house prices, shown in the upper-right panel, continued to grow robustly through 2006. This pattern is suggestive of the importance of interest rates in homeowners' equity extraction decisions.

The unemployment rate, shown in the middle-right panel, was relatively elevated in 2002 and 2003, suggesting that some equity extraction may have been a response to income disruptions. The bottom-left panel presents the time-series of our proxy for credit conditions (defined in the previous section). Credit availability tightened slightly from 2000 to 2003, then recovered to some extent, and then tightened sharply after 2007 during the financial crisis.[22] Finally, the bottom right panel shows the fraction of mortgages privately securitized; that is, securitized by institutions unaffiliated with the government such as Fannie Mae, Freddie Mac and Ginnie Mae. Subprime and "jumbo" mortgages often went into private mortgage-backed securities, and the boom in securitization from 2004-2006 has been associated with increased mortgage credit availability (Mian and Sufi 2009).

Figure 5 shows that the overall national time series pattern of extraction varied substantially by geographic location and credit score group (where scores are measured at the beginning of a given year, prior to extraction decisions), providing some initial evidence on who extracted equity and why. First, the top-left panel separates the equity extraction rate by credit score category. High credit score homeowners (the dotted line) are less likely to extract equity on average, perhaps because they have other sources of credit or are less liquidity constrained. When these high credit borrowers do choose to extract equity, their timing is highly correlated with the mortgage rate, with a sharp peak in their extraction rates in 2003. Middle credit score homeowners (the dashed line) are more likely to extract equity than their high credit score counterparts, and also appear to respond to low interest rates. Indeed, over 20 percent of middle score homeowners extracted equity in 2003.

In contrast, equity extraction by low credit score homeowners (the solid line) was fairly steady from 2003 to 2006, with a slight peak in 2005. Low score households could be more responsive to a given house price shock than higher score homeowners because a rise in house prices is more likely to relax a collateral constraint for low score households. Alternatively, the differential pattern for

[22]Note that our credit availability measure is not mortgage-specific, so we cannot separately isolate access to mortgage credit, which may have had a different time-series pattern over this period, relative to other sources of consumer credit.

low score homeowners could reflect differential house price growth; that is, house price growth may have been exceptionally strong in neighborhoods with higher concentrations of subprime homeowners (Mayer and Pence 2009; Mian and Sufi 2009). Yet another possible story is that credit was extremely loose around 2005, allowing lower score borrowers the opportunity to take on additional mortgage debt regardless of home price dynamics. Our regression analysis below will help distinguish between these competing explanations, but the remaining panels of Figure 5 suggest that lower score borrowers are relatively more responsive to house price increases. In particular, middle and low score homeowners in the "sand states," where the boom and bust in house prices was extreme, extracted equity at substantially elevated rates in 2005 and 2006. In contrast, the rate of extraction among high credit score homeowners in these states was more subdued and peaked in 2003.

IV.C Determinants of Equity Extraction

To estimate the magnitude of the homeowner equity extraction response to changes in interest rates and house prices, Table 3 presents regression specifications of the form described above in Section III. The unit of observation is the homeowner-year, and as discussed earlier, excludes movers and investors in a given year. All of the regressions include state or zip code fixed effects and standard errors are clustered at the state level.

Column 1 shows a basic strong and negative correlation between the mortgage rate and the probability of extraction. Column 2 controls for recent home price appreciation in one's zip code. This variable is highly significant, and including it leads to a large increase in the magnitude of the interest rate coefficient. This pattern is consistent with the idea that house price changes help explain extractions in 2005 and 2006 when interest rates were relatively high, and the low rate of extraction after the financial crisis despite low interest rates. The next regression adds in controls for credit availability and employment conditions. Inclusion of these controls further increases the estimated relationship between interest rates and equity extraction, but dampens the relationship with house price growth. Column 4 adds in a number of individual level controls (e.g. borrower age, credit score, initial debt balances, and credit card utilization) as well as zip code and year of mortgage origination fixed effects, in order to account for possibly confounding changes in the composition of homeowners over time. However, the coefficients on the mortgage rate and home price growth remain qualitatively unchanged relative to column 3. Columns 3 and 4 indicate that a one percentage point drop in the 1-year ARM rate (roughly one standard deviation) leads to a 3 percentage point rise in equity extraction — a 25 percent increase over the 12 percent average extraction rate across all years.

House price growth also has a large effect on extraction. The estimates in columns 3 and 4 imply that a one standard deviation increase in house price growth leads to an increase in the likelihood of extraction of 3.5 percentage points. As discussed in the previous section, we do not instrument for house price growth.[23] Instead, we rely on several controls for local economic conditions — county-level unemployment, wage growth, and employment growth — to capture income trends and expectations that are highly correlated with house price growth and might also be related to borrowing.[24]

In column 5, we instrument for the mortgage rate with the Fed Funds rate to address potential simultaneity bias associated with regressing quantity on price. The Fed Funds rate, conditional on unemployment and wage growth, provides an exogenous source of variation in the cost of funds for banks. Comparing these results to the OLS coefficients, the instrumental variable estimate is slightly larger in magnitude, but the difference is not statistically significant. This finding suggests that variation in short-term mortgage rates in the U.S. is driven largely by credit supply shocks rather than U.S. household demand shocks, and thus we continue to focus on the OLS coefficient.

With respect to some of the other control variables, the county unemployment rate is negatively related to equity extraction and statistically significant in column 3. In column 4, the credit card utilization rate, which is measured at the individual level in the CCP, is positively related to extraction until utilization gets close to or exceeds 100 percent, suggesting that homeowners with greater liquidity needs, perhaps because of a temporary income disruption, are more likely to extract. Borrower age is negatively related to equity extraction, which one would expect since younger borrowers may have a steeper earnings profile. Credit scores are strongly related to equity

[23] Given the absence of a compelling instrument, it is possible that our estimate of the responsiveness of equity extraction to house price growth is biased upward; Nonetheless, the effect of interest rates is our primary interest, and the house price variable may instead be capturing other drivers of extraction at the local level.

[24] We also examined allowing for nonlinear effects, but, in results not shown, found evidence of only modest nonlinear responses to interest rates and house price growth.

extraction in a non-linear way. The middle two score groups have a considerably higher likelihood of extracting equity relative to the lowest score group, while the likelihood of extraction for someone in the highest score group is only slightly higher than someone in the lowest score group. This nonlinearity can best be explained by credit constraints at the bottom of the score distribution and lack of demand for additional borrowing at the top.

IV.C.1 Alternative Specifications

In sum, the specifications above suggest an important role for both house price growth and mortgage rates in the home equity extraction decision. Table 4 examines alternative specifications and explores the robustness of the findings above along a number of dimensions. For brevity, we suppress the coefficients on the control variables shown in Table 3.

In column 1, we allow for an interactive relationship between the mortgage rate and house price growth. Theory suggests that rates and home prices should have an interactive effect that is negative (the derivative of Equation (1) or (2)), and that is precisely what we find. The interaction estimate implies that house price growth significantly amplifies the effect of interest rates, and vice versa. At the same time, it is notable that the mortgage rate coefficient in this specification implies that even when average annual price growth over the past three years is zero, a rate drop of one percentage point leads to a 2 percentage point increase in extraction. In other words, significant house price growth may not be necessary for monetary policy to spur equity extraction. Still, house price growth helps: the interaction coefficient suggests that this effect increases to 3 percentage points if house price growth were one standard deviation higher. With respect to the house price coefficient in the interaction specification (column 1), the magnitude is similar to the previous specifications in Table 3 because we have re-centered the mortgage rate variable to have mean zero. If the 1-year ARM rate were to decline by one percentage point from the mean, the coefficient on house price growth would increase by about 25 percent.

In column 2, we return to our previous specification without an interaction term, and include a linear time trend that might help account for technological changes making it cheaper to tap into home equity, but the rate and house price growth coefficients are basically unchanged. In column 3, we address the concern that in fact the mortgage interest rate with the greatest influence on homeowners' extraction decisions may be something other than the short-term rate. In column 3, we include the average offer rate reported in the PMMS for a 30-year fixed rate mortgage, but it appears to be uncorrelated (at least over this period) with extraction conditional on shorter-term rates and other factors.

Column 4 includes an indicator for whether an individual extracted last year. If extracting in one year reduces the likelihood of extracting the next year, this "burnout" effect might influence the time pattern of extraction and confound our estimate of the influence of interest rates on extraction. Lagged extraction is actually positively correlated with extraction in the current period, and the mortgage rate coefficient estimate is largely unchanged. As noted earlier in our discussion of Table 1, extracting in consecutive years is not uncommon, and most extractors extract more than once (not necessarily consecutively) during the observation period.

Columns 5 and 6 examine the effect of rates and house price growth separately for cash-out refinance and junior lien extractions, respectively. We expect that cash-out refinancings should be considerably more sensitive to interest rates because the interest rate resets on the entire mortgage balance. Junior lien loans, in contrast, allow one to borrow without having to reset the rate (or amortization schedule) on the entire balance. Indeed, we find that cash-out refinancings are substantially more sensitive to interest rates. The coefficient estimate in column 5 implies that a one percentage point reduction in the 1-year ARM rate leads to an increase in cash-out refinancings of 2 percentage points, or nearly 40 percent relative to the baseline probability of 5.4 percent. In contrast, the semi-elasticity of extraction with respect to rates for junior liens is just 10 percent (shown in column 6). Interestingly, cash-out refinancings also appear to be more sensitive to house price gains. One explanation might be that when house prices grow sharply, homeowners who want to unlock a large amount of equity must do so through their first lien, as lenders may not be willing to take a junior position on a large loan.

IV.D Aggregate Equity Extraction and Counterfactual Exercise

The results thus far have focused on the extraction decision of homeowners — the extensive margin. However, the amount of equity extracted — the intensive margin — may vary with the price of credit and home price growth as well. Figure 6 plots the aggregate amount extracted based on the CCP and our definition of extraction over the period 1999 to 2010.[25] The dashed line represents the aggregate increase in mortgage balances for equity extractors (again, excluding investors, movers, and renters) for the full CCP, while the solid line represents aggregate extractions from the subsample where we have HPI data coverage. The figure shows that annual aggregate equity extraction rose sharply to nearly $300 billion in 2003 and in 2005, and fell sharply after 2007.[26]

Comparing the aggregate amount extracted (Figure 6) to the likelihood of extraction (Figure 1), the graphs indicate that extraction done in the later years of the housing boom, 2004 to 2006, led to larger amounts being extracted on average. Thus, as the price of credit was rising between 2004 and 2006, extractors' average amount borrowed was actually increasing. This increase in the average amount borrowed likely reflects compositional changes, as homeowners in high appreciation states – California in particular where the house price level is relatively high as well – responded to increased home values in the later years of the housing boom (recall Figure 5).

To estimate the overall equity extraction response to interest rates and house price growth — that is, the combined intensive and extensive margin responses — we employ a two-tiered model combining probit estimation of the extensive margin (the decision to extract) and OLS estimation of the intensive margin (how much to extract).[27] Thus, we estimate:

(1) $Pr(extract_{it} = 1|\boldsymbol{x}) = \Phi(\boldsymbol{x\delta})$, and

(2) $E[ln(amountextracted_{it})|\boldsymbol{x\beta}, extract_{it} = 1]$

where $\boldsymbol{x}$ includes the interaction of rates and house price growth, as well as all of the covariates in

[25] Our estimate of the dollar volume of extractions in a given year is defined as the dollar change in mortgage balances over a given year across extractors. The CCP data provide information on jointly held mortgage accounts and we adjust appropriately for such accounts before aggregating up. Notably, aggregates calculated from the CCP for various types of credit align quite well other sources such as the Federal Reserve's Flow of Funds (see Lee and van der Klaauw 2010)

[26] Greenspan and Kennedy (2008) define extraction more expansively than we do, including cash generated from home sales, and consequently find, using aggregate data, that equity extraction continued to rise until 2006. Selling one's home to obtain cash suggests trading off housing consumption for non-housing consumption, whereas we are primarily interested in equity withdrawal through borrowing, which permits housing consumption to remain constant while trading future consumption for current non-housing consumption. Moreover, leveraged equity extraction is of key interest with respect to understanding the growth of household debt and the recent housing crisis.

[27] For a discussion of this approach, see Wooldridge (2002). This method is more flexible than a Tobit model as it allows the coefficients on the explanatory variables to affect the intensive and extensive margins differently. Also, we are able to include a time-trend in the intensive margin OLS regression to account for a secular rise in extraction amounts over time.

column 4 of table 3. Expected extraction at the mean of $\boldsymbol{x}$, our baseline, can then be estimated as

$$\Phi(\boldsymbol{x}\hat{\boldsymbol{\delta}})exp(\boldsymbol{x}\hat{\boldsymbol{\beta}} + \frac{\hat{\sigma}^2}{2})$$

where $\hat{\sigma}$ is the standard error from the intensive margin OLS regression. The results are shown in Table 5. Based on this framework, we estimate that a one standard deviation decline in the short-term mortgage rate (100 basis points) leads to an average increase in extraction of $1,716 or about 23 percent above baseline predicted extraction of $7,558 (includes zeros for those who do not extract), while a one standard deviation increase in house price growth (8.7 percentage points over three years) leads to an average increase in extraction of $2,888 or 38 percent above the baseline. Assuming, conservatively, an average initial home value of $150,000, a growth rate of 8.7 percent per year for three years would yield $42,000 of home equity. Thus, our estimate of a $2,888 increase in extraction suggests that on average homeowners extract about $7 per $100 increase in home value, which is significantly smaller than the $25 per $100 estimate of Mian and Sufi (2011), but in line with the recent literature on consumption responses to housing wealth (Bostic et al. 2009, Carroll et al. 2010, Case et al. 2011).

We further gauge the aggregate effect of the drop in interest rates in the early 2000s by estimating how much home equity would have been extracted had the 1-year mortgage rate followed an alternate path. For example, the Federal Reserve could have begun tightening in 2003, as Taylor (2010) has noted. Figure 7 shows this counterfactual Fed Funds rate (dotted line), taken directly from Taylor (2010), and the implied counterfactual 1-year ARM rate (long dashed line).[28] Using the coefficients from our two-tiered model, the top left panel of Figure 8 shows what aggregate extraction would have been under the "Taylor Rule" (dotted line). The figure also shows the actual amount extracted each year (solid line), and the predicted amount based on the coefficients of the model (dashed line). Relative to the predicted amount, counterfactual extraction would have been about 30 percent lower from 2003–2005.

The remaining panels of Figure 8 provide counterfactual estimates had the 1-year ARM rate

[28] Using quarterly data since 1984, a simple regression of the 1-year ARM rate on the Fed Funds rate suggests that a 100 basis point increase in Fed Funds is associated with a 67 basis point increase in the ARM rate. We apply this 67 per 100 basis point effect to the difference between the actual and counterfactual Fed Funds rate and add it to the actual ARM rate to obtain the counterfactual ARM rate.

remained constant over time at various levels (5, 6 or 7 percent). These counterfactuals provide relevant benchmarks: 5 percent is the average 1-year ARM rate over the period where data is available (1984-2012); a 6 percent rate is the level at the beginning of our observation period; and 7 percent is the maximum observed value in our sample period (in 2000). Focusing on the counterfactual where rates held constant at 6 percent — the intermediate counterfactual — extraction would have been about 35 percent lower (dotted vs. dashed lines). Given nearly $1.1 trillion in cumulative extraction from 2002–2005 shown in Figure 6 (dashed line), this estimate implies that relatively low short-term rates generated close to $400 billion of equity extraction during these four years.

Note that these counterfactual estimates represent lower bounds, as higher interest rates could have also have had a negative effect on other economic factors that further dampen the equity extraction response. Although our reduced-form approach does not capture potential general equilibrium responses to increased interest rates, these counterfactuals nonetheless underscore the importance of interest rate declines in the early 2000s in helping spur the equity extraction boom.

IV.E Heterogeneity in the Equity Extraction Response

Table 6 presents regression specifications where we stratify our sample by borrower age and credit score. All specifications include the basic set of controls from column 3 of Table 3. We run separate regressions for eight different age-by-credit score groups, and report coefficients, standard errors and implied semi-elasticities for the rate and house price growth variables for each regression. The discussion below focuses on the reported semi-elasticities, which are in bold in Table 6.

The results indicate that younger homeowners have a stronger response to house price growth than older homeowners, consistent with findings in Mian and Sufi (2011). In contrast, life-cycle models (also recall our discussion of equation (1)) suggest older homeowners' consumption should be the most responsive to house prices (Campbell and Cocco 2007). The negative correlation between age and the extraction response to house prices may reflect younger homeowners — even those with excellent credit scores — being more likely to be collateral constrained. However, to the extent that older homeowners have significant liquid assets (see Bucks et al. 2009), a positive house price shock may lead older homeowners to consume out of liquid savings rather than borrowing against their home, depending on the relative cost of doing so; this difference across age groups might help explain the relatively small extraction response among older homeowners.

Further evidence of collateral constraints can be seen *within* age groups in Table 6. Here we find that homeowners with middle to low credit scores are both more sensitive to house price gains *and* less sensitive to interest rates. As noted above in Section II, when collateral constraints bind, borrowers will be insensitive to interest rate changes (because they would already like to borrow more at current rates) and quite sensitive to changes in collateral values. Thus the patterns of heterogeneity we find in the data provide new evidence for financial frictions in the form of collateral constraints.[29] This finding is important because such frictions are thought to amplify cyclical fluctuations (e.g. Bernanke, et al. 1999). More precisely, because lenders require collateral in the face of various credit market imperfections, when a shock to the economy impacts collateral values, there is a knock-on effect on borrowing capacity, which further influences economic activity.

IV.F What did Homeowners do with Extracted Equity?

In Figures 9 and 10, we use the panel aspect of the credit record data to explore the impact of home equity extraction on the debt portfolio of households. As noted earlier, in order for equity extractions to have substantive real effects, it must be the case that extractors were not simply swapping more expensive uncollateralized debt for cheaper collateralized debt. We plot event-study style figures, with year zero representing the year of extraction (the x-axis is measured in years before/after extraction), to study how households' indebtedness changes around the timing of extraction.

Panel A of Figure 9 shows how total mortgage debt for the average extractor changes before and after an extraction, regardless of the type of extraction. The solid line shows that average mortgage debt rises leading up to the year of extraction, but this increase reflects some extractors having zero mortgage debt in years prior to $t-1$. Excluding the most recent home buyers by conditioning on having a mortgage at 4 years prior to extraction (the dotted line), average mortgage debt holds fairly steady, and then jumps by about $40,000 in the year of extraction. This increase in mortgage debt is strongly persistent, with average balances substantively higher five years after

[29] Recalling equation (2), another factor that might help explain the weaker response to interest rates among lower score homeowners is that their future income may be relatively low.

extraction, a point we will refer back to when we examine the relationship between extraction and default. HELOC-based extractions (shown in Panel B) also are large and exhibit steady persistence. Finally, the size and persistence of increased leverage is apparent among both low and high score homeowners, as shown in Panel C.

Figure 10 shows changes in non-mortgage debt before and after extraction, looking separately at uncollateralized consumer loans and credit card balances ("consumer debt"), and collateralized auto loans. Panel A at the top left shows consumer debt rises prior to extraction, suggesting increased credit demand helps precipitate home equity withdrawals. Consumer debt then drops at the time of extraction, implying that some of the proceeds from the extraction went to partially paying off relatively expensive consumer debt. Finally, extractors quickly re-accumulate consumer debt, offsetting some of the decrease due to the extraction.

Panels B and C show how consumer debt evolves for high and low credit score extractors separately. The drop in consumer debt is most pronounced for lower score, longer term borrowers (dashed line in Panel C), and this drop is quite persistent. The price differential for housing versus non-collateralized debt may be larger for lower score borrowers, pushing them to use home equity to pay down consumer debt more so than higher score borrowers. This figure provides evidence that lower score borrowers used extracted equity to re-balance their household portfolios away from expensive credit card debt to some extent.

Panels D through F show how auto loan balances evolve for extractors. There is little indication that home equity is used to pay down auto debt. This should not be too surprising given that extractors generally pay down only a small portion of their unsecured consumer loans, which are typically more expensive than collateralized auto loans.

Overall, extractors appear to use only a small portion of the cash generated from home equity extractions to pay down other, more expensive debt. For the median extractor who increases his mortgage debt by about $25,000, we estimate that his uncollateralized consumer debts fall by about $2,800 during the year of extraction.[30]

[30]This finding corroborates the results of Cooper (2010), who uses the PSID and finds that less than one-fifth of extracted funds are used to pay down debts.

IV.G Equity Extraction and Default

Finally, we relate the timing of equity extraction to subsequent mortgage default. The risk created by equity extraction depends not only on the potential for house prices to decline, but also on borrowers' changes in leverage, which depend on how extractors use borrowed funds. For example, extractors could use the funds to invest in relatively liquid assets, diversifying their portfolio and mitigating the rise in leverage. To assess the relationship between equity extraction and default, we run the following regression:

$$delinquent_{i,c,t+j} = a + \beta_t extract_{it} + \boldsymbol{x'_{it}\theta} + \eta_{ct} + \epsilon_{ict}$$

β_t measures the difference in delinquency status between extractors and non-extractors j years after the year of potential extraction, t. To help account for differences in the ex-ante risk attributes across extractors and non-extractors, we control for a variety of factors, $\boldsymbol{x_{it}}$, including credit score prior to extraction. We also include county-by-year fixed effects, η_{ct}, as well as house price growth at the zip code level before and after extraction, to control for economic and housing conditions.

We examine instances of severe delinquency (60 days or more past due) both on mortgage and non-mortgage debt over a short horizon of two years as well as a longer horizon of 2 to 4 years after the year of potential extraction.[31] The coefficients of interest are on the extract-by-year variables.[32] These coefficients, scaled by the mean cohort delinquency rate, are shown in Figure 11 (the unadjusted coefficients and controls are reported in Table 7). The solid line shows mortgage delinquency two to four years after extraction.

From 1999 through 2003, homeowners who extracted equity were 10 to 40 percent more likely to default than those who did not extract, again, conditional on county-by-year fixed effects and ex-ante credit risk attributes. One factor that may have contributed to the decline in the effect of extraction on delinquency from 2000 to 2003 is the decline in interest rates and consequently smaller increases in payments after extraction (see Table 1, column 9). After 2003, the delinquency

[31] More specifically, the outcome variable, for example on longer-term mortgage delinquency, equals one if a borrower has textitany delinquent mortgage account on record at the 2-year, 3-year or 4-year mark from the end of the year of extraction.

[32] For the regressions looking at delinquency over 2 to 4 years, we exclude 2007 and 2008 since our data only extends through 2010.

rate of extractors relative to non-extractors increased sharply. In 2006, extraction heightened the probability of subsequent severe delinquency by about 90% (on a base delinquency rate of 10.5 percent).

Why did 2006 extractors exhibit such excessive default risk? One contributing factor is that these later extractors faced relatively large increases in payment burden due to heightened interest rates in 2006 (again, see Table 1). But a more important factor is that these later extractors were more at-risk of reaching negative equity. As we showed in Figure 9, extractions tend to lead to large, long term increases in debt and those who extracted in 2006 were particularly vulnerable to house price declines soon after extracting. Negative equity is a key determinant of mortgage default for two reasons. First, borrowers with significant negative equity have a financial incentive to "walk away" or strategically default (see, e.g. Kau et al. 1994). Second, borrowers with little or no equity who experience a negative income shock or life event are at high risk of default because they have no equity to tap into either through selling or extraction.

Recent research suggests that most defaults in recent years have been the "double-trigger" variety, rather than purely strategic (see, e.g. Bhutta et al. 2010, Foote et al. 2008). Indeed, we also find that 2006 extractors were significantly more likely to become delinquent on non-mortgage debt than non-extractors (the dotted line in Figure 11). This finding is the first to our knowledge to document the consequences of high loan-to-value (LTV) ratio mortgage borrowing on the non-mortgage portion of the household balance sheet. However, we recognize that although we include several measures of household liquidity and risk, and county-by-year fixed effects to control for local economic conditions, we can not rule out the possibility that these results reflect particularly extreme negative selection into extraction in 2006, such that extractors would have defaulted on mortgage and non-mortgage debt even if they had never extracted equity in 2006. In this case, the estimated direct effect of extraction on default may be overstated.

V Conclusion

In this paper, we use a large, high-frequency panel dataset of individual credit records to examine the role that low interest rates may have played in homeowners' equity extraction decisions from 1999 to 2010. The previous literature has surprisingly ignored the interest rate channel, despite its obvious importance, both in theory and in public discourse, to the equity extraction decision. Understanding this role has the potential to shed light on the mechanisms by which monetary policy is transmitted into the macroeconomy.

To be sure, having home equity is a necessary, but not sufficient, condition to extracting it, and there are other channels through which low interest rates stimulate the economy besides equity extraction. Indeed, in the current housing market, equity extraction activity has been subdued as house price declines have wiped out trillions in home equity, while low interest rates nonetheless could have had a stimulative effect on the economy through other mechanisms such as altering firms' investment decisions. Our emphasis on interest rates and equity extraction is not to argue that house price fluctuations are unimportant, but rather to highlight an additional unexplored channel by which monetary policy can influence household decision-making and thereby affect real economic activity.

We show that the likelihood of extraction peaked in 2003 as the Federal Reserve pushed short-term rates to historic lows, and then estimate the relationship between interest rates and extraction, exploiting the geographic variation in employment conditions and the timing of house price booms to precisely separate the effect of interest rates from other economic factors that affect equity extraction. We find that a 100 basis point (bps) drop in short-term mortgage rates leads, on average, to a three percentage point rise in the likelihood of extraction, or 25 percent relative to the average extraction rate during the period of 12 percent. This effect can vary, as our results show, depending on the strength of recent house price growth, but it is important to note that a rate reduction is found to have a significant effect on extraction even when recent house price growth has been quite modest. One potential caveat to our estimates is that they are identified from fluctuations in interest rates within a generally low interest rate environment; a drop in rates of a similar magnitude in a high rate environment may not produce the same impact. In addition, as would be the case with any study seeking to understand the effects of monetary policy in more recent periods, we are constrained by the fact that we have a rather short time series of data and observe only two episodes of declining interest rates and one episode of rising rates.

Within age group, particularly among younger homeowners, we find that homeowners with mid- to low- credit scores are more sensitive to house price gains *and* less sensitive to interest rates in their equity extraction response. These findings are consistent with the presence of binding collateral constraints, and thus financial frictions affecting the transmission of monetary policy, despite recent technological advances in underwriting that have expanded access to mortgage credit and home equity (Muellbauer 2007).

Finally, our analysis indicates that extracting home equity leaves homeowners more indebted for at least several years thereafter, and that extraction substantially increases the probability of mortgage delinquency. Notably, though, the default risk of extractions was lowest for 2003 extractors (and again in 2008), suggesting that low mortgage rates, by easing payment burdens, can help to mitigate the risks associated with extraction. In contrast, those who extracted in 2006 when rates were high and house prices were on the verge of collapsing were nearly twice as likely to default as homeowners who did not extract that year.

Going forward, it is worth noting that new mortgage market regulations under the Dodd-Frank Wall Street Reform and Consumer Protection Act (i.e. the Qualified Mortgage and Qualified Residential Mortgage rules) could influence how monetary policy affects household mortgage borrowing. In particular, in an effort to protect consumers and curtail risk-taking, the new rules make it more costly for lenders to make mortgage loans that push consumers' overall financial obligations to over 43 percent of income. Of course, as we showed earlier, when interest rates are pushed down, equity extractions are less likely to be associated with a sharp increase in payments. In addition, to help balance consumer protection and credit access, the new rules do not restrict LTV ratios, generally exempt HELOCs from additional regulation, and allow lenders to make hybrid ARMs (but with fixed rate periods of less than 5 years facing more scrutiny). Overall, the new rules may not significantly dampen the ability of monetary policy to influence household mortgage borrowing, but their impact will be an interesting area for future research.

VI References

Agarwal, Sumit, Brent W. Ambrose, Souphala Chomsisengphet, and Chunlin Liu, "Asymmetric Information in Dynamic Contract Settings: Evidence from the Home Equity Credit Market," Journal of Money, Credit, and Banking, 43(4), 2011.

Agarwal, Sumit, Brent W. Ambrose, Souphala Chomsisengphet, and Chunlin Liu, "An Empirical Analysis of Home Equity Loan and Line Performance," Journal of Financial Intermediation, 15(4), 2006.

Agarwal, Sumit, John C. Driscoll, and David I. Laibson, "Optimal Mortgage Refinancing: A Closed Form Solution," Journal of Money, Credit, and Banking, Forthcoming.

Aoki, Kosuke, James Proudman, and Gertjan Vlieghe, "House Prices, Consumption, and Monetary Policy: A Financial Accelerator Approach," Journal of Financial Intermediation, 13(4), pp. 414-435, October 2004.

Attanasio, Orazio P., Laura Blow, Robert Hamilton, and Andrew Leicester, "Booms and Busts: Consumption, House Prices, and Expectations," Economica, 76(301), pp. 20-50, February 2009.

Bennett, Paul, Richard Peach, and Stavros Peristiani, "Implied Mortgage Refinancing Thresholds," Real Estate Economics, 28(3), 2000.

Bernanke, Ben S., and Mark Gertler, "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," Journal of Economic Perspectives, 9(4), pp. 27-48, Fall 1995.

Bernanke, Ben S., Mark Gertler, and Simon Gilchrist, "The Financial Accelerator in a Quantitative Business Cycle Framework," in J. Taylor and M. Woodford, eds., Handbook of Macroeconomics, Volume 1, Elsevier Science, 1999.

Bhutta, Neil, Jane Dokko, and Hui Shan, "The Depth of Negative Equity and Mortgage Default Decisions," Federal Reserve Board Finance and Economics Discussion Series 2010-35, May 2010.

Boivin, Jean, Michael T. Kiley, and Frederic S. Mishkin, "How Has the Monetary Transmission Mechanism Evolved Over Time?" Federal Reserve Board Finance and Economics Discussion Series (FEDS) 2010-26, May 2010.

Bostic, Raphael, Stuart Gabriel, and Gary Painter, "Housing Wealth, Financial Wealth, and Consumption: New Evidence from Micro Data," Regional Science and Urban Economics, 39 (1), January 2009.

Bucks, Brian K., Arthur B. Kennikell, Traci L. Mach, and Kevin B. Moore, "Changes in U.S. Family Finances from 2004 to 2007: Evidence from the Survey of Consumer Finances," Federal Reserve Bulletin, 95, pp. A1-A56, February 2009.

Campbell, John Y., and Joao F. Cocco, "How do House Prices Affect Consumption? Evidence from Micro Data," Journal of Monetary Economics, 54(3), pp. 591-621, April 2007.

Canner, Glenn B., Karen Dynan, and Wayne Passmore, "Mortgage Refinancing in 2001 and Early 2002," Federal Reserve Bulletin, 88(12), pp. 469-481, 2002.

Carroll, Christopher D., Misuzu Otsuka, and Jiri Slacalek, "How Large are Housing and Financial Wealth Effects? A New Approach," Johns Hopkins Working Paper 535, July 2010.

Case, Karl E., John M. Quigley, and Robert J. Shiller, "Wealth Effects Revisited 1978-2009," NBER Working Paper 16848, March 2011.

Chen, Hui, Michael Michaux, and Nikolai Roussanov, "Houses as ATMs? Mortgage Refinancing and Macroeconomic Uncertainty," University of Pennsylvania Working Paper, June 2012.

Christiano, Lawrence J., Martin Eichenbaum, and Charles Evans, "The Effects of Monetary Policy Shocks: Evidence from the Flow of Funds," Review of Economics and Statistics, 78 (1), pp. 16-34, February 1996.

Cooper, Daniel, "Did Easy Credit Lead to Overspending? Home Equity Borrowing and Household Behavior in the Early 2000s," Federal Reserve Bank of Boston Public Policy Discussion Paper 09-7, revised March 2010.

Davidoff, Thomas, "Supply Elasticity and the Housing Cycle of the 2000s," Real Estate Economics, Forthcoming.

Disney, Richard, and John Gathergood, "House Price Growth, Collateral Constraints, and the Accumulation of Homeowner Debt in the United States," B. E. Journal of Macroeconomics: Contributions, 11(1), 2011.

Dorsey, Robert E., Haixin Hu, Walter J. Mayer, and Hui-chen Wang, "Hedonic versus repeat-sales housing price indices for measuring the recent boom-bust cycle," Journal of Housing Economics, 19 (2), pp. 75-93, June 2010.

Dynan, Karen E., and Donald L. Kohn, "The Rise in U.S. Household Indebtedness: Causes and Consquences," Federal Reserve Board Finance and Economics Discussion Series, 2007-37, August 2007.

Elul, Ronel, Nicholas S. Souleles, Souphala Chomsisengphet, Dennis Glennon, and Robert Hunt, "What "Triggers" Mortgage Default?" American Economic Review Papers & Proceedings, 100(2), pp. 490-494, May 2010.

Ferreira, Fernando, and Joseph Gyourko, "Anatomy of the Beginning of the Housing Boom: U.S. Neighborhoods and Metropolitan Areas, 1993-2009," NBER Working Paper 17374, August 2011.

Foote, Chris, Kristopher Gerardi, and Paul S. Willen, "Negative Equity and Foreclosure: Theory and Evidence," Journal of Urban Economics, 64(2), pp. 234-245, 2008.

Geanakoplos, John, "The Leverage Cycle," in D. Acemoglu, K. Rogoff, and M. Woodford, eds., NBER Macroeconomics Annual 2009, 24, pp. 1-65, 2009.

Glaeser, Edward L., Joshua D. Gottlieb, and Kristina Tobio, "Housing Booms and City Centers," American Economic Review Papers & Proceedings, 102(2), pp. 127-133, May 2013.

Greenspan, Alan, and James Kennedy, "Sources and Uses of Equity Extracted from Homes," Oxford Review of Economic Policy, 24(1), pp. 120-144, 2008.

Himmelberg, Charles, Christopher Mayer, and Todd Sinai, "Assessing High House Prices: Bubbles, Fundamentals, and Misperceptions," Journal of Economic Perspectives, 19(4), pp. 67-92, Fall 2005.

Hurst, Erik, and Frank Stafford, "Home is Where the Equity Is: Mortgage Refinancing and Household Consumption," Journal of Money, Credit, and Banking, 36(6), December 2004.

Iacoviello, Matteo, "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," American Economic Review, 95(3), pp. 739-764, 2005.

Kau, James B., Donald C. Keenan, and Kim Taewon, "Default Probabilities for Mortgages," Journal of Urban Economics, 35(3), pp. 278-296, May 1994.

Keys, Benjamin J., Tanmoy Mukherjee, Amit Seru, and Vikrant Vig, "Did Securitization Lead to Lax Screening? Evidence from Subprime Loans," Quarterly Journal of Economics, 125(1), February 2010.

Kiyotaki, Nobuhiro, and John Moore, "Credit Cycles," Journal of Political Economy, 105(2), pp. 211-248, 1997.

Laufer, Steven, "Equity Extraction and Mortgage Default," Federal Reserve Board FEDS Working Paper 2013-30, March 2013.

Lee, Donghoon, and Wilbert van der Klaauw, "An Introduction to the FRBNY Consumer Credit Panel," Federal Reserve Bank of New York Staff Report No. 479, 2010.

Mian, Atif, and Amir Sufi, "The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis," Quarterly Journal of Economics, 124(4), pp. 1449-1496, November 2009.

Mian, Atif, and Amir Sufi, "House Prices, Home Equity-Based Borrowing, and the US Household Leverage Crisis," American Economic Review, 101, pp. 2132-2156, August 2011.

Mayer, Chris, and Karen Pence, "Subprime Mortgages: What, Where, and to Whom?" in Glaeser, Edward L., John M. Quigley eds., Housing Markets and the Economy: Risk, Regulation, and

Policy. Cambridge, MA: Lincoln Institute of Land Policy, 2009.

Muellbauer, John N., "Housing, Credit, and Consumer Expenditure," in Housing, Housing Finance, and Monetary Policy, A Symposium Sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming, pages 267-334, 2007.

National Federation of Independent Business (NFIB), "Small Business Problems and Priorities," August 2012.

Saiz, Albert, "The Geographic Determinants of Housing Supply," Quarterly Journal of Economics, 125 (3), pp. 1253-1296, August 2010.

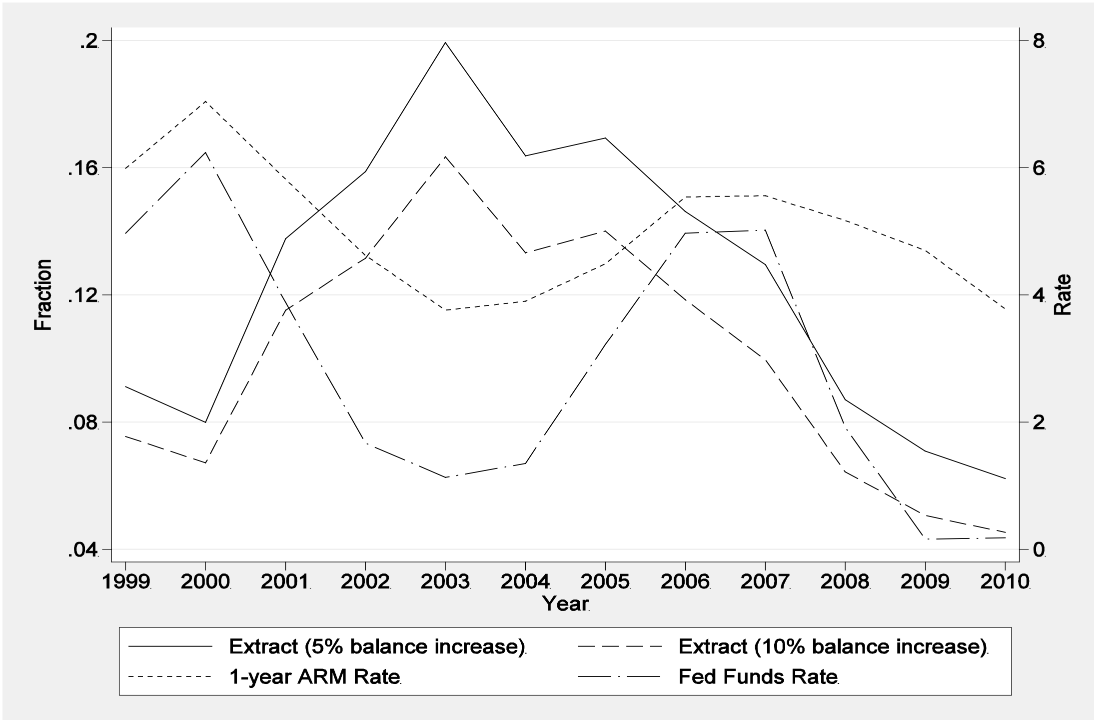
Taylor, John B., "Getting Back on Track: Macroeconomic Policy Lessons from the Financial Crisis," Federal Reserve Bank of St. Louis Review, 92(3), pp. 165-176, May/June 2010.

Wooldridge, Jeffrey M., Econometric Analysis of Cross Section and Panel Data. Cambridge, MA: MIT Press, 2002.

Taylor, John B., "Getting Back on Track: Macroeconomic Policy Lessons from the Financial Crisis," Federal Reserve Bank of St. Louis Review, 92(3), pp. 165-176, May/June 2010.

Wooldridge, Jeffrey M., Econometric Analysis of Cross Section and Panel Data. Cambridge, MA: MIT Press, 2002.

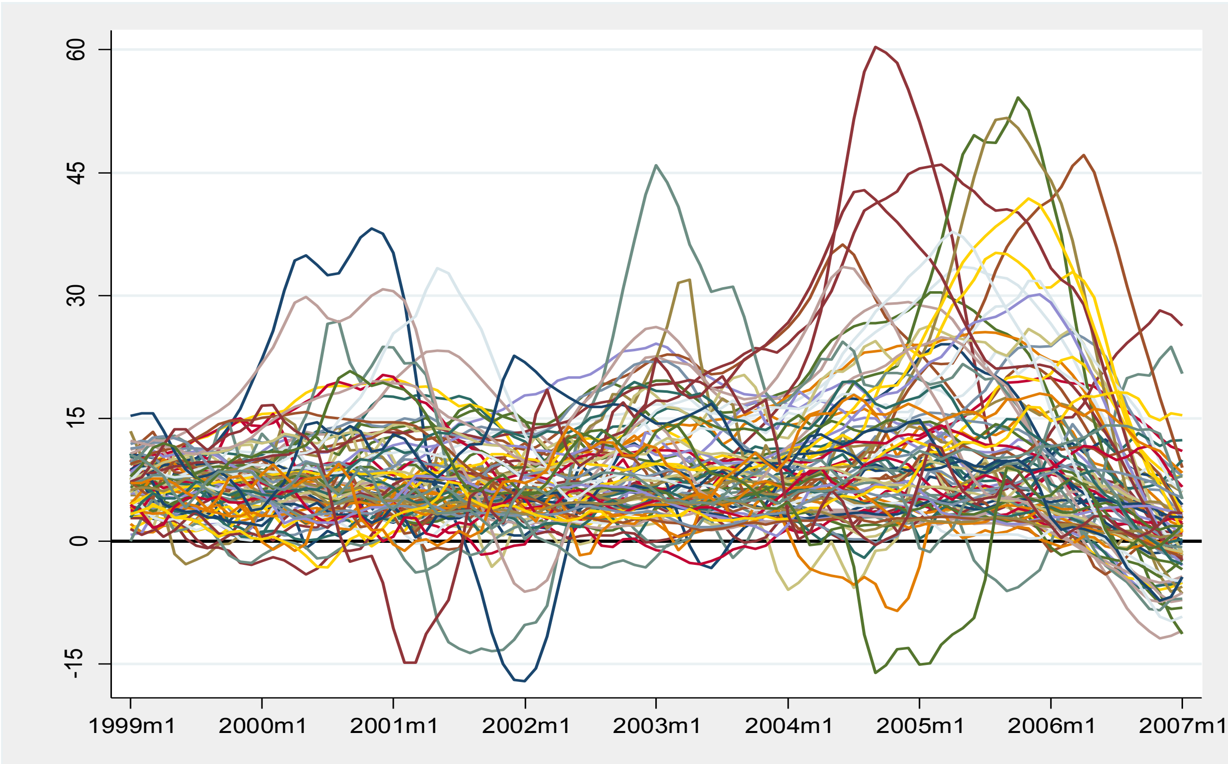
Figure 1. Probability of extracting equity in a given year versus interest rates



Sources: FRBNY CCP/Equifax, Freddie Mac PMMS and Federal Reserve.

Notes: Mortgage rate measures the average offer rate for a 1-year adjustable rate mortgage in the Freddie Mac Primary Mortgage Market Survey, averaged over the year. Two different equity extraction definitions are shown; our preferred measure is an increase in total mortgage debt of at least 5% during a given year. Potential equity extractors in a given year exclude real estate investors and movers, and those in zip codes not covered by the CoreLogic home price index data.

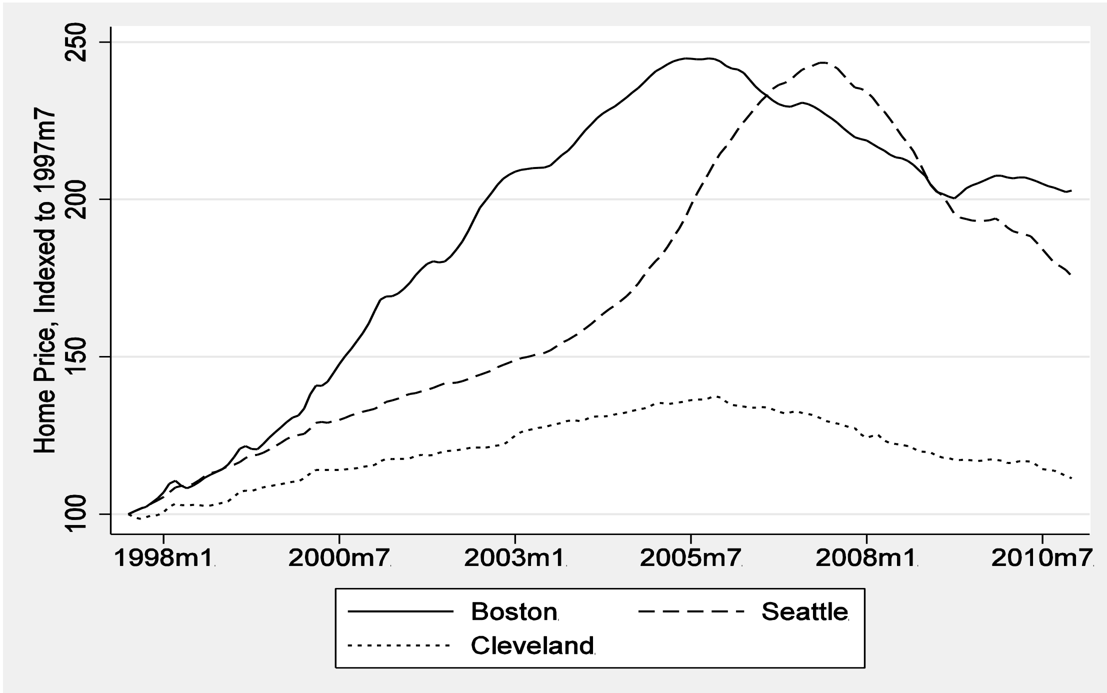
Figure 2. Heterogeneity across cities in house price growth



Source: Zillow monthly house price data.

Notes: Figure shows year-over-year growth rates in home prices each month from January, 1999 through December, 2006 for 80 major cities.

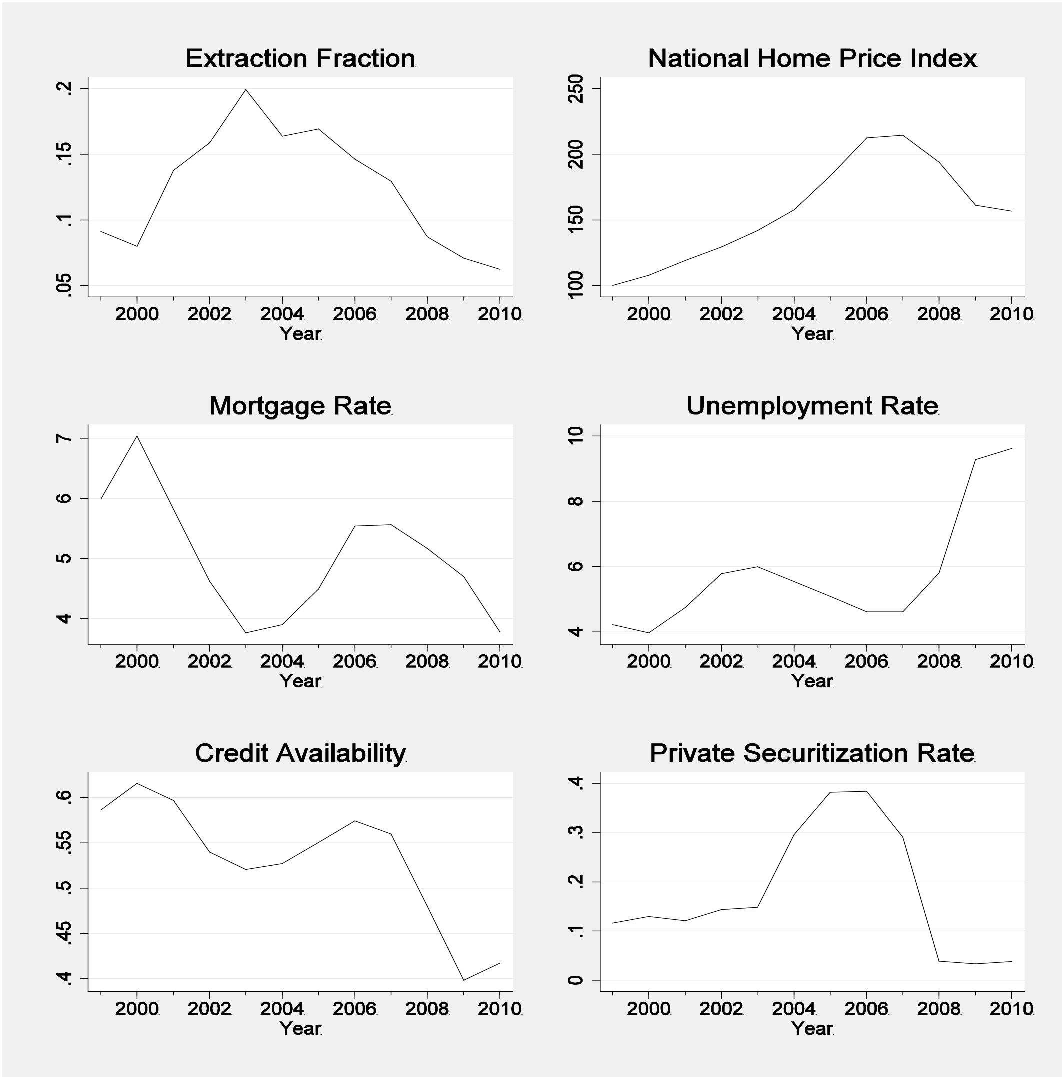
Figure 3. House price growth in Boston, Cleveland and Seattle, 1997-2010



Source: Zillow monthly house price data.

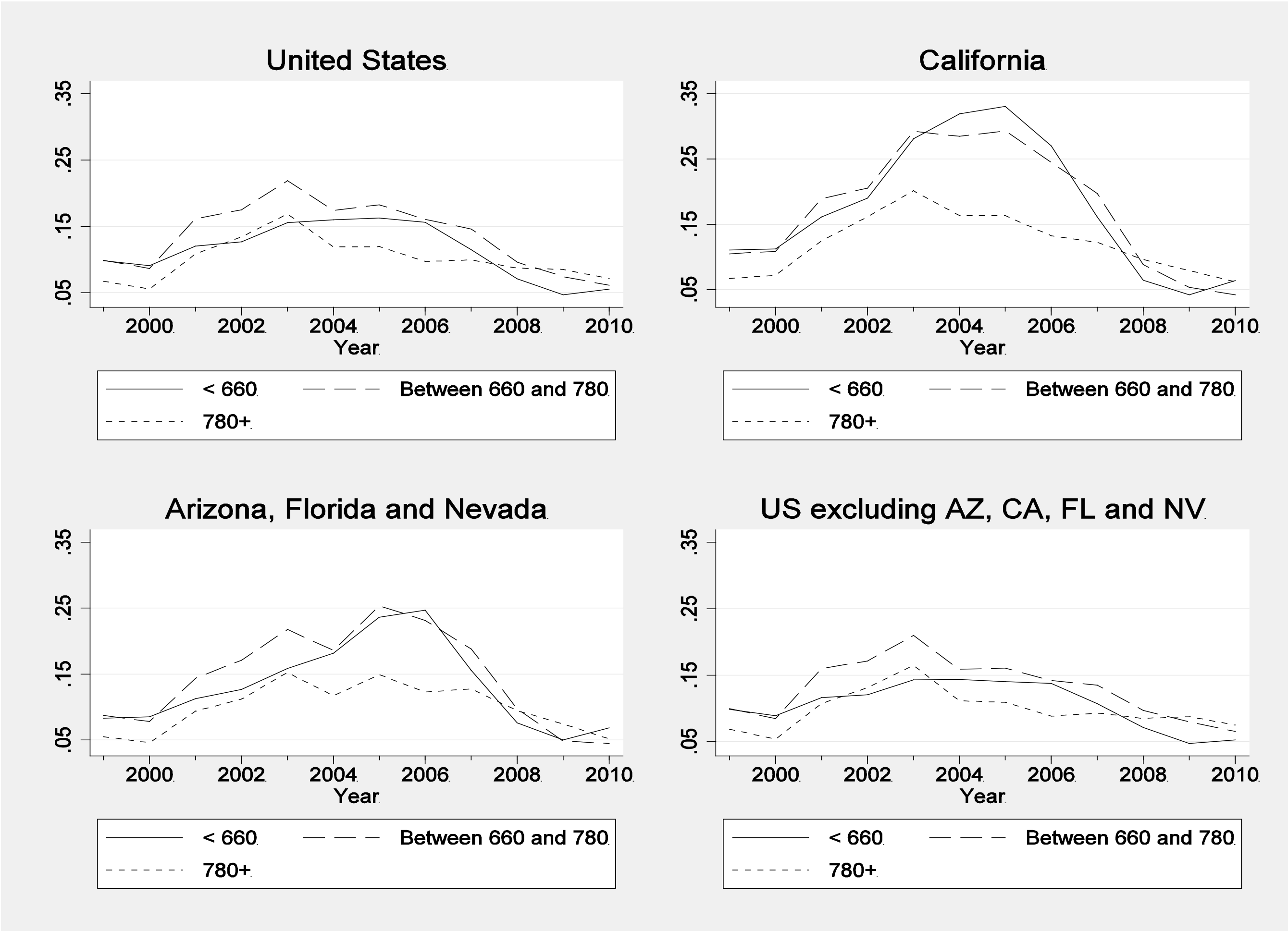
Notes: Data are indexed to equal 100 in July, 1997.

Figure 4. Equity extraction versus other macroeconomic indicators



Sources: FRBNY CCP/Equifax, Freddie Mac PMMS, BLS, CoreLogic, Inside Mortgage Finance.
Notes: Extraction fraction based on our preferred definition of increasing mortgage balances by at least 5 percent; home price index is from CoreLogic; mortgage rate refers to the initial offer rate on a 1-year adjustable rate mortgage according to Freddie Mac; credit availability is derived from the CCP and measures the fraction of marginal applicants for credit of any type who open a new account (see text for more details); the private securitization rate is based on data from Inside Mortgage Finance and measures the fraction of mortgages in securities not guaranteed by Fannie Mae, Freddie Mac or Ginnie Mae.

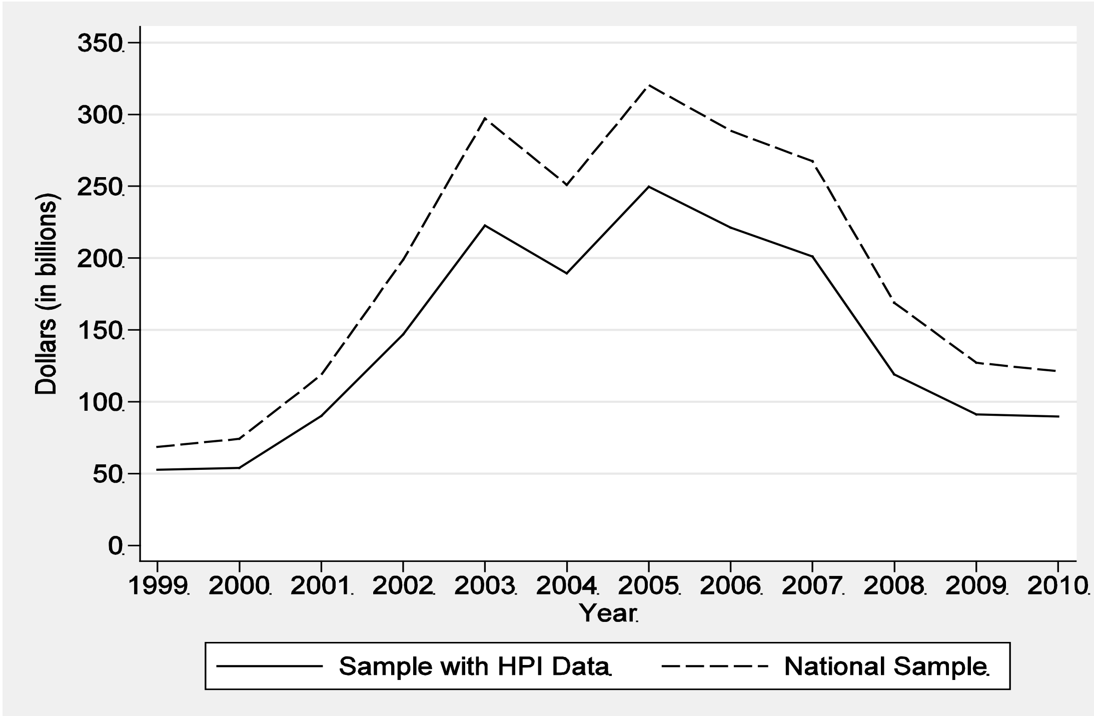
Figure 5. Probability of equity extraction, by credit score group and geography



Source: FRBNY CCP/Equifax.

Notes: Equity extraction identified as an increase of at least 5 percent in total mortgage balance during the year; sample for a given year excludes movers and those with multiple mortgaged properties in the year as discussed in the text. Credit scores of potential extractors measured at the start of the year of potential extraction.

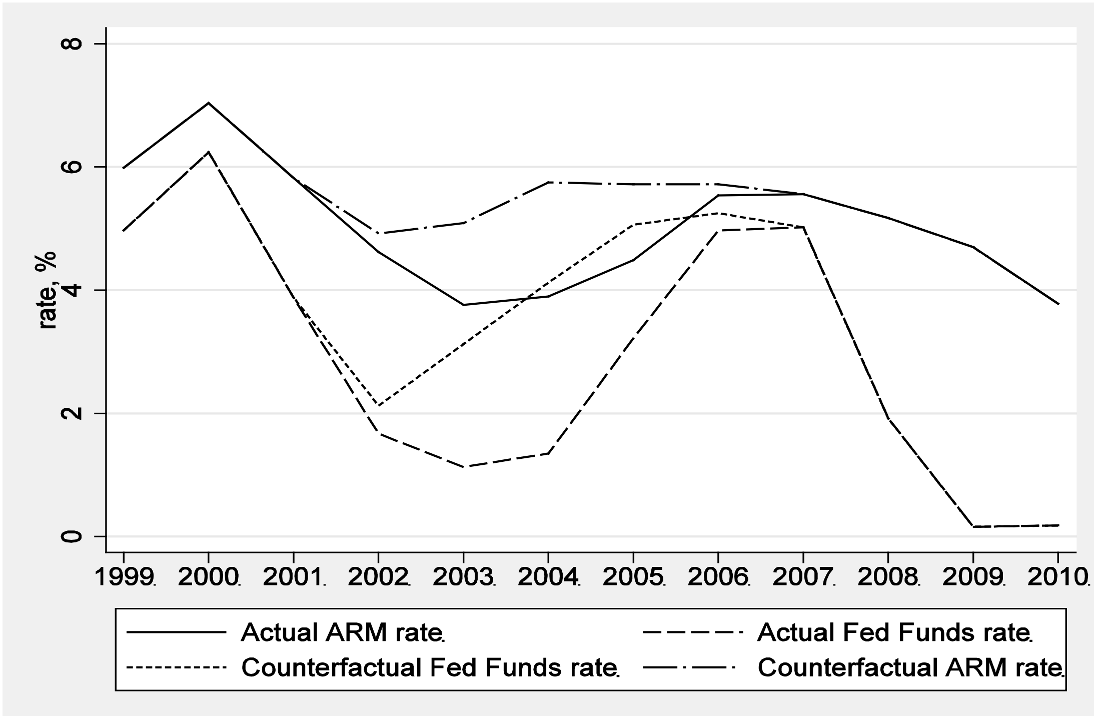
Figure 6. Aggregate equity extraction



Source: FRBNY CCP/Equifax.

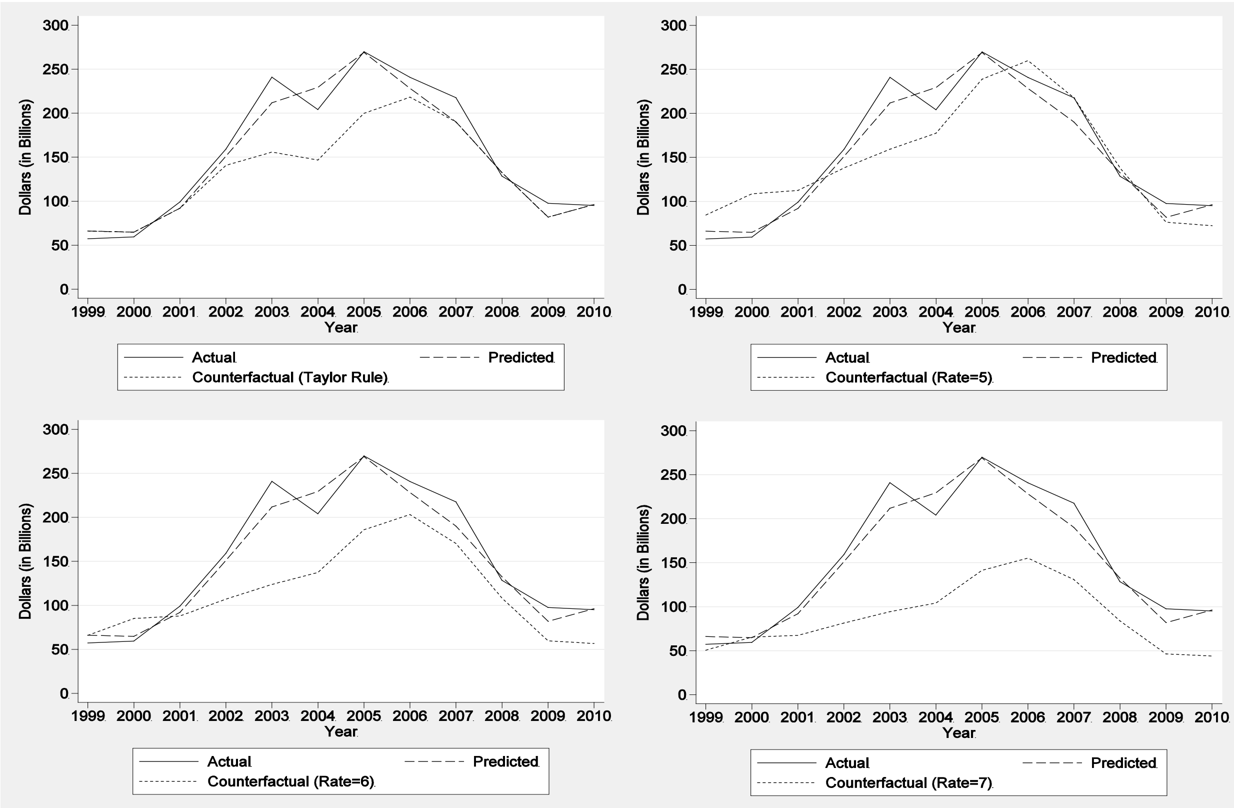
Notes: Aggregate extraction measured as the total increase in mortgage balances across all equity extractors, adjusting for the increased likelihood of sampling joint accounts in the CCP. Equity extraction identified as an increase of at least 5 percent in total mortgage balance during the year; sample for a given year excludes movers and those with multiple mortgaged properties in the year as discussed in the text. National sample refers to aggregate extractions among all potential extractors in CCP; solid line shows our analysis sample of individuals with coverage in the CoreLogic ZIP code house price data.

Figure 7. Counterfactual Interest Rates



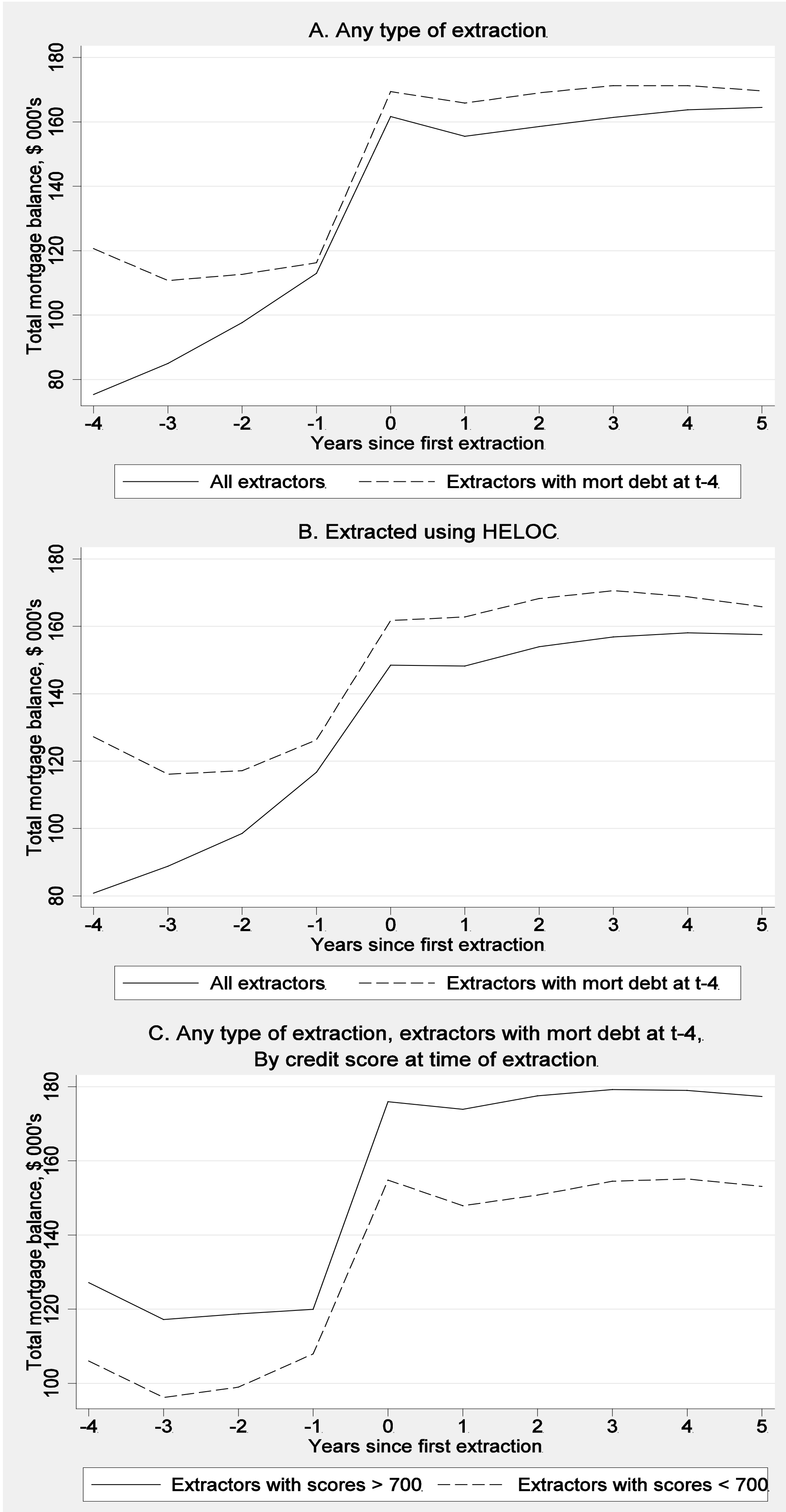
Sources: Federal Reserve, Taylor (2010) and Freddie Mac PMMS.
Notes: The counterfactual Fed Funds rate is taken from Taylor (2010). To obtain the counterfactural 1-year ARM rate, we add 67 percent of the difference between the actual and counterfactual Fed Funds rates to the actual 1-year ARM rate, based on regression results indicating that a 100 basis point increase in Fed Funds is associated with a 67 basis point increase in the ARM rate.

Figure 8. Aggregate equity extraction under counterfactual interest rate scenarios



Notes: 'Actual' refers to actual aggregate amount of extraction in the data, as shown in Figure 6. 'Predicted' refers to predicted aggregate extraction from a two-tiered model of equity extraction (see Section IV.D. of the text for details). 'Counterfactual' refers to predicted equity extraction using the estimated coefficients from our two-tiered model, under alternative interest rates.

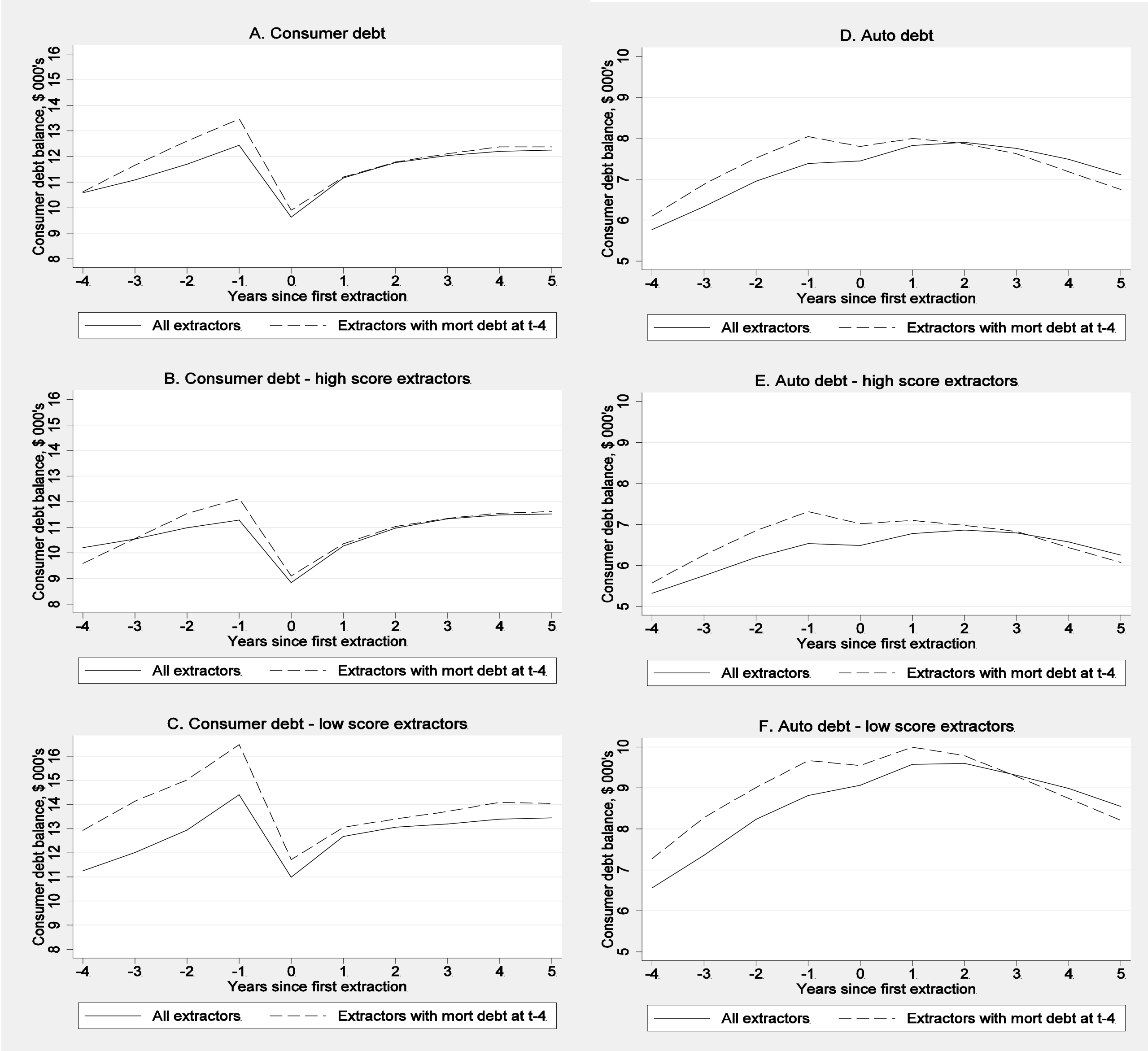
Figure 9. Average mortgage balance before and after extraction



Source: FRBNY CCP/Equifax.

Notes: Each graph uses extractors from all sample years, with time zero corresponding to the end of the year in which the extraction occurred. For those who extracted multiple times, time zero refers to the first extraction. Zero balances are included, but the dashed line in panels A and B conditions on extractors who have positive mortgage debt four years prior to extraction (see text for more details). Middle panel includes only those extractors whose first extraction was through a HELOC. Equity extraction identified as an increase of at least 5 percent in total mortgage balance during the year; sample for a given year excludes movers and those with multiple mortgaged properties in the year.

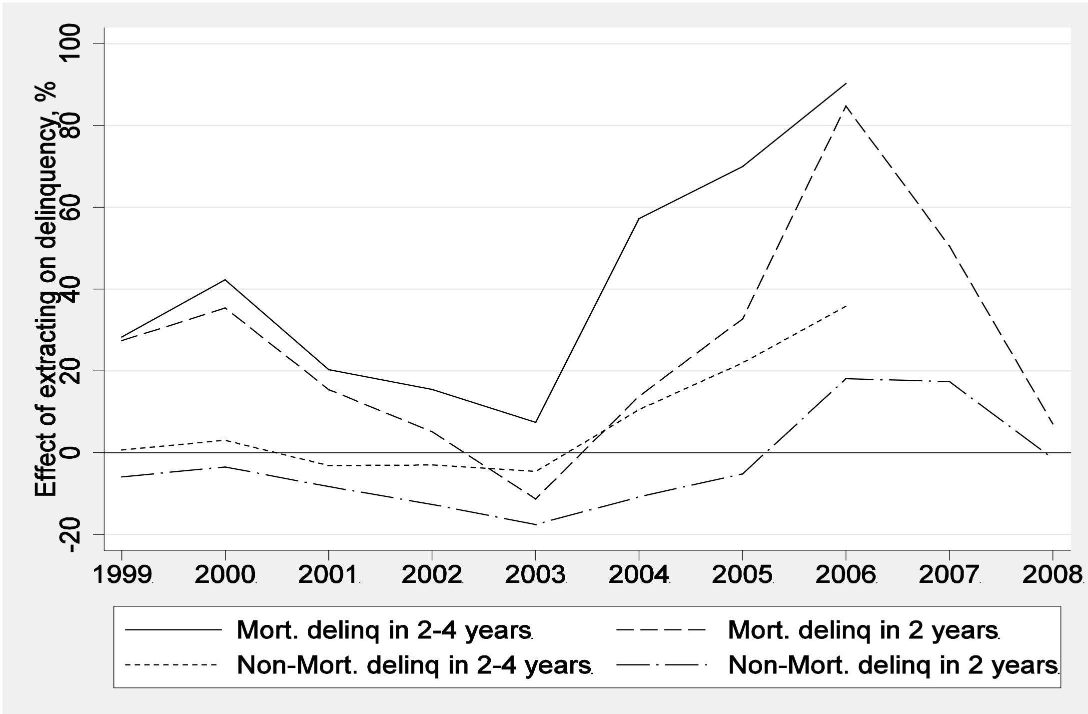
Figure 10. Average consumer debt and auto debt balances before and after home equity extraction



Source: FRBNY CCP/Equifax.

Notes: Each graph uses extractors from all sample years, with time zero corresponding to the end of the year in which the extraction occurred. For those who extracted multiple times, time zero refers to the first extraction. The dashed line conditions on extractors who have positive mortgage debt four years prior to extraction. Consumer debt includes bankcard (revolving and transaction) balances, retail card balances and uncollateralized consumer installment loans. Auto debt includes bank auto loans and auto finance company loans. Zero balances are included when computing averages. High/low score extractors defined as those with Equifax risk score above/below 700 at the end of the year before extraction. Equity extraction identified as an increase of at least 5 percent in total mortgage balance during the year; sample for a given year excludes movers and those with multiple mortgaged properties in the year.

Figure 11. Effect of extracting equity on probabilty of subsequent delinquency, by year of potential extraction



Notes: Graphs plot coefficient estimates on the extract-by-year variables in Table 6, scaled by the mean delinquency rate for the given cohort. See text for more details.

Table 1. Equity extractions by year

						Extractors						Inferred method of extraction			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Year	N	Number Extracting Equity	Fraction Who Extracts	Avg. credit score	Initial balance ($) (median)	Avg. credit score	Initial balance ($) (median)	% Change in balance (median)	% Chng in monthly payment (median)	Share only year with extraction	Share extracted last year	Share Cash-out Refi	Share HELOC Draw	Share 2nd mortgage	Share Other
1999	61,574	5,611	0.091	716.5	82,728	709.3	81,956	22.8	26.3	0.35	--	0.35	0.30	0.24	0.11
2000	68,584	5,484	0.080	721.3	87,400	708.4	88,127	23.2	30.6	0.34	0.09	0.28	0.35	0.29	0.09
2001	67,591	9,306	0.138	718.6	89,056	718.9	95,313	23.8	18.1	0.32	0.08	0.51	0.27	0.12	0.10
2002	81,988	13,015	0.159	715.7	93,570	718.3	101,000	23.6	14.9	0.34	0.13	0.54	0.26	0.08	0.12
2003	88,556	17,656	0.199	715.0	100,000	719.1	104,499	23.2	11.7	0.36	0.15	0.56	0.23	0.06	0.15
2004	86,403	14,146	0.164	720.0	110,000	711.6	122,000	22.4	17.0	0.31	0.21	0.40	0.43	0.08	0.10
2005	95,730	16,212	0.169	725.8	117,000	716.3	134,367	23.2	20.8	0.32	0.20	0.41	0.41	0.08	0.11
2006	95,114	13,913	0.146	730.6	125,396	715.7	142,519	22.0	24.4	0.32	0.23	0.37	0.41	0.12	0.10
2007	97,809	12,671	0.130	730.0	132,090	725.4	139,126	20.2	18.5	0.32	0.21	0.35	0.44	0.11	0.10
2008	102,023	8,878	0.087	729.2	138,242	735.7	123,138	18.7	7.3	0.32	0.20	0.36	0.51	0.06	0.06
2009	101,209	7,177	0.071	729.4	140,558	747.0	111,574	18.0	8.0	0.34	0.17	0.47	0.42	0.04	0.07
2010	100,691	6,268	0.062	728.5	141,118	728.0	110,017	18.8	8.9	0.37	0.15	0.50	0.37	0.05	0.08
All Years	1,047,272	130,337	0.124	724.1	113,000	720.3	114,880	22.1	17.3	--	0.17	0.43	0.36	0.10	0.10

Source: FRBNY CCP/Equifax.

Notes: Sample each year comprised of individuals from the CCP with positive mortgage debt as of the end of the first quarter on just one property, who did not move or accumulate debt on a second property during over the course of the year, and live in ZIP codes covered by the CoreLogic data. Extractors are those whose mortgage debt grows by at least 5 percent after one year. Credit score refers to the Equifax 3.0 Risk Score. Monthly payments reported in Equifax refer to the scheduled payments to the mortgage servicer, which may include taxes and insurance. For details on how the method of extraction is inferred, please see text.

Table 2. Summary Statistics

	Mean	Standard Deviation	Median
1-Year ARM Mortgage Rate Annual Average (%)	4.893	0.946	4.773
ZIP HPI 3-Year Growth (%, annualized)	4.197	8.726	4.615
County Unemp Rate Annual Avg	0.058	0.025	0.052
County Employment 3-Year Growth Rate	0.008	0.024	0.008
County Wage 3-Year Growth Rate	0.033	0.017	0.034
Credit Availability	0.520	0.074	0.538
Private securitization rate	0.180	0.129	0.143

Sources: FRBNY CCP/Equifax, Freddie Mac PMMS, BLS, CoreLogic, Inside Mortgage Finance.
Notes: Summary statistics across all observations in all years. Mortgage rate is the annual average from the Freddie Mac Primary Mortgage Market Survey; home price indices are from CoreLogic; and county employment and wage measures are from the Bureau of Labor Statistics. Credit availability is derived from the CCP and measures the fraction of marginal applicants for credit of any type who open a new account (see text for more details). The private securitization rate is based on data from Inside Mortgage Finance and measures the fraction of mortgages in securities not guaranteed by Fannie Mae, Freddie Mac or Ginnie Mae.

Table 3. Models for whether homeowner *i* extracted equity in year *t*

	Outcome variable is *Extract* $_{it}$ = {0,1}				
	OLS				2SLS[a]
	(1)	(2)	(3)	(4)	(5)
1-year ARM Mtg Rate	-0.0147**	-0.0231**	-0.0307**	-0.0290**	-0.0349**
	(0.0021)	(0.0022)	(0.0018)	(0.0014)	(0.0021)
Zip Code HPI Growth		0.0052**	0.0040**	0.0042**	0.0038**
		(0.0002)	(0.0002)	(0.0002)	(0.0001)
Credit Availability			0.1484**	0.1877**	0.1904**
			(0.0428)	(0.0310)	(0.0439)
Private Securitization Rate			-0.0004	-0.0455**	-0.0077
			(0.0148)	(0.0074)	(0.0156)
County Unemployment Rate			-0.2418**	-0.1925	-0.2575**
			(0.0622)	(0.0997)	(0.0604)
County Employment Growth			0.0452	-0.0678	0.0797*
			(0.0382)	(0.0467)	(0.0396)
County Wage Growth			-0.1102	-0.0688	-0.0765
			(0.0822)	(0.0752)	(0.0732)
Has a HELOC at Start of Year				0.0685**	
				(0.0035)	
Credit card utilization (zero balance omitted)					
0 < utilization =< .5				0.0001	
				(0.0012)	
.5 < utilization =< .75				0.0172**	
				(0.0022)	
.75 < utilization =< 1				0.0094**	
				(0.0021)	
utilization > 1				-0.0092**	
				(0.0023)	
no credit ards				0.0010	
				(0.0010)	
ln(initial mort balance)				-0.0120**	
				(0.0022)	
ln(1+initial non-mort balance)				0.0141**	
				(0.0006)	
Zero initial non-mort bal (dummy)				0.0876**	
				(0.0038)	
ln(Borrower Age)				-0.0231**	
				(0.0025)	
Borrower age missing dummy				-0.1155**	
				(0.0116)	
Credit Score a Start of Year (< 520 omitted)					
520-579				0.0207**	
				(0.0040)	
580-659				0.0438**	
				(0.0060)	
660-739				0.0400**	
				(0.0059)	
740-800				0.0183**	
				(0.0047)	
800+				0.0048	
				(0.0048)	
credit score missing				-0.0568*	
				(0.0282)	
State fixed effects	Y	Y	Y		Y
Zip code fixed effects				Y	
Origination year fixed effects[b]				Y	
R-squared	0.007	0.0244	0.0249	0.0703	0.0249
N	1,047,272	1,047,272	1,046,223	1,046,223	1,046,223

Notes: * p < 0.05; ** p < 0.01. Standard errors, clustered at state level, in parentheses. See notes for Tables 1 and 2 text for more on data sources, sample selection and variable definitions. Credit score refers to the Equifax 3.0 Risk Score. Age estimated from year of birth.

a. Two-stage least squares, using annual average Fed Funds rate as an instrument for the mortgage rate.

b. Year of origination for person *i* 's implied first lien closed-end mortgage; those with only a HELOC have a separate dummy.

Table 4. Alternative models for whether homeowner *i* extracted equity in year *t*

	Outcome variable is $Extract_{it}$ = {0,1}					
	(1)	(2)	(3)	(4)	(5)	(6)
					Cashout (mean outcome = 0.054)[a]	Junior lien (mean outcome = 0.058)[b]
1-year ARM Mtg Rate	-0.0214**	-0.0273**	-0.0302**	-0.0283**	-0.0180**	-0.0063**
	(0.0017)	(0.0013)	(0.0023)	(0.0016)	(0.0011)	(0.0007)
Zip Code HPI Growth	0.0041**	0.0042**	0.0042**	0.0039**	0.0030**	0.0009**
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0001)
(Short Mtg Rate)*(HPI growth)[c]	-0.0011**					
	(0.0002)					
30-Year Fixed Mtg Rate			0.0034			
			(0.0043)			
Extracted last year[d]				0.0375**		
				(0.0053)		
Time Trend		Y				
R-squared	0.0706	0.0704	0.0249	0.0729	0.0358	0.0585
N	1,046,223	1,046,223	1,046,223	984,826	1,032,732	1,032,732

Notes: * $p < 0.05$; ** $p < 0.01$. Standard errors, clustered at state level, in parentheses. See notes for Tables 1 and 2 text for more on data sources, sample selection and variable definitions. All regressions include controls shown in Column 4 of Table 3.

a. Outcome variable equals one for cash-out refinance extractions and zero otherwise; undefined extractions (last column of Table 1) excluded.

b. Outcome variable equals one for HELOC or home equity installment extractions and zero otherwise; undefined extractions (last column of Table 1) excluded.

c. Mortgage rate re-centered to have mean equal to zero.

d. Borrowers not eligible for inclusion in sample in previous year get a zero value, and a separate indicator for the exclusion reason (e.g. did not have a mortgage) was included in the regression.

Table 5. Combined intensive margin and extensive margin estimates of the effect of interest rates and house price growth on dollar amount extracted

	Dollar change	Percent change
Change in amount extracted given a one standard deviation increase in interest rate	-$1,716.12	-22.7%
Change in amount extracted given a one standard deviation increase in 3-year annual HPI growth	$2,888.16	38.2%

Notes: Table shows combined extensive and intensive margin estimates based on a two-tiered model combining probit estimates of the probability of extracting equity with OLS estimates of the amount extracted given extraction (see text in Section IV.D for details). Percent changes calculated relative to a baseline average extraction amount of $7,558, including zeros for homeowners who do not extract. See Table 2 for standard deviations. Changes computed using sample means of variables, and the state fixed effect of the most common state of residence, California.

Table 6. OLS estimates of effect of interest rates and home price growth on the probability of extraction, by homeowner age and credit score

		Under 40 years old			Over 40 years old		
		Coefficient	SE	Semi-elasticity	Coefficient	SE	Semi-elasticity
Score > 739	Mortgage Rate	-0.0376	(0.00268)	**-0.357**	-0.0268	(0.00153)	**-0.235**
	Zip code HPI growth	0.0042	(0.00021)	**0.040**	0.0027	(0.00020)	**0.024**
	N	126,302			452,846		
	Fraction who extracts	0.105			0.114		
Score 660 - 739	Mortgage Rate	-0.0436	(0.00330)	**-0.301**	-0.0369	(0.00247)	**-0.233**
	Zip code HPI growth	0.0066	(0.00037)	**0.046**	0.0050	(0.00021)	**0.031**
	N	80,818			164,730		
	Fraction who extracts	0.145			0.158		
Score 580 - 659	Mortgage Rate	-0.0344	(0.00396)	**-0.244**	-0.0318	(0.00364)	**-0.216**
	Zip code HPI growth	0.0066	(0.00069)	**0.047**	0.0050	(0.00032)	**0.034**
	N	43,888			81,820		
	Fraction who extracts	0.141			0.147		
Score < 580	Mortgage Rate	-0.0143	(0.00326)	**-0.160**	-0.0194	(0.00227)	**-0.190**
	Zip code HPI growth	0.0033	(0.00071)	**0.037**	0.0025	(0.00047)	**0.025**
	N	35,183			60,619		
	Fraction who extracts	0.089			0.102		

Notes: Standard errors, clustered at state level, in parentheses. Borrower age estimated from year of birth reported in the CCP. Credit score refers to the Equifax 3.0 Risk Score; see text for more details. Semi-elasticity for a given group calculated as the regression coefficient divided by the fraction who extracts. Separate regressions were run for each group; each regression includes the basic set of controls as in column 3 of Table 3.

Table 7. Estimates of the effect of equity extraction on future delinquency

Outcome variable	Mortgage debt		Non-mortgage debt	
	60+ days late 1 or 2 years later	60+ days late 1,2,3 or 4 years later	60+ days late 1 or 2 years later	60+ days late 1,2,3 or 4 years later
Extract*1[t=1999]	0.0070**	0.0115**	-0.0064	0.0010
	(0.0025)	(0.0031)	(0.0039)	(0.0044)
Extract*1[t=2000]	0.0095**	0.0174**	-0.0038	0.0045
	(0.0027)	(0.0033)	(0.0042)	(0.0049)
Extract*1[t=2001]	0.0044*	0.0089**	-0.0100**	-0.0050
	(0.0019)	(0.0025)	(0.0032)	(0.0035)
Extract*1[t=2002]	0.0014	0.0069**	-0.0155**	-0.0048
	(0.0015)	(0.0019)	(0.0024)	(0.0029)
Extract*1[t=2003]	-0.0031*	0.0037*	-0.0208**	-0.0075**
	(0.0012)	(0.0017)	(0.0023)	(0.0026)
Extract*1[t=2004]	0.0036*	0.0363**	-0.0114**	0.0169**
	(0.0016)	(0.0024)	(0.0029)	(0.0032)
Extract*1[t=2005]	0.0111**	0.0609**	-0.0057*	0.0380**
	(0.0021)	(0.0040)	(0.0023)	(0.0035)
Extract*1[t=2006]	0.0458**	0.0951**	0.0216**	0.0630**
	(0.0033)	(0.0051)	(0.0033)	(0.0045)
Extract*1[t=2007]	0.0431**		0.0236**	
	(0.0036)		(0.0041)	
Extract*1[t=2008]	0.0072*		-0.0021	
	(0.0032)		(0.0030)	
Credit Score at start of year of potential extraction (< 520 omitted)[a]				
520-579	-0.0382**	-0.0424**	-0.0914**	-0.0741**
	(0.0040)	(0.0048)	(0.0041)	(0.0041)
580-659	-0.0996**	-0.1192**	-0.2214**	-0.2194**
	(0.0044)	(0.0056)	(0.0042)	(0.0046)
660-739	-0.1556**	-0.1979**	-0.3722**	-0.4241**
	(0.0049)	(0.0063)	(0.0047)	(0.0054)
740-800	-0.1781**	-0.2301**	-0.4261**	-0.5102**
	(0.0046)	(0.0063)	(0.0047)	(0.0055)
800+	-0.1827**	-0.2317**	-0.4297**	-0.5175**
	(0.0045)	(0.0062)	(0.0047)	(0.0055)
Credit card utilization (zero balance omitted)[b]				
0 < utilization =< .5	-0.0026**	-0.0032*	-0.0078**	-0.0091**
	(0.0009)	(0.0013)	(0.0011)	(0.0017)
.5 < utilization =< .75	0.0025	0.0041*	0.0223**	0.0235**
	(0.0014)	(0.0018)	(0.0021)	(0.0028)
.75 < utilization =< 1	0.0082**	0.0086**	0.0441**	0.0434**
	(0.0014)	(0.0020)	(0.0018)	(0.0026)
utilization > 1	0.0241**	0.0294**	0.1100**	0.1123**
	(0.0034)	(0.0041)	(0.0039)	(0.0045)
Has a 60+ days late mortgage at start of year of potential extraction	0.1314**	0.1219**		
	(0.0048)	(0.0059)		
Has a 60+ days late non-mortgage at start of year of potential extraction			0.2054**	0.1832**
			(0.0040)	(0.0047)
Has any 30+ days late accounts at start of year of potential extraction	0.0024	-0.0038	-0.0006	-0.0098**
	(0.0019)	(0.0025)	(0.0032)	(0.0037)
Extract next year[c]	-0.0058**	0.0154**	-0.0246**	-0.0035*
	(0.0007)	(0.0012)	(0.0011)	(0.0014)
ZIP HPI growth last 3 years	-0.0472*	0.0491	-0.0281	0.0251
	(0.0201)	(0.0346)	(0.0230)	(0.0330)
ZIP HPI growth next 3 years	-0.1841**	-0.1951**	-0.0809**	-0.1164**
	(0.0253)	(0.0289)	(0.0235)	(0.0318)
Constant	0.2302**	0.3507**	0.5470**	0.7532**
	(0.0201)	(0.0299)	(0.0293)	(0.0415)
R-squared	0.1517	0.154	0.3257	0.3377
N	804,043	613,254	804,043	613,254

Notes: * $p < 0.05$; ** $p < 0.01$. Standard errors, clustered at county level, in parentheses. All regressions include county-by-year fixed effects. All regressions also include individual-level controls for age, initial mortgage balance, initial non-mortgage balance, joint account status, and whether the borrower had a HELOC account at the start of the year of potential extraction, as well as census-tract level demographic controls for the black share of the population, Hispanic share of the population, owner-occupied share of housing units, share of adult population with a college degree or higher, median family income, and median house value. For brevity, these coefficent estimates are suppressed.

a. We include a separate category for the few whose credit score is missing

b. We include a separate category for those without any credit card accounts

c. For those out of sample in the following year, we set the 'extract next year' variable to zero and include an 'out of sample' indicator variable.

Readers with comments may address them to:

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1. Lee Anne Fennell and Eduardo M. Peñalver, Exactions Creep, December 2013
2. Lee Anne Fennell, Forcings, November 2013
3. Neil Bhutta and Benjamin J. Keys, Interest Rates and Equity Extraction during the Housing Boom, January 2014