# Interest Rates and Equity Extraction During the Housing Boom*

Neil Bhutta
Federal Reserve Board

Benjamin J. Keys
Harris School of Public Policy
University of Chicago

July 2015

**Abstract**

Using credit record panel data from 1999–2010, we show that the likelihood of home equity extraction (borrowing, on average, about $40,000 against one's home) peaked in 2003 when mortgage rates hit historic lows, and estimate that a 100 basis point rate decline is associated with a 25 percent rise in the likelihood of extraction. Further, this relationship is amplified in ZIP codes with substantial house price growth. Differential responses to interest rates and home price appreciation by age and credit score provide new evidence of financial frictions. Finally, equity extraction is associated with higher default risk, especially for extractors in 2006 who were more than twice as likely to become delinquent on a mortgage than non-extractors over the next four years.

*We thank Mark Aguiar, Moshe Buchinsky, Brian Bucks, John Campbell, Glenn Canner, Jane Dokko, Ryan Goodstein, Neale Mahoney, Michael Palumbo, Karen Pence, Amit Seru, Jeremy Tobacman, Razvan Vlahu, Jiro Yoshida, two anonymous referees, and seminar participants at the American Economics Association Meetings, NBER Summer Institute Real Estate Workshop, Federal Reserve Bank of Chicago, AREUEA Mid-year Conference, FDIC Consumer Research Symposium, UC-Davis GSM Household Finance Conference, Western Economics Association Meetings, and Penn State Risk Management Symposium for helpful comments and suggestions. Cailin Slattery provided outstanding research assistance. The views expressed are those of the authors and do not necessarily reflect the opinions of the Federal Reserve Board or its staff. Any remaining errors are our own. First draft: October 2012.
Contact: neil.bhutta@frb.gov; benkeys@uchicago.edu.

# 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 policymakers have 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.

Previous literature provides compelling evidence that the Federal Reserve can significantly influence market interest rates, including mortgage rates, across the maturity spectrum, representing the first step in the transmission of monetary policy (e.g. Kuttner 2001, Gilchrist et al. 2013). In this paper, we provide novel evidence on a second step in the transmission process: home-equity based borrowing, or "equity extraction," by households in response to mortgage rate fluctuations.

Equity extraction in general 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 nearly $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."

To study equity extraction, we use a large, nationally representative borrower-level panel dataset

[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.

of consumer credit records, the Federal Reserve Bank of New York's Consumer Credit Panel (CCP), which provides details on the liability side of individuals' balance sheets at a high frequency. Figure 1 presents our estimate of the fraction of homeowners who extracted 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 hit lows.[2]

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.

To identify the response of household equity extraction to interest rates, we start by relying on our detailed micro data to control for employment shocks and household liquidity positions, including controls for employment and income trends at the county level, house price trends at the ZIP code level, and household-level variables such as age, credit score, and credit utilization rates. In addition, to account for variation in regional lending conditions over time, we create a novel measure of credit acceptance rates using the CCP data. While interest rates vary at the national level, other economic and housing conditions that drive household decisions vary substantially across the country and thus disaggregated data significantly improves our ability to separately identify the role of interest rates from other potential determinants of equity extraction.

After including all of these controls, we find that a 100 basis point (bps) drop in mortgage rates (about one standard deviation) is associated with a three percentage point rise in the likelihood of

[2]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 concurrent boom in equity extraction. As we describe later, the average extraction amount is about $40,000 and thus extractions go well beyond decisions simply to refinance.

extraction, or 27 percent relative to the average extraction rate of 11 percent over the observation period. We also find that, during this period, the relationship between extraction and interest rates was similar in magnitude to the relationship with home price growth.[3]

Notably, because interest rates are set at the national level, we cannot include time fixed effects in these specifications. Thus, a key identification assumption is that our set of time-varying controls at the individual, local, and regional levels capture potentially confounding drivers of the choice to extract home equity. Any remaining unobserved aggregate shocks affecting extraction that are orthogonal to our controls (including house price changes) and yet correlated with interest rate fluctuations would threaten identification. While it may be difficult to conceive of a preference or supply shock of this nature (i.e. something other than interest rates that might have led to rising extraction from 2000-2003 and declining extraction even as the housing market continued to boom), we caution a causal interpretation.

To provide further evidence of a link between rates and extraction, we estimate models focusing on the interaction effect between rates and house price growth, which omit the main effect of interest rates but crucially allow us to include time fixed effects. Geographic variation in the timing of housing cycles implies that interest rates will differ for a given set of housing conditions.[4] With sufficient variation in local house price growth (measured at the ZIP code level), we are able to include time fixed effects to account for aggregate shocks that drive extraction decisions (including rate movements).

For example, Figure 2 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. In addition, some cities like Cleveland experienced little home price growth throughout the period. The interactive approach asks whether homeowners in Boston (for example) were differentially more likely to extract equity than homeowners in Seattle, since Boston's housing

[3]Unlike Mian and Sufi (2011), we do not instrument for house price growth, which may lead to upward biased estimates of the effect of house price growth on extraction if our controls do not account for economic factors that would increase both home prices and borrowing (Attanasio et al. 2009). That said, 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]Ferreira and Gyourko (2012) document the wide variation in the timing of housing booms across the U.S. Online Appendix Figure 1 shows the wide variation in year-over-year house price growth for 80 major housing markets.

boom coincided more closely with the drop in interest rates.

Indeed, we find that interest rates significantly enhance the effect of home price growth on equity extraction decisions and vice versa, highlighting the potential importance of asset and collateral values in the transmission of monetary policy. This interaction effect is especially strong during the boom years of 1999—2007, but attenuates during the bust when home price growth turned negative in almost every ZIP code across the nation. We estimate that a 100 basis point decline in interest rates amplifies the effect of house price growth on extraction by 25 to 30 percent.

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. 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), but our lack of information on older homeowners' consumption out of liquid assets instead of borrowing complicates this interpretation. That said, 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 evidence for binding collateral constraints that might propagate cyclical fluctuations (e.g. Kiyotaki and Moore 1997, Iaocoviello 2005).

Finally, we examine the longer-term implications of equity extraction for homeowner leverage and risk and highlight two key findings. First, using an event-study framework, we find that while the average extraction amount is about \$40,000, only about \$2,500 is used to reduce relatively expensive uncollateralized consumer debts. Second, in any given year, and conditional on county-by-year fixed effects and an extensive array of borrower credit characteristics, those extracting equity are more likely to become delinquent over the next four years than non-extractors. Extractors in 2006 were over twice as likely as non-extractors to become delinquent on mortgage debt, and almost 40 percent more likely to become delinquent on *non*-mortgage debt. These results suggest that extractors may not be using the funds to control borrowing costs or diversify their portfolio, and that liquidity issues were an important factor in driving up default rates during the housing bust, in contrast to "ruthless" defaults where homeowners walk away only from their mortgage debt (see, e.g., Bhutta et al. 2010, Foote et al. 2008).

To our knowledge, our paper is the first to closely examine the relationship between interest rates and equity extraction, and how this relationship might interact with home prices. While there is a large literature on mortgage refinance decisions, less work has been done on decisions to extract home equity, perhaps in part because of data limitations. Similar to Mian and Sufi (2011), we use consumer credit record data to help overcome these limitations. Whereas Mian and Sufi focus on the role of house prices using cross-sectional data, we simultaneously explore time series and cross-sectional variation in extraction using higher frequency panel data. Hurst and Stafford (2004) use a small household survey to study equity extraction decisions in response to unemployment shocks in the early 1990s, and Chen et al. (2015) map this idea into a theoretical model to try to understand the growth in household leverage during the housing boom.[5] The size, frequency, comprehensiveness and panel aspect of the CCP provide new opportunities to study macroeconomically important household borrowing decisions at the micro level, and contribute to a growing literature on the responsiveness of households to monetary policy (see, e.g. Christiano et al. 1996; Aladangady 2014; DiMaggio et al. 2014; Keys et al. 2014). These features of the data help us plausibly separate the effects of home prices and interest rates on extraction decisions, and study how equity extractions contributed to mortgage defaults during the housing crisis.[6]

The next section outlines a theoretical framework for the equity extraction decision. Section III describes our data sources, provides our empirical approach, and discusses how monetary policy influences mortgage rates. 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 recent housing crisis.

## II Conceptual Framework

In this brief section, we motivate our empirical approach by discussing the household equity extraction decision. An optimizing homeowner who maximizes over multiple periods may want to increase collateralized borrowing against his home for a number of reasons. First, a widening in the difference between current and future income, which could reflect either a negative shock to

[5] See also work by Greenspan and Kennedy (2008) and Disney and Gathergood (2011) on macro patterns of extraction, and Cooper (2010) and Lovenheim (2011) on consumers' use of borrowed home equity funds.

[6] Laufer (2013) studies the link between extraction and default, but his data are limited to Los Angeles.

current income or a positive shock to expected future income, may encourage borrowing in the current period (Hurst and Stafford 2004). Next, a relaxation in credit standards allows households to borrow more at a given income level or house value, relaxing either a debt-to-income (DTI) or loan-to-value (LTV) constraint, respectively.[7]

Two additional potential reasons for borrowing are theoretically ambiguous in their sign. First, the focus of our paper is how home equity extraction responds to changes in interest rates. A drop in the price of credit makes borrowing more desirable and reduces debt service payments, which can relax a household's debt-to-income constraint. However, other factors make the effect of a rate decline theoretically ambiguous. For example, there may be an offsetting income effect for some subset of households where, as rates fall, more saving is required to afford the same amount of future consumption.[8]

Moreover, there may be institutional or behavioral reasons that influence the relationship between interest rates and borrowing. For example, households that face collateral constraints (such a limit on their LTV ratio) will be unable to respond to interest rate shocks if they are near the collateralized leverage constraint. We will explore this constraint empirically. In addition, individuals may be inattentive to changes in the costs of borrowing, as a growing literature on failure to refinance has documented (Deng et al. 2000; Hubbard and Mayer 2009; Keys et al. 2014; Andersen et al. 2014).

Second, an increase in the value of collateral could either increase or decrease borrowing. Generally an increase in home values will both increase the value of consumption smoothing across periods because of a wealth effect and also relax a collateral constraint that makes desired borrowing feasible. However, some households may not be able to borrow against their home equity if there is a binding payment-to-income constraint. Also, if a homeowner—particularly younger homeowners—anticipates climbing the property ladder to consume substantially more housing in the future, this increase may actually make the homeowner worse off, leading to a reduction in borrowing. Alternatively, a rise in house prices increases the implicit rental cost of the home, which may have no impact on either real wealth or consumption decisions (see, e.g. Sinai and Souleles

[7]For a recent cross-country discussion of financial liberalization with regard to consuming out of home equity, see Aron et al. (2012). In Geanakoplos (2009), these credit constraints vary over time in response to house price trends, amplifying boom and bust cycles.

[8]For a detailed discussion, see Elmendorf (1996).

2005).

Using data from the U.K., Campbell and Cocco (2007) find that older consumers are more responsive to house price shocks. In contrast, in the U.S., research prior to the 2000s has found that older households seldom tap into their home equity, perhaps in part because of bequest motives (see, e.g., Hurd 1990; Venti and Wise 1991; Mayer and Simons 1994). In our analysis below, we explore the relationship between age and extraction patterns directly for the U.S. context over the housing boom and bust.

An important caveat to this discussion is that additional extraction is not necessarily equivalent to additional consumption. Households may increase consumption out of liquid savings rather than borrowing, and extracted equity may be used to purchase assets for diversification purposes. 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—which has an investment component but provides little diversification—and 13% say they invested some funds in the stock market or other financial investment (see Table 6 of Canner et al. 2002). Given our data on the credit side of the household ledger, we are unable to directly observe whether the funds extracted are put towards consumption or to these asset-building or –diversifying efforts. We next turn to describing this data in more detail.

## III Data, Methodology, and Identification

Our primary objective in this paper is to study the effect of interest rates on households' decisions to borrow against their home equity. In the first part of this section we discuss the credit record and house price data, and how we define "extraction." The second part discusses methodology, identification, and some of the other data sources used. Finally, the third section describes the link between Federal Reserve actions and mortgage rates.

### III.A Credit Record and House Price Data

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.[9]

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.[10] 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 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.[11] Information on house prices at such a disaggregated level is potentially important for obtaining precise estimates of the relationship between house price appreciation and equity extraction given the within-MSA heterogeneity in house price dynamics documented by others (Dorsey et al. 2010; Ferreira and Gyourko 2012; Glaeser et al. 2013).

To make the dataset more manageable we draw a 10 percent sample from the CCP data, implying a 0.5 percent sample of the U.S. 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

[9]For more information on the CCP, see Lee and van der Klaauw (2010). Individuals records are linked over time through a unique, anonymous consumer identification number assigned by Equifax.

[10]Similar to the FICO score, the Equifax 3.0 model 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.

[11]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. Online Appendix Figure 3 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.

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).[12] 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 $1,000. This minimum 5% increase matches the definition of cash-out refinancing used by Freddie Mac. 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.[13] Thus, if a borrower's total mortgage debt rises from $100,000 to $125,000, 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.[14]

## III.B Methodology and Identification

There are two basic challenges in identifying the effect of interest rates on the likelihood that a homeowner will extract equity. First is a potential reverse causality problem. An exogenous surge in credit demand in general, including a surge in home equity borrowing, might cause interest rates to rise depending on the elasticity of credit supply. This effect would induce a bias toward finding a positive relationship between interest rates and equity extraction (i.e. against the negative relationship that we find).

Second is a potential omitted variables problem. In a poor economic environment, for example,

[12] 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 three or more mortgage accounts, (2) he has exactly two closed-end mortgages where the smaller loan is at least one-third the size of the larger, or (3) he has two or more home-equity lines of credit (HELOC), or a HELOC with a line size that is more than 50 percent the size of his only closed-end loan.

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

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

at a given interest rate more homeowners may want to extract equity to smooth consumption through a shock to liquidity (Hurst and Stafford 2004). At the same time, the Fed would likely lower rates in response to the weak economy. In this case, the bias would lead to an overstatement of the role of lower interest rates in the equity extraction decision, but an omitted variable in the opposite direction is also plausible.

Our primary approach to identification is to take advantage of our detailed micro data to control for employment shocks, housing conditions, and household liquidity positions that might influence borrowing and be correlated at an aggregate level with interest rates. More specifically, we regress an indicator variable for extracting equity on interest rates while controlling for employment and income trends at the county level, house price trends at the ZIP code level, and measures of liquidity at the household level:

$$\begin{aligned} extract_{itzc} = \quad & \alpha + \beta_1(rate_t) + \beta_2(HPIgrowth_{tz}) + \beta_3(creditconditions_t) \\ & + \beta_4(securitizationrate_t) + \beta_5(unemp_{tc}) + \beta_6(empgrowth_{tc}) \\ & + \beta_7(wagegrowth_{tc}) + X_{it}\Gamma + \delta_c + \epsilon_{itzc} \end{aligned}$$

for person $i$ in ZIP code $z$ and county $c$ during year $t$.[15] In the above equation, $HPIgrowth$ represents the average annual house price growth rate over the past 3 years; $empgrowth$ the average annual employment growth over the past 3 years; $wagegrowth$ the average annual growth in the average wage per worker over the past 3 years; and $unemp$ the average unemployment rate during the year.[16] We also include county fixed effects, $\delta_c$, to account for constant geographic differences.

The vector $X_{it}$ includes a number of individual-level covariates from the credit bureau data including age, credit score, total mortgage and non-mortgage debt, and credit card utilization rate, measured at the start of a given year. These variables help capture liquidity and creditworthiness. Notably, they also allow us to explore heterogeneous effects across the age and creditworthiness distributions as an indirect test for credit constraints. Finally, $X_{it}$ also includes a dummy for whether the homeowner has a HELOC at the start of the period (which might make it easier to

[15] In an Online Appendix section, we simultaneously examine both the extensive margin (choosing to extract) and intensive margin (how much money to extract) of extraction.

[16] The county-level labor market data are from the Bureau of Labor Statistics.

quickly tap into home equity) and a set of fixed effects for the year of origination of the primary mortgage held at the start of a given year.

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 (i.e. a credit score between 550 and 620) who were able to obtain credit (of any type) during the year. This measure contrasts with previous measures of credit availability, which have relied on bank-level surveys of "loosening" or "tightening" standards and are not easily quantified. Our measure provides a simple summary measure of credit availability that varies over time and space: For example, about 60 percent of marginal consumers across the country actively searching for credit opened a new account in 2006, declining sharply to just 34 percent by 2009 in west division states like California and more moderately to about 50 percent in south central states like Texas. Unfortunately, our credit availability measure is not mortgage-specific, so we cannot separately isolate access to mortgage credit, which may have had a somewhat different time-series pattern over this period relative to other sources of consumer credit. To help capture mortgage-specific credit conditions, we also include a measure of the private securitization rate each year (that is, securitized by institutions unaffiliated with the government such as Fannie Mae, Freddie Mac and Ginnie Mae), calculated from Inside Mortgage Finance (see Keys et al. 2010).[17]

Regarding *rate*, we initially focus on short-term mortgage rates for 30-year adjustable rate mortgages (ARMs), which may be most closely tied to monetary policy. The mortgage rate data are annual averages of offer rates from Freddie Mac's Primary Mortgage Market Survey (PMMS), a weekly survey of mortgage lenders. Equity extraction activity could respond to shorter-term rates because rates for HELOCs and home equity loans are priced off of the shorter end of the yield curve, and ARMs tend to be popular among those who take cash-out when refinancing (Canner et al. 2002). Of course, in the U.S. 30-year fixed rate mortgages (FRMs) are popular. Notably, as we discuss in the next subsection, previous research suggests the Fed also influences FRM rates. Given some ambiguity in the best choice for the *rate* variable, we also show results for FRM and Federal Funds Rates, as well as instrumenting *rate* with the Federal Funds Rate, which may help solve what might be viewed as an errors-in-variables problem, and makes the link between monetary

[17]Online Appendix Figure 2 presents a plot of this variable (and other macroeconomic indicators) over time.

policy and household borrowing more explicit.[18]

Further, the Fed Funds Rate captures a direct measure of the banks' cost of capital, an input in the mortgage rate. An additional advantage of the Fed Funds Rate as an instrument is that it reflects broader economic conditions beyond the scope of the housing or mortgage markets, and thus may help break potential feedback from mortgage borrowing activity back to rates. That said, it is not an ironclad instrument in the sense that other economic factors may be correlated with both the Fed Funds Rate and households' desire to extract equity today or in the future. Thus, we recognize the limitations of this IV approach and do not make it our primary empirical specification. Rather, we offer it as a possible alternative driver of banks' cost of capital that may be independent of supply and demand factors in the mortgage market (conditional on a range of economic indicators).

A limitation of the above regression is that because interest rates vary at the national level, we cannot include time fixed effects. Thus, a key identification assumption is that our extensive set of time-varying controls at the individual, local, and regional levels capture potentially confounding factors in the equity extraction decision. Remaining unobserved time-varying shocks that are orthogonal to these controls, including house price growth, yet correlated with interest rates would threaten identification. One possibility, as hypothesized in Chen et al. (2012), is that households might have a precautionary motive to extract equity in *anticipation* of economic downturns or credit tightening. Of course, precautionary extraction would tend to be positively correlated with interest rates and thus attenuate our results. More importantly, such procyclical extraction may largely be picked up by our set of controls for local economic conditions. Overall, we believe this identification assumption to be reasonable in the absence of plausible unobserved preference or supply shocks that would have peaked in 2003 and then declined even as the housing boom gained strength.

That said, to help address this limitation, we estimate models that add the interaction of home

[18] The Federal Funds Rate, or "Fed Funds Rate," is the rate of interest used by depository institutions for overnight lending, the target trading value of which is set by the Federal Reserve's FOMC.

price growth and interest rates to the earlier regression equation:

$$\begin{aligned} extract_{itzc} = \quad & \alpha + \beta_1(rate_t) + \beta_2(HPIgrowth_{tz}) + \beta_3(rate_t \times HPIgrowth_{tz}) \\ & + \beta_4(creditconditions_t) + \beta_5(securitizationrate_t) + \beta_6(unemp_{tc}) \\ & + \beta_7(empgrowth_{tc}) + \beta_8(wagegrowth_{tc}) + X_{it}\Gamma + \delta_c + \epsilon_{itzc} \end{aligned}$$

Because, in this case, our interest lies in the coefficient on the interaction term ($\beta_3$), this specification allows us to relax the identifying assumption by including time fixed effects that absorb all aggregate shocks. This regression exploits differences in the magnitude and timing of housing booms across the United States. Referring back to Figure 2 and our earlier discussion, here we ask whether homeowners in Boston were differentially more likely to extract equity than homeowners in Seattle following a given amount of house price growth, since house price growth in Boston coincided more closely with the drop in interest rates; this interactive specification therefore tests whether the propensity to extract in a boom is larger when coupled with low interest rates.

Throughout our analysis we treat house price dynamics, conditional on our 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 the supply elasticity is not, in theory, a good instrument since negative housing demand shocks should cause house price declines in both elastic and inelastic areas due to the durability of housing.

Instead, we control for other economic fundamentals at the county level, as described above, that might drive both house prices and borrowing out of home equity. In addition, we assess robustness to the inclusion of MSA-by-year fixed effects, relying exclusively on within-MSA variation in local economic conditions. Although including such a rich set of fixed effects absorbs much of the identifying variation, this specification provides an estimate of the relationship between rates, house prices, and extraction that controls for unobservable factors that may vary at a fine level of geography.

### III.C Fed Policy and Mortgage Rates

The main question posed in this paper is how do households' extraction decisions respond to movements in interest rates, particularly mortgage rates. One key motivation for studying this question is that, to the extent that the Federal Reserve can influence mortgage rates, then home equity extraction may be a key channel through which monetary policy could affect the economy.

Not surprisingly, there exists a sizeable literature studying how the Fed affects interest rates in the economy. In recent years researchers have used high frequency (daily and intra-day) data to identify the causal effect of monetary policy using unanticipated changes in Fed target rates. Pioneering work by Kuttner (2001) and Cochrane and Piazzesi (2002) finds large effects of unanticipated changes in the Fed Funds target rate not just on short-term bond yields, but also on longer-term 10-year Treasury yields. Newer work also finds that the Fed influences medium to longer term nominal *and real* yields, and suggests that the effect of Fed policy shocks across the maturity spectrum may reflect changes in the term premium (Hanson and Stein 2015) and substantial price rigidities (Nakamura and Steinsson 2013). Finally, recent research has also shown that movements in Treasury yields due to monetary shocks pass through to borrowing costs for firms and households; Gilchrist et al. (2013) find that a monetary shock of 10 basis points lowers 30-year FRM rates by about 6 basis points (also see Gertler and Karadi 2013). Here, it is important to recognize that, despite a maturity of 30 years, mortgages are priced off of medium-term (5-10 year) Treasuries as households tend to prepay their mortgages within the first 10 years.

In sum, a large literature provides strong evidence that the Fed can significantly influence market interest rates across the maturity spectrum. This effect on market rates represents the first step in the transmission process. In this paper, we provide novel evidence on a second step in the transmission process: borrowing behavior by households in response to interest rates changes. To be sure, not all of the interest rate volatility we exploit in our in our empirical work was necessarily generated by Fed policy (e.g. some of the decline in rates from 2000 to 2003 may partially reflect the long-term decline in interest rates). Nonetheless, because Fed actions typically influence mortgage rates, our estimates help inform the question of how monetary policy transmits into the economy.

# IV Results

## IV.A Summary Statistics

Tables 1 and 2 describe our sample and provide new information on equity extraction activity. 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 their average credit scores and initial mortgage balances.[19] Columns 4 through 11 provide summary statistics for those who extracted equity, with columns 4 and 5 showing the number and share that extracted equity each year. Eleven percent of homeowners extracted equity on average between 1999 and 2010, but in 2003 over 18 percent did so. Comparing columns 2 and 6, extractors tend to have somewhat lower credit scores, with the biggest difference in 2006.

Column 8 shows that extractors (defined as an increase in mortgage debt of at least 5 percent) 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 60 percent of extractors in a given 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 divide equity extractions into possible methods.[20] 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 from 2004 to 2007 as interest rates rose. 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

[19] The sample size changes from year to year in large part because of changes in the number of people with a mortgage. The samples in the years prior to 2002 are relatively small because geographic location was unavailable for a larger proportion of mortgage borrowers in those years.

[20] 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.

in the sample is about 4.9 percent, with a standard deviation of 0.94 percent. The average annualized three-year house price growth rate is about 4.3 percent, with a sizable standard deviation of 8.5 percent. The remaining columns of the table show the tremendous dispersion in many of our explanatory variables. For instance, across ZIP codes, the range between the 1st and 99th percentiles of annualized house price growth is 42 percentage points. Heterogeneity in the timing and extent of the housing boom across the United States provides us with the variation necessary to precisely estimate the drivers of equity extraction.

### 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, in which the national unemployment rate peaked. 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 over 18 percent of sample homeowners extracting equity in that year. Extraction rates fell after 2003 even though house prices on average continued to grow robustly through 2006. This pattern is suggestive of the importance of interest rates in homeowners' equity extraction decisions. However, the unemployment rate was elevated in 2002 and 2003, suggesting that some equity extraction may have been a response to income disruptions.[21]

Figure 3 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

[21]For context, the broader macroeconomic patterns from 1999 to 2010 are shown in Online Appendix Figure 2.

have responded 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. 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 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 3 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 from 2003—2006. In contrast, the rate of extraction among high credit score homeowners in these states was more subdued and peaked in 2003. The variation in households' equity extraction decisions highlighted across the four panels of Figure 3 foreshadows our regression results and approach to isolating key drivers of extraction.

## 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. Most of the regressions include county fixed effects, and standard errors are clustered at the year level to address concerns related to correlated macroeconomic shocks.[22] We employ a linear probability model (OLS) approach to estimation because we have a large

[22]In results not shown, we explored clustering to account for serial correlation within states as opposed to across region at a point in time, as well as double-clustered standard errors. Clustering at the year level is generally the most conservative and thus our preferred approach.

dataset, a large number of fixed effects, and in many specifications focus on the interpretation of an interaction term.[23]

Column 1 shows an unconditional negative correlation between the mortgage rate and the probability of extraction. Column 2 controls for recent home price appreciation in one's ZIP code and includes county fixed effects. The house price growth variable is highly statistically significant, and including it leads to a larger and more precisely estimated interest rate coefficient. This pattern is consistent with the idea that house price changes help explain both 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.

Including the full set of geographic and individual-level controls (see the note to Table 3) further increases the interest rate coefficient, but dampens the relationship with house price growth (Column 3). These estimates 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 27 percent increase relative to the 11 percent average extraction rate across all years.

House price growth also has a large effect on extraction. The estimate in column 3 implies that a one standard deviation increase in house price growth leads to an increase in the likelihood of extraction of 3.2 percentage points.[24] As discussed in the previous section, we do not instrument for house price growth, which raises the possibility that house price growth may be capturing other drivers of extraction, such as income expectations, at the local level. Instead, we rely on several controls for local economic conditions — county-level unemployment, wage growth, and employment growth — to capture income trends and expectations. As mentioned above, including these variables, as well as the other controls, dampens the house price growth coefficient. Finally, it is worth noting that, in the Online Appendix, we estimate that the effect of house price growth on the dollar amount extracted is about $7 per $100 increase in home equity, which is significantly smaller than the $25 per $100 estimate of Mian and Sufi (2011), but more in line with other recent papers on consumption responses to housing wealth (Bostic et al. 2009, Carroll et al. 2010, Case

[23]All of these features raise challenges for a probit specification related to computation and interpretation. Furthermore, comparing the main results from our estimated linear probability model with the appropriate marginal effects (including accounting for the interaction term) from a probit model yielded virtually identical estimates.

[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.

et al. 2011).[25]

As discussed in the previous section, we explore the possibility of an interactive relationship between interest rates and house price growth, exploiting the fact that interest rate declines occur across regional housing markets at different points in their cycles. The interaction estimate shown in column 4 implies that house price growth significantly amplifies the effect of interest rates, and vice versa. If the 1-year ARM rate declined by one percentage point (note that from 2000—2003 it declined by about 3 percentage points), the effect of house price growth would increase by about 25 percent relative to the mean effect. At the same time, a one standard deviation increase in home price growth amplifies the effect of mortgage rates on extraction by about 25 percent. This specification provides unique evidence on how the effectiveness of monetary policy might depend on households' available collateral.

We also present estimates that include time fixed effects to absorb any common, annual level shocks. In these restrictive regressions, mortgage rates are collinear with the year fixed effects but the interaction term remains identified from the cross-region variation within a given time period. To start, column 5 of Table 3 indicates that the house price effect holds up to the addition of year fixed effects. The sixth column adds in the interaction term, which is somewhat attenuated relative to the magnitude shown in column 4. To better understand this attenuation, we turn to a more detailed year-by-year analysis in the next subsection.

### IV.C.1 Extraction in the Boom and Bust

Why do our estimates of the interaction of mortgage rates and house prices appear to be sensitive to the inclusion of annual fixed effects? To explore further, Figure 5 plots year-by-year coefficients on the house price growth variable from a specification identical to that in column 6 of Table 3, but where house price growth is interacted with year dummies, thus allowing the house price growth coefficient to vary over time non-parametrically.

[25] See Online Appendix Table 1. In results not shown, we estimated cross-sectional regressions for 2003 and 2006 to compare the house price growth coefficient in an OLS regression to the coefficient where we use the housing supply elasticity (Saiz 2010) as an instrument for house price growth. In both years, the OLS coefficient is similar to the instrumental variables (IV) coefficient if we do not include geographic fixed effects. Once we add state fixed effects, the OLS estimate shrinks considerably, and the IV estimate breaks down. Consistent with Davidoff (2013), the house price elasticity instrument cannot be distinguished from a state fixed effect; Indeed, when we include state fixed effects in the IV regressions, the house price growth coefficient changes sign and becomes statistically insignificant.

The top panel of Figure 5 shows a stark pattern: The house price effect rises sharply from 2000—2003 as interest rates declined (the coefficient in 2003 is about 6 times the size of the coefficient in 2000 and is also significantly larger than the coefficient in 2006), and overall from 1999—2007 moves opposite the pattern in interest rates. However, during the recession years of 2008—2010, the house price coefficient declines despite falling interest rates. This positive correlation between rates and the house price coefficient during the housing bust offsets, to some degree, the strong negative relationship prior to 2008.

In the bottom panel of Figure 5, we explore one potential reason for the dampened house price effects during the recession. The figure shows the distribution of house price growth across ZIP codes for each year from 1999 to 2010. In 2009 and 2010 house prices were declining virtually everywhere in the United States. With house prices falling in almost every ZIP code, it seems likely that the relationship between house price growth and equity extraction would be relatively weak: Less severe house price *declines* are not much more likely to spark equity extractions than severe house price declines, especially in a tight lending environment and if homeowners and lenders expect house price declines to continue.

The year-by-year patterns in Figure 5 motivate a set of specifications exploring the extraction decision that focus solely on the years prior to the financial crisis of 1999—2007 when house prices were rising, shown in Table 4. The magnitudes of the coefficients on the mortgage rate and house price growth variables in column 1 are somewhat larger in this period relative to the estimated coefficients for our full sample (shown in Table 3). Column 2 provides an estimate of the interaction coefficient, which is considerably larger than the estimate over the entire 12-year period. Moreover, as shown in columns 3 and 4, the main house price coefficient and the interaction coefficient are robust to including year fixed effects.

In columns 5 and 6 we further test robustness by including MSA-by-year fixed effects, thus accounting for any common shocks at the MSA-year level. Including such a detailed level of fixed effects absorbs about 95 percent of the identifying variation in local house prices, yet the coefficients on house price growth in column 4 and the interaction term in column 5 continue to be significant; they are smaller in magnitude than in columns 1 and 2, but the interaction coefficient *relative* to the house price growth coefficient is comparable.

In columns 7 and 8 of Table 4, we replace the one-year ARM rate with the Fed Funds Rate as a "reduced form" approach. Given the uncertainty regarding what mortgage rate is most salient for households, using the Fed Funds Rate provides a specification that utilizes one of the underlying drivers of all mortgage rates. In addition, the Fed Funds rate, conditional on unemployment and wage growth, provides a potentially exogenous source of variation in the cost of funds for banks. In column 7, the Fed Funds rate effect is statistically significant (the magnitude is smaller than the ARM rate effect, but the standard deviation of the Fed Funds rate is roughly twice that of the ARM rate). The interaction effect in column 8 is also statistically significant, and implies that if the Fed Funds rate were to decline by one standard deviation (about two percentage points), the coefficient on house price growth would increase by almost 25 percent.

Finally, in columns 9 and 10, we instrument for the ARM rate with the Fed Funds rate. The estimates in column 9 are nearly identical to those in column 1. In column 10, where we instrument for the interaction term with house price growth multiplied by the Fed Funds rate, the estimated interaction effect remains significant but is somewhat smaller than the estimate in column 2.

### IV.C.2 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 5 examines some alternative specifications and explores the robustness of the findings above along a number of dimensions.

Columns 1 and 2 of Table 5 present our baseline specification using the full sample period (see Table 3, column 3), substituting the average offer rate for a 30-year fixed rate mortgage and the Fed Funds rate, respectively, in place of the one-year ARM rate. Because all of these rates tend to move together, not surprisingly they all have a statistically significant relationship with equity extraction.

As noted above, the Fed Funds rate, conditional on unemployment and wage growth, provides a potentially exogenous source of variation in banks' cost of funds. However, when setting interest rates, the Fed might also take into account housing activity. In column 3, using data from the Census Bureau we control for housing permit activity in the previous year at the county level as a measure of local housing activity. While permit activity is positively related to extraction, the coefficients on interest rate and house price growth are basically unchanged.

Column 4 of Table 5 includes an indicator for whether an individual extracted in the prior 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.

The response of equity extraction to home price growth, particularly in 2005—2007 when interest rates were relatively high, may reflect a strategic default story rather than a collateral constraint or wealth effect story: Individuals extracting equity may have been anticipating a house price correction and liquidated their housing wealth with the idea of defaulting if the correction were to be realized. In column 5 we control for a measure of ex-post default (becoming 60 days or more past due on a mortgage within two years) in a regression using only the 1999-2007 period. While ex-post default is highly correlated with equity extraction, the house price growth coefficient is basically unchanged compared to the same regression where we do not include ex-post default (Table 4, column 1).

Finally, we examine the effect of rates and house price growth separately for cash-out refinance and junior lien extractions in columns 6 and 7 of Table 5, respectively. We find that cash-out refinancings are considerably more sensitive to interest rates, as expected because the interest rate resets on the entire mortgage balance (the rate coefficient in the junior-lien regression is significant only at the 10 percent level). 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 Heterogeneity in the Equity Extraction Response

Table 6 presents regression specifications where we stratify our sample by borrower age and credit score, using the specification from column 1 of Table 4. We run separate regressions for six 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 semi-elasticities, which are reported in bold in Table 6.

The results indicate that younger homeowners tend to have a stronger response to house price growth than older homeowners, consistent with findings in Mian and Sufi (2011). In contrast, life-cycle models 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.

That said, 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. 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. 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.

Finally, younger borrowers, particularly those in the highest credit score category, appear to be more responsive to interest rates. This pattern could reflect a steep earnings profile of younger high-score homeowners and as a result a stronger inclination to shift consumption forward when rates decline. The difference across age groups could also reflect some role for payment-to-income constraints present in the mortgage market (mentioned in Section II). This type of constraint may be more binding for younger individuals and make them more sensitive to interest rate declines. In sum, although overall extraction rates are quite similar between younger and older borrowers (see

Table 6), younger homeowners' extraction decisions appear to be much more sensitive to changes in both house prices and mortgage rates, suggestive of more binding constraints facing younger households.

### IV.E What did Homeowners do with Extracted Equity?

In Figures 5 and 6, we use the panel aspect of the credit record data to explore the impact of home equity extraction on the debt portfolio of households. One possible reason to extract equity is to re-price the household's debt portfolio, 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 5 shows how sharply total mortgage debt for the average extractor increases 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 extraction. HELOC-based extractions (shown in Panel B) are also large and exhibit steady persistence. Finally, both the size and persistence of increased leverage is apparent among both low and high score homeowners, as shown in Panel C.

Figure 6 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.[26]

[26] Note that in the CCP credit card balances include transactional balances that do not incur interest.

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 of Figure 6 show how auto loan balances evolve for extractors. There is little indication that home equity is used to pay down auto debt. This result 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 average extractor who increases his mortgage debt by about $40,000, we estimate that his uncollateralized consumer debts fall by about $2,000 to $3,000 during the year of extraction.[27]

### IV.F Equity Extraction and Default

While we lack precise information on how extractors use the borrowed funds, the preceding analysis is suggestive that the money often is not saved, unless borrowers are able to earn risk-adjusted returns on their investments that would exceed the interest rate on uncollateralized debt.

The risk created by equity extraction depends to some extent on how extractors use borrowed funds. For example, if extractors tend to use the funds to invest in relatively liquid assets and to diversify their portfolio, their likelihood of default may be similar to or less than those who do not extract, all else equal. Furthermore, if extraction results in a safer household balance sheet, we would expect to see similar patterns in the diminished likelihood of default across both mortgage and non-mortgage debt.

[27]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.

To assess the relationship between equity extraction and default, we run the following regression:

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

$\beta_t$ 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, delinquency status, total debt, and credit utilization, all measured just prior to extraction. We also include homeowner characteristics including age and joint account status (a proxy for being married) and other demographics such as race, income and education measured at the census tract level. Finally, we include county-by-year fixed effects, $\eta_{ct}$, as well as house price growth at the ZIP code level before and after extraction to control for economic and housing conditions.[28]

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.[29] The coefficients of interest are on the extract-by-year variables, presented in Figure 7 scaled by the mean cohort delinquency rate.[30]

Figure 7 indicates that over longer horizons of two to four years, equity extractions are generally associated with elevated risk, conditional on a wide array of controls. One potential reason for elevated risk, as discussed above, is that extracting equity leads to substantially higher leverage (recall Figure 6), which could be especially difficult to manage when hit by a financial shock or a negative shock to house prices. This reason could help explain the U-shaped pattern in Figure 7, as extractors in 2000 and 2006 were subsequently hit with such shocks.[31] It might also help explain the striking gap between short-term and longer-term performance among extractors in 2004. Extractors in 2004 performed just as well as non-extractors on mortgage debt, and *better*

[28]In Online Appendix Tables 2 and 3, we present additional specification checks on this result, including an especially restrictive specification that includes ZIP code-by-year fixed effects. The resulting pattern of yearly extraction coefficients is qualitatively the same across specifications.

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

[30]The unadjusted coefficients and controls are reported in Online Appendix Tables 2 and 3. For the regressions looking at delinquency over 2 to 4 years, we exclude 2007 and 2008 since our data only extends through 2010.

[31]In other words, because we control for county-by-year fixed effects, the idea here is that if two households are hit by same set of shocks, the one that is more leveraged will be more likely to default.

than non-extractors on non-mortgage debt in the first two years. But as the recession unfolded in 2007 and 2008, those who extracted in 2004 performed far worse on mortgage debt and somewhat worse on non-mortgage debt.

Despite our extensive set of controls and the stability of the results as we add many more credit and demographic controls (shown in Appendix Tables 2 and 3), we cannot rule out that our coefficient estimates and their time series pattern may additionally reflect unobservable borrower characteristics. Although we observe much of the same information lenders use in underwriting, the results could reflect variation in credit standards over the business cycle along dimensions that are orthogonal to our controls. It is also possible that the especially poor performance of extractors in 2000 and 2006 reflects adverse selection as described in Stiglitz and Weiss (1981), where the relatively high interest rates in those years may have attracted individuals who are riskier in ways that are unobservable even to lenders.

One final result to highlight is that while extractors in 2006 were more than twice as likely as non-extractors to become severely delinquent over the next four years, they were also almost 40 percent more likely to become delinquent on *non-mortgage* debt. The literature proposes two key reasons for mortgage default. First, when home prices fall to such an extent that homeowners owe significantly more than the house is worth, there is a financial incentive to "walk away" or strategically default (see, e.g. Kau et al. 1994). Second, borrowers who experience a negative income shock or life event may have difficulty servicing their mortgage debt and are at high risk of default if they also have little or 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). Our finding that extractors were more likely to default on both mortgage and non-mortgage debt, rather than observing differential behavior across debt types, lends further support to the "double-trigger" perspective.

## 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 equity extraction decisions from 1999 to 2010. Understanding this role has the potential to shed light on the mechanisms by which monetary policy is transmitted into the macroeconomy. Conditional on an extensive set of local and individual characteristics, we find that lower interest rates were strongly associated with greater equity extraction during the housing boom. This association is shown to be robust to a variety of measurement techniques and specification checks. Furthermore, we provide new evidence on financial frictions by examining heterogeneity in the response to interest rates and house prices across different age and credit score groups. For example, we find that those who are more plausibly collateral constrained are less responsive to interest rate declines, as theory predicts.

A necessary limitation of our analysis is that we cannot entirely rule out the potential presence of time-varying preference or supply shocks that may interact with house price growth (and thus available home equity). While we have a rich set of controls, given that these shocks are nonetheless possible, we hesitate to extrapolate any underlying structural parameters of the monetary policy transmission mechanism from our reduced form analysis of the conditional relationship between rates and extracting equity during a unique episode when interest rates fell to historic lows.

However, our controls, including house price growth, local labor market conditions, and individual measures of liquidity, capture the most central observable determinants of equity extraction posited in the literature. For the first time, our research uses microdata to document the sensitivity of household extraction behavior to variation in policy-driven interest rates, and hopefully encourages more research on the important topic of how monetary policy is transmitted through the household sector. In particular, our data is confined to borrowing behavior, but better data on consumption responses to monetary policy shocks would allow for an especially valuable research agenda to emerge.

## 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, 45(4), pp. 591-622, 2013.

Aladangady, Aditya, "Homeowner Balance Sheets and Monetary Policy," University of Michigan Working Paper, 2014.

Andersen, Steffen, John Y. Campbell, Kasper Meisner-Nielsen, and Tarun Ramadorai, "Inattention and Inertia in Household Finance: Evidence from the Danish Mortgage Market," 2014.

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.

Aron, Janine, John V. Duca, John Muellbauer, Keiko Murata, and Anthony Murphy, "Credit, Housing Collateral, and Consumption: Evidence from Japan, the U.K., and the U.S." Review of Income and Wealth, 58(3), September 2012.

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. Kennickell, 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.

Cochrane, John H., and Monika Piazzesi, "The Fed and Interest Rates: A High-Frequency Identification," American Economic Review Papers & Proceedings, 92(2), pp. 90-95, May 2002.

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, 41(4), pp. 793-813, 2013.

Deng, Yongheng, John M. Quigley, and Robert Van Order, "Mortgage Terminations, Heterogeneity, and the Exercise of Mortgage Options," Econometrica, 68(2), pp. 275-307, March 2000.

DiMaggio, Marco, Amir Kermani, and Rodney Ramcharan, "Monetary Policy Pass-Through: Household Consumption and Voluntary Deleveraging," Columbia Business School Working Paper, 2014.

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.

Gertler, Mark, and Peter Karadi, "Monetary Policy Surprises, Credit Costs, and Economic Activity, NYU Working Paper, October 2013.

Gilchrist, Simon, David Lopez-Salido, and Egon Zakrajsek, "Monetary Policy and Real Borrowing Costs at the Zero Lower Bound," FEDS Working Paper 2014-03, December 2013.

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.

Hanson, Samuel G., and Jeremy C. Stein, "Monetary Policy and Long-Term Real Rates," Journal of Financial Economics, 115(3), pp. 429-448, March 2015.

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.

Hubbard, R. Glenn, and Christopher J. Mayer, "The Mortgage Market Meltdown and House Prices," B.E. Journal of Economic Analysis & Policy, 9(3), 2009.

Hurd, Michael D., “Issues and Results from Research on the Elderly: Economic Status, Retirement, and Savings,” Journal of Economic Literature, 28, pp. 565-637, 1990.

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.

Keys, Benjamin J., Tomasz Piskorski, Amit Seru, and Vincent W. Yao, “Mortgage Rates, Household Balance Sheets, and the Real Economy,” NBER Working Paper 20561, October 2014.

Keys, Benjamin J., Devin G. Pope, and Jaren C. Pope, “Failure to Refinance,” NBER Working Paper 20401, August 2014.

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

Kuttner, Kenneth N., “Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market,” Journal of Monetary Economics, 47 (3), pp. 523-544, June 2001.

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.

Lovenheim, Michael F., “The Effect of Liquid Housing Wealth on College Enrollment,” Journal of Labor Economics, 29(4), pp. 741-771, October 2011.

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.

Mayer, Christopher J., and Katerina V. Simons, “Reverse Mortgages and the Liquidity of Housing Wealth,” Real Estate Economics, 22(2), pp. 235-255, June 1994.

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.

Nakamura, Emi, and Jon Steinsson, “Price Rigidity: Microeconomic Evidence and Macroeconomic Implications,” Annual Review of Economics, 5, pp. 133-163, 2013.

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.

Sinai, Todd, and Nicholas S. Souleles, “Owner-Occupied Housing as a Hedge against Rent Risk,” Quarterly Journal of Economics, 120(2), pp. 763-789, 2005.

Stiglitz, Joseph E., and Andrew Weiss, “Credit Rationing in Markets with Imperfect Information,” American Economic Review, 71(3), pp. 393-410, 1981.

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.

Venti, Steven F., and David A. Wise, “Aging and the Income Value of Housing Wealth,” Journal of Public Economics, 44(3), pp. 371-397, 1991.

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

Zinman, Jonathan, “Consumer Credit: Too Much or Too Little (or Just Right)?” Journal of Legal Studies, 43(2), pp. S209-S237, 2014.

# A-1 FOR ONLINE PUBLICATION: Appendix

## A-1.A Aggregate Equity Extraction

The results in the main text 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. Appendix Figure 3 plots the aggregate amount extracted based on the CCP and our definition of extraction over the period 1999 to 2010.[32] 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.[33]

Comparing the aggregate amount extracted (Appendix Figure 3) 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 3).

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).[34] 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

[32] 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)

[33] 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.

[34] 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

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

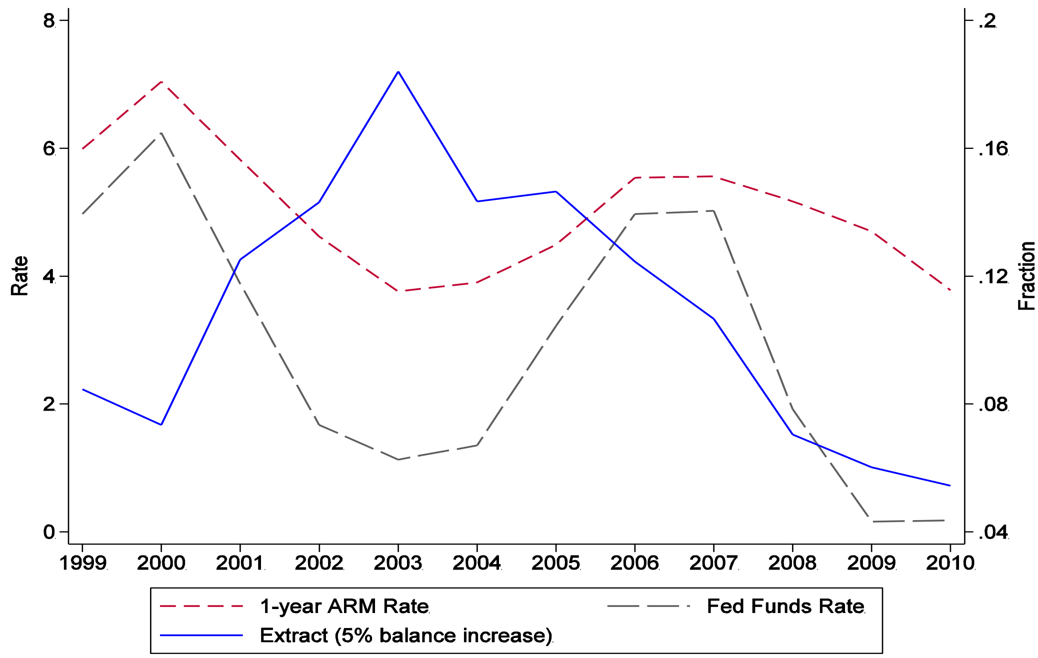
where $\hat{\sigma}$ is the standard error from the intensive margin OLS regression.

The results of this exercise are shown in Appendix Table 1. 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 $1,860 or about 28 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 $2,633 or 40 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 $2,633 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).

### A-1.B Sensitivity of Default Results to Controls

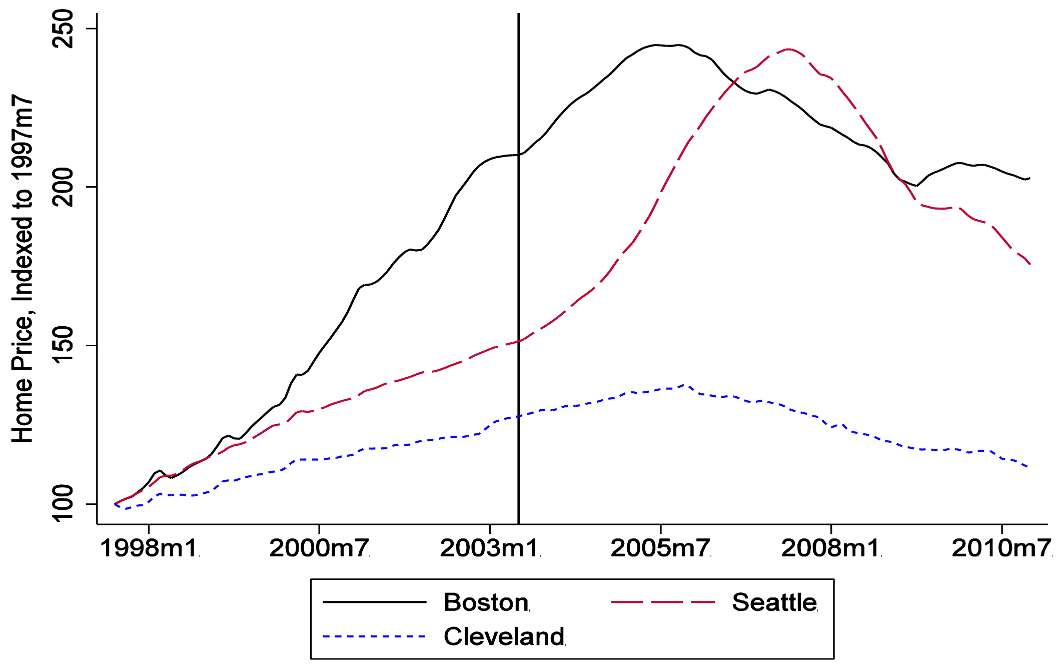
Appendix Tables 2 and 3 show the results relating extraction to subsequent (mortgage and non-mortgage) default (discussed in section IV.F of the text) with and without controls. For any of the four outcome variables, the first column of the appendix table includes no controls, and moving from column 1 to column 4 we progressively add different covariates. Column 2 adds county-by-year fixed effects and credit scores, column 3 adds a wide set of individual-level credit characteristics and census tract-level demographic controls, and column 4 includes zip-by-year fixed effects instead of county-year fixed effects. In general, when we move from the most basic set of controls in column 2 to the most extensive set of controls, there is little change in the time series pattern or magnitude of the extract $\times$ year coefficients.

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. Extracting equity is defined as 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.

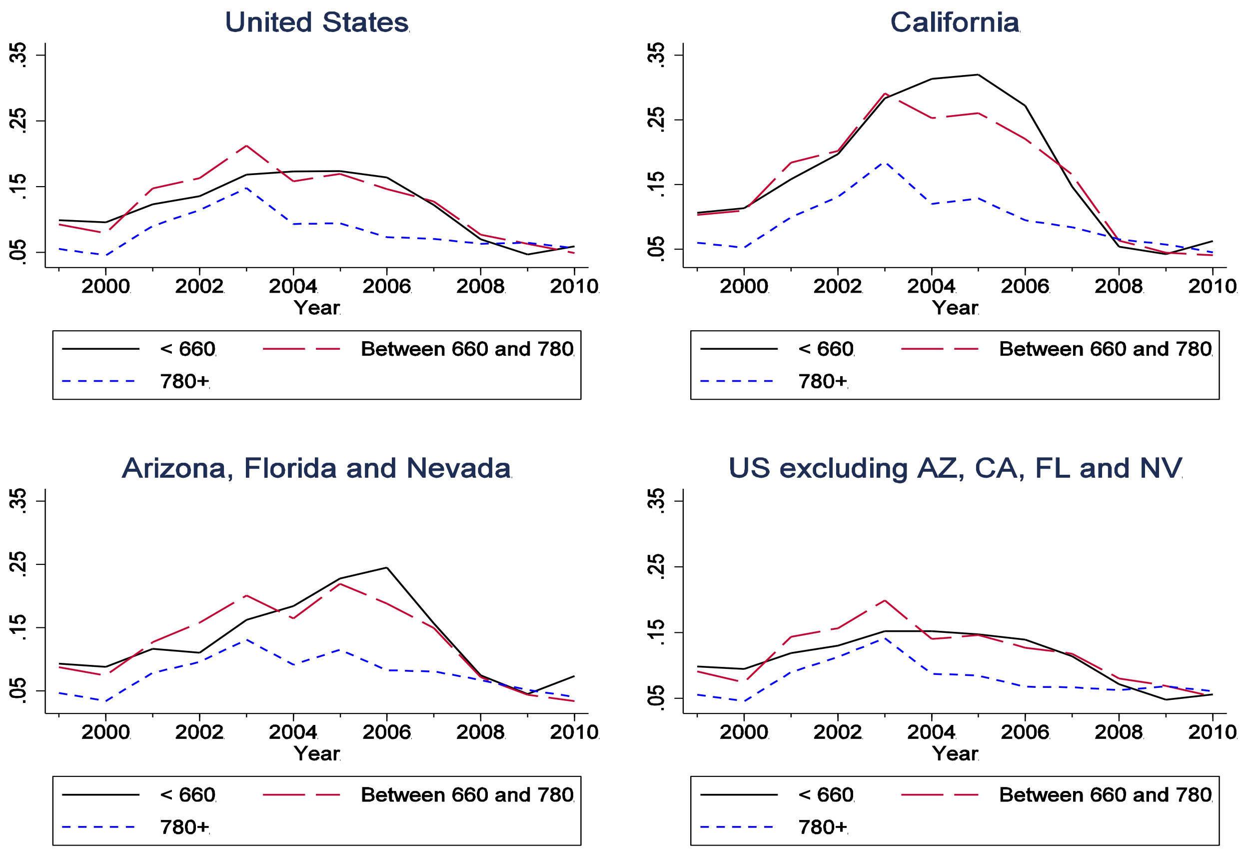
Figure 2. House price growth in Boston, Cleveland, and Seattle, 1997-2010




Source: Zillow monthly house price data.

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

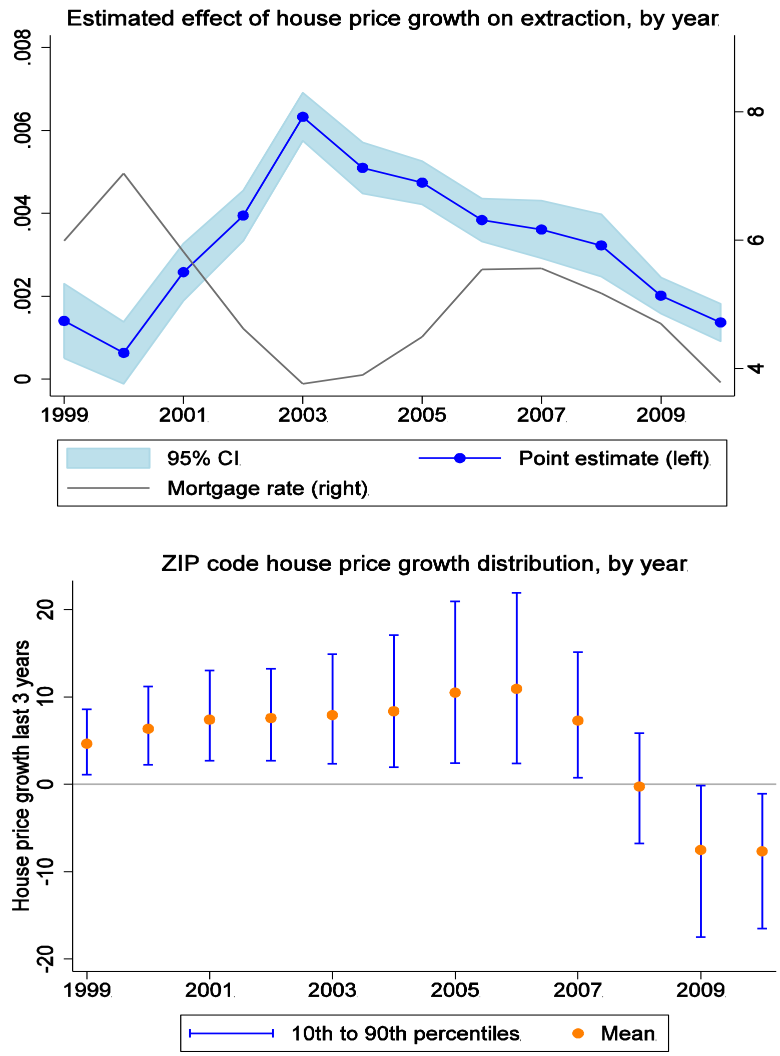
Figure 3. Probability of equity extraction, by credit score group and geography




Source: FRBNY CCP/Equifax.

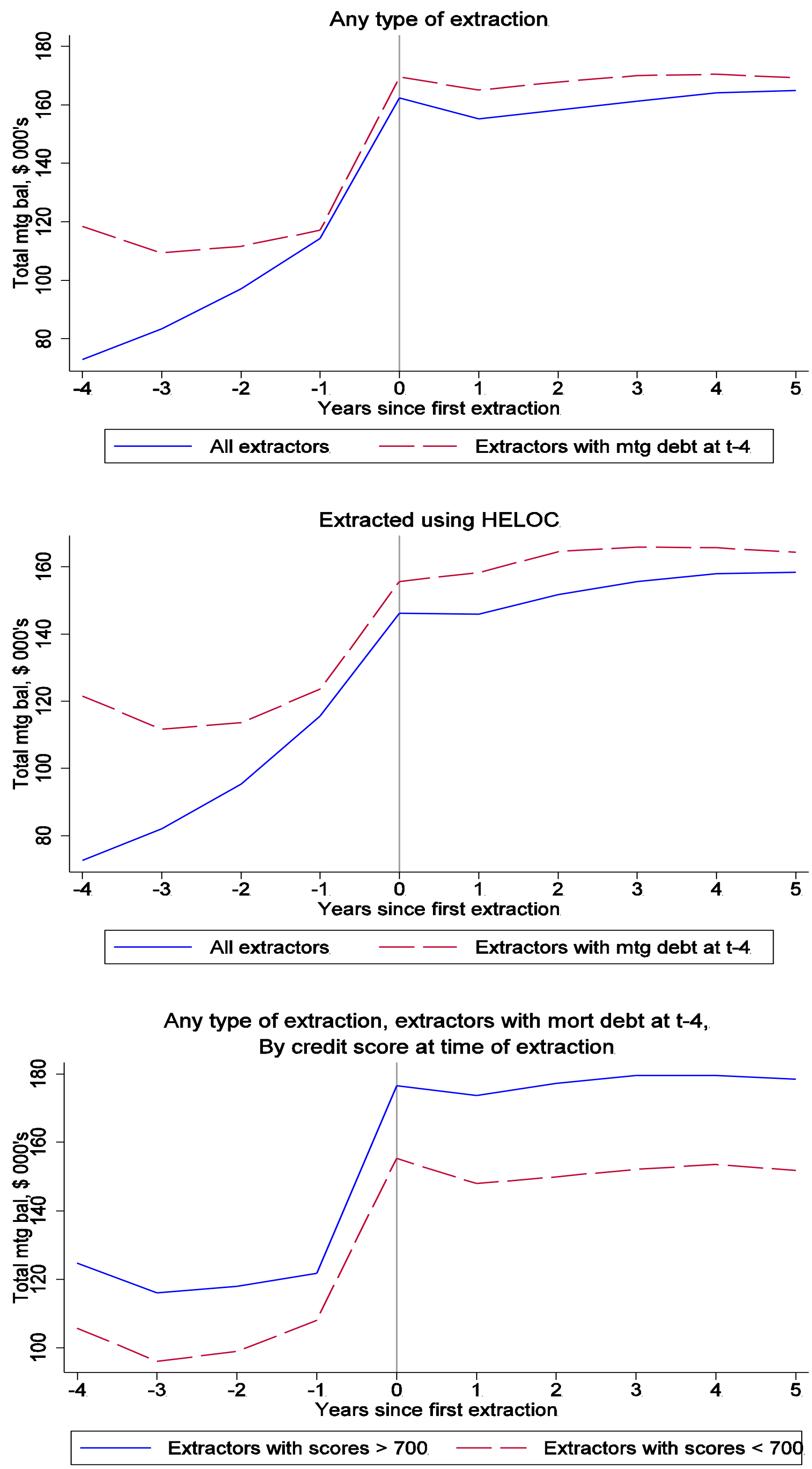
Notes: Equity extraction defined as an increase of at least 5 percent in total mortgage balance during the year; sample for a given year excludes movers and those with multiple mortgaged properties in the year as discussed in the text. Credit scores of potential extractors measured at the start of the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

Figure 4. Variation in the effect of home price growth on equity extraction over time




Notes: Top panel shows the year-by-year estimated effect of house price growth on equity extraction. Point estimates in the top chart are from a regression identical to that in column 6 of Table 3, but allowing the house price growth coefficient to vary each year. Bottom panel shows the distribution of house price growth across zip codes by year.

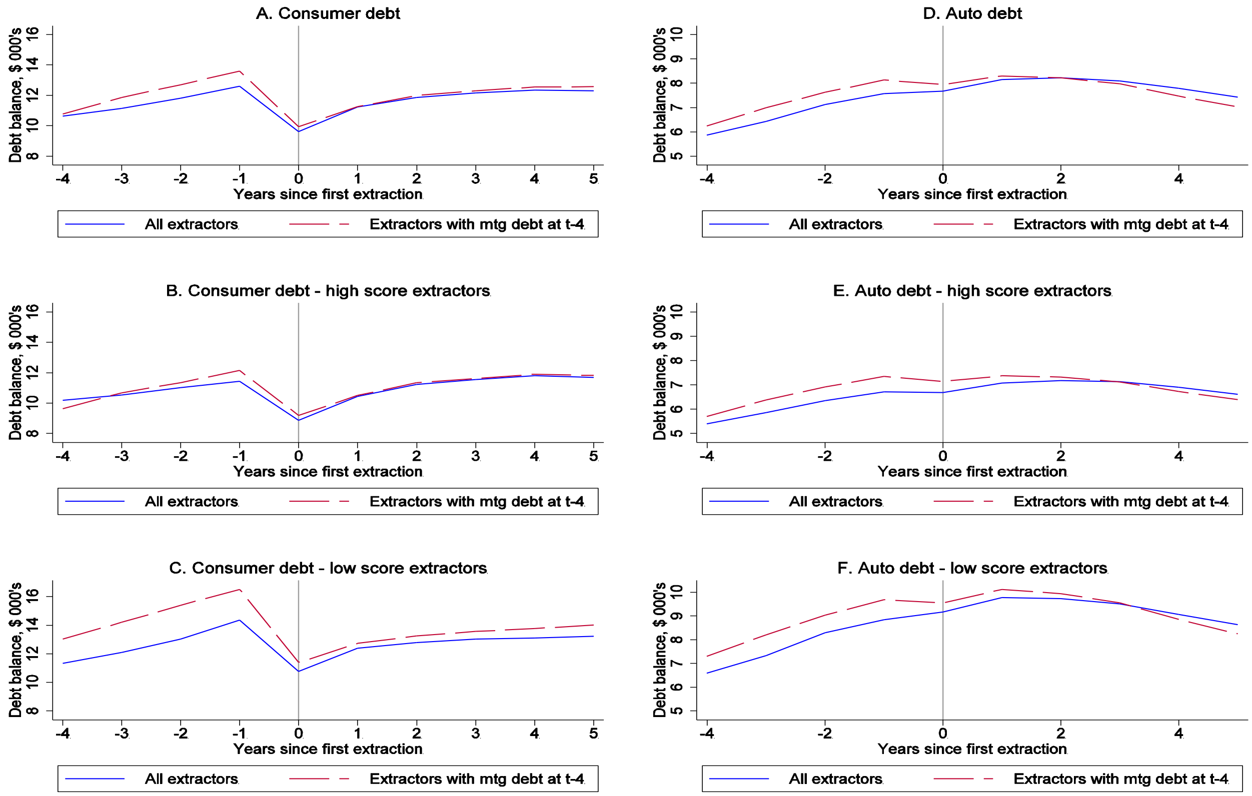
Figure 5. Average mortgage balance before and after extraction




Source: FRBNY CCP/Equifax.

Notes: Each graph is based on consumers who extracted equity at least once during the sample period, and plots the average mortgage balance of these extractors before and after their 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.

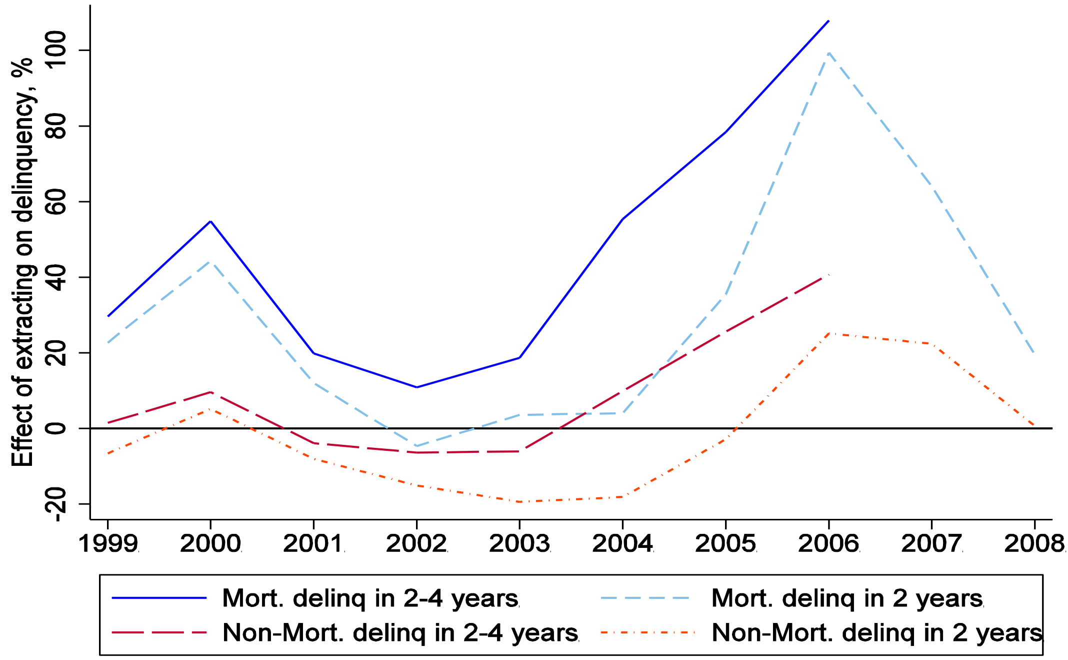
Figure 6. Average consumer debt and auto debt balances before and after home equity extraction




Source: FRBNY CCP/Equifax.

Notes: Each graph is based on consumers who extracted equity at least once during the sample period, and plots the average non-mortgage debt balances of these extractors before and after their 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. 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.

Figure 7. Estimates of the effect of extracting equity on subsequent delinquency, by year of potential extraction




Notes: Graph plots coefficient estimates on extract-by-year variables from four different linear probability regressions of delinquency on extraction interacted with year of potential extraction, controlling for risk and demographic characteristics, and county-by-year fixed effects. See text for more details. Coefficients are scaled by the mean delinquency rate for the given cohort. Full regression results are available in the Appendix.

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 | Avg. credit score | Initial balance ($) (median) | Number Extracting Equity | Fraction that Extracts | Avg. credit score | Initial balance ($) (median) | % Change in balance (median) | % Change 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 | 134,043 | 715.5 | 81,502 | 10,960 | 0.085 | 702.9 | 82,553 | 23.22 | 27.25 | 0.47 | -- | 0.35 | 0.21 | 0.30 | 0.13 |
| 2000 | 136,670 | 720.3 | 86,175 | 9,688 | 0.073 | 700.0 | 90,877 | 23.25 | 31.78 | 0.42 | 0.08 | 0.27 | 0.23 | 0.37 | 0.12 |
| 2001 | 147,065 | 717.4 | 88,211 | 17,629 | 0.125 | 712.5 | 99,865 | 23.30 | 17.94 | 0.41 | 0.08 | 0.54 | 0.18 | 0.16 | 0.13 |
| 2002 | 177,313 | 714.5 | 92,884 | 24,086 | 0.143 | 713.5 | 105,000 | 23.21 | 15.37 | 0.43 | 0.12 | 0.57 | 0.18 | 0.11 | 0.14 |
| 2003 | 189,586 | 713.8 | 98,787 | 32,849 | 0.184 | 713.7 | 107,000 | 23.20 | 12.13 | 0.44 | 0.14 | 0.57 | 0.17 | 0.08 | 0.17 |
| 2004 | 183,465 | 718.4 | 108,000 | 24,485 | 0.143 | 701.7 | 122,000 | 21.93 | 16.84 | 0.38 | 0.20 | 0.45 | 0.32 | 0.12 | 0.12 |
| 2005 | 200,730 | 724.3 | 115,000 | 26,645 | 0.146 | 706.6 | 132,335 | 23.04 | 20.48 | 0.38 | 0.20 | 0.46 | 0.29 | 0.12 | 0.13 |
| 2006 | 198,924 | 729.4 | 123,369 | 22,219 | 0.125 | 704.5 | 141,860 | 21.99 | 24.71 | 0.39 | 0.22 | 0.40 | 0.28 | 0.18 | 0.14 |
| 2007 | 205,696 | 728.8 | 130,140 | 19,648 | 0.107 | 711.1 | 138,134 | 20.07 | 20.47 | 0.40 | 0.18 | 0.39 | 0.29 | 0.17 | 0.14 |
| 2008 | 213,547 | 728.3 | 136,768 | 13,539 | 0.070 | 720.7 | 122,484 | 18.58 | 9.43 | 0.41 | 0.16 | 0.45 | 0.35 | 0.10 | 0.10 |
| 2009 | 212,342 | 728.7 | 139,377 | 11,575 | 0.060 | 733.8 | 111,256 | 18.20 | 8.98 | 0.43 | 0.14 | 0.51 | 0.31 | 0.07 | 0.11 |
| 2010 | 210,575 | 728.3 | 139,728 | 10,451 | 0.054 | 715.8 | 107,928 | 18.21 | 9.56 | 0.47 | 0.13 | 0.51 | 0.29 | 0.07 | 0.13 |
| **All Years** | 2,209,956 | 722.9 | 111,142 | 223,774 | 0.110 | 710.7 | 114,000 | 21.99 | 17.97 | 0.42 | 0.15 | 0.47 | 0.25 | 0.14 | 0.13 |

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 over the course of the year, and who 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 | 1st Percentile | Median | 99th Percentile |
|---|---|---|---|---|---|
| 1-Year ARM Mortgage Rate Annual Average (%) | 4.886 | 0.939 | 3.540 | 4.772 | 6.991 |
| ZIP HPI 3-Year Growth (%, annualized) | 4.289 | 8.504 | -19.413 | 4.608 | 23.266 |
| County Unemp Rate Annual Avg | 5.913 | 2.503 | 2.283 | 5.267 | 13.992 |
| County Employment 3-Year Growth Rate | 0.946 | 2.460 | -4.632 | 0.894 | 7.488 |
| County Wage 3-Year Growth Rate | 3.417 | 2.349 | -2.047 | 3.507 | 9.187 |
| Regional Credit Availability | 0.557 | 0.074 | 0.348 | 0.580 | 0.678 |
| Private Securitization Rate | 0.179 | 0.128 | 0.033 | 0.143 | 0.384 |
| Individual-level variables | | | | | |
| Credit Score | 722.9 | 94.1 | 427 | 751 | 829 |
| Credit Card Utilization Rate | 0.293 | 0.315 | 0 | 0.154 | 1 |
| Age of Homeowner | 48.4 | 13.3 | 24 | 47 | 83 |
| Mortgage Debt Balance ($) | 143,052 | 132,794 | 7,938 | 111,142 | 629,697 |
| Non-mortgage Debt Balance ($) | 15,823 | 25,115 | 0 | 8,581 | 95,825 |
| HELOC present | 0.198 | 0.399 | 0 | 0 | 1 |
| No closed-end, only HELOC | 0.050 | 0.218 | 0 | 0 | 1 |
| Year of Mortgage Origination | 2000.7 | 5.251 | 1980 | 2002 | 2009 |

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. Credit score refers to the Equifax 3.0 Risk Score. Year of origination is for the individual's (implied) first-lien closed end mortgage.

Table 3. Models for whether homeowner *i* extracted equity in year *t,* boom and bust years (1999-2010)

| | Outcome variable is $Extract_{it}$ = {0,1} | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 1-year ARM Mtg Rate | -0.01132 | -0.02225** | -0.02930** | -0.02320** | | |
| | (0.01357) | (0.00533) | (0.00480) | (0.00407) | | |
| Zip Code HPI Growth | | 0.00512** | 0.00380** | 0.00836** | 0.00347** | 0.00593* |
| | | (0.00042) | (0.00029) | (0.00141) | (0.00036) | (0.00267) |
| (Mtg Rate)*(HPI growth) | | | | -0.00096* | | -0.00051 |
| | | | | (0.00031) | | (0.00049) |
| County fixed effects | | Y | Y | Y | Y | Y |
| Additional Controls | | | Y | Y | Y | Y |
| Year fixed effects | | | | | Y | Y |
| Adjusted R-squared | 0.001 | 0.024 | 0.056 | 0.056 | 0.057 | 0.057 |
| N | 2,041,513 | 2,041,513 | 2,041,267 | 2,041,267 | 2,041,267 | 2,041,267 |
| Years | 1999-2010 | 1999-2010 | 1999-2010 | 1999-2010 | 1999-2010 | 1999-2010 |

Notes: * p < 0.05; ** p < 0.01. Standard errors, clustered at year level, in parentheses. See notes for Tables 1 and 2 for more on data sources, sample selection and variable definitions. Additional controls refer to the variables listed in Table 2. Private securitization rate is omitted in regressions with year fixed effects; age, mortgage balance and non-mortgage balance are in logs; individual credit score and credit card utilization rate are included in bins; year of origination is controlled for as a set of dummy variables and those with a HELOC only have a separate dummy variable.

Table 4. Models for whether homeowner *i* extracted equity in year *t,* boom years *only* (1999-2007)

| | OLS | | | | | | | | 2SLS[a] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| 1-year ARM Mtg Rate | -0.03669** | -0.02629** | | | | | | | -0.03335** | -0.02731** |
| | (0.00289) | (0.00293) | | | | | | | (0.00253) | (0.00333) |
| Fed Funds Rate | | | | | | | -0.01652** | -0.01242** | | |
| | | | | | | | (0.00225) | (0.00224) | | |
| Zip Code HPI Growth | 0.00438** | 0.01172** | 0.00422** | 0.01222** | 0.00238** | 0.00527** | 0.00465** | 0.00681** | 0.00429** | 0.00835** |
| | (0.00023) | (0.00137) | (0.00025) | (0.00078) | (0.00026) | (0.00093) | (0.00035) | (0.00069) | (0.00037) | (0.00150) |
| (Mtg Rate)*(HPI growth) | | -0.00143** | | -0.00157** | | -0.00057* | | | | -0.00080** |
| | | (0.00026) | | (0.00015) | | (0.00017) | | | | (0.00028) |
| (Fed Funds Rate)*(HPI growth) | | | | | | | | -0.00056* | | |
| | | | | | | | | (0.00018) | | |
| County fixed effects | Y | Y | Y | Y | | | Y | Y | Y | Y |
| Additional Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Year fixed effects | | | Y | Y | | | | | | |
| MSA by year fixed effects | | | | | Y | Y | | | | |
| Adjusted R-squared | 0.055 | 0.056 | 0.056 | 0.056 | 0.058 | 0.058 | 0.055 | 0.055 | 0.048 | 0.048 |
| N | 1,464,445 | 1,464,445 | 1,464,445 | 1,464,445 | 1,395,688 | 1,395,688 | 1,464,445 | 1,464,445 | 1,464,445 | 1,464,445 |
| Years | 1999-2007 | 1999-2007 | 1999-2007 | 1999-2007 | 1999-2007 | 1999-2007 | 1999-2007 | 1999-2007 | 1999-2007 | 1999-2007 |

Notes: * $p < 0.05$; ** $p < 0.01$. Standard errors, in parentheses, are clustered at the year level in all other columns. See notes for Tables 1 and 2 text for more on data sources, sample selection and variable definitions. Additional controls refer to the variables listed in Table 2. Private securitization rate is omitted in regressions with year fixed effects; age, mortgage balance and non-mortgage balance are in logs; individual credit score and credit card utilization rate are included in bins; year of origination is controlled for as a set of dummy variables and those with a HELOC only have a separate dummy variable.

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

Table 5. Alternative models for whether homeowner *i* extracted equity in year *t,* boom and bust years (1999-2010)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | | | | | | Cashout (mean outcome = 0.052)[b] | Junior lien (mean outcome = 0.044)[c] |
| 1-year ARM Mtg Rate | | | | -0.02868** | -0.03738** | -0.02077** | -0.00405 |
| | | | | (0.00476) | (0.00314) | (0.00339) | (0.00209) |
| 30-Year Fixed Mtg Rate | -0.03450* | | | | | | |
| | (0.01225) | | | | | | |
| Fed Funds Rate | | -0.01645** | -0.01560** | | | | |
| | | (0.00283) | (0.00262) | | | | |
| Zip Code HPI Growth | 0.00440** | 0.00385** | 0.00374** | 0.00371** | 0.00436** | 0.00300** | 0.00056** |
| | (0.00039) | (0.00052) | (0.00051) | (0.00030) | (0.00024) | (0.00033) | (0.00009) |
| ln(Single-Family Housing Permits in County Last Year) | | | 0.01059** | | | | |
| | | | (0.00313) | | | | |
| Extracted last year[a] | | | | 0.03136** | | | |
| | | | | (0.00820) | | | |
| Delinquent on Mtg 1 or 2 Years Later | | | | | 0.04954** | | |
| | | | | | (0.01381) | | |
| County fixed effects | Y | Y | Y | Y | Y | Y | Y |
| Additional Controls | Y | Y | Y | Y | Y | Y | Y |
| Year fixed effects | | | | | | | |
| Adjusted R-squared | 0.055 | 0.056 | 0.056 | 0.059 | 0.057 | 0.032 | 0.059 |
| N | 2,041,267 | 2,041,267 | 2,037,180 | 1,911,732 | 1,464,445 | 2,011,339 | 2,011,339 |
| Years | 1999-2010 | 1999-2010 | 1999-2010 | 2000-2010 | 1999-2007 | 1999-2010 | 1999-2010 |

Notes: * $p < 0.05$; ** $p < 0.01$. Standard errors, clustered at year level, in parentheses. Annual permits data are from the Census Bureau. See notes for Tables 1 and 2 text for more on data sources, sample selection and variable definitions. Additional controls refer to the variables listed in Table 2. Individual credit score and credit card utilization rate are included in bins; year of origination is controlled for as a set of dummy variables and those with a HELOC only have a separate dummy variable; age, mortgage balance and non-mortgage balance are in logs.

a. 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.

b. Outcome variable equals 1 for cash-out refinances and zero otherwise; undefined or 'other' extractions (see last column of Table 1) excluded.

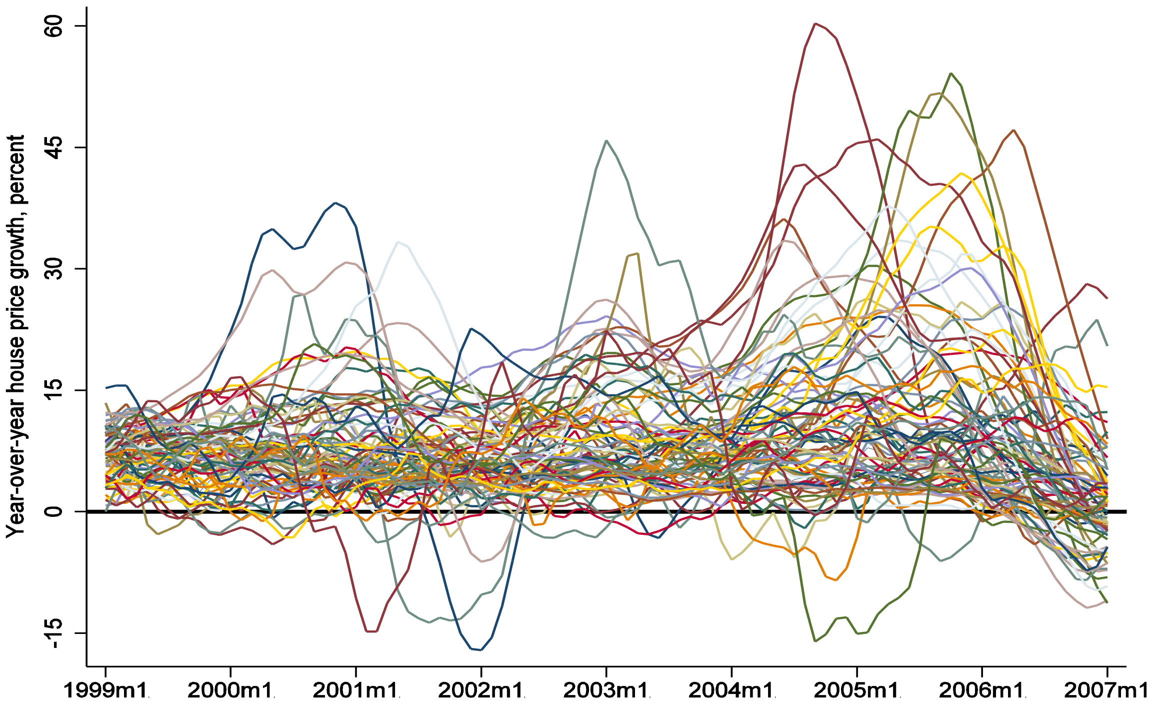
c. Outcome variable equals 1 for extractions through HELOC or home equity loan and zero otherwise; undefined or 'other' extractions (see last column of Table 1) excluded.

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 |
| Credit Score > 779 | Mortgage Rate | -0.0447 | (0.00458) | **-0.471** | -0.0280 | (0.00359) | **-0.322** |
| | Zip code HPI growth | 0.0033 | (0.00033) | **0.035** | 0.0020 | (0.00021) | **0.023** |
| | N | 78,430 | | | 361,461 | | |
| | Fraction who extracts | 0.095 | | | 0.087 | | |
| Credit Score 620 - 779 | Mortgage Rate | -0.0477 | (0.00457) | **-0.318** | -0.0416 | (0.00356) | **-0.275** |
| | Zip code HPI growth | 0.0062 | (0.00038) | **0.041** | 0.0046 | (0.00027) | **0.031** |
| | N | 264,196 | | | 542,793 | | |
| | Fraction who extracts | 0.150 | | | 0.151 | | |
| Credit Score < 620 | Mortgage Rate | -0.0204 | (0.00590) | **-0.179** | -0.0217 | (0.00974) | **-0.163** |
| | Zip code HPI growth | 0.0062 | (0.00048) | **0.055** | 0.0057 | (0.00040) | **0.043** |
| | N | 80,406 | | | 137,099 | | |
| | Fraction who extracts | 0.114 | | | 0.133 | | |

Notes: Standard errors, clustered at year 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 for the boom years (1999-2007) only and include county fixed effects and other controls as in column 1 of Table 4.

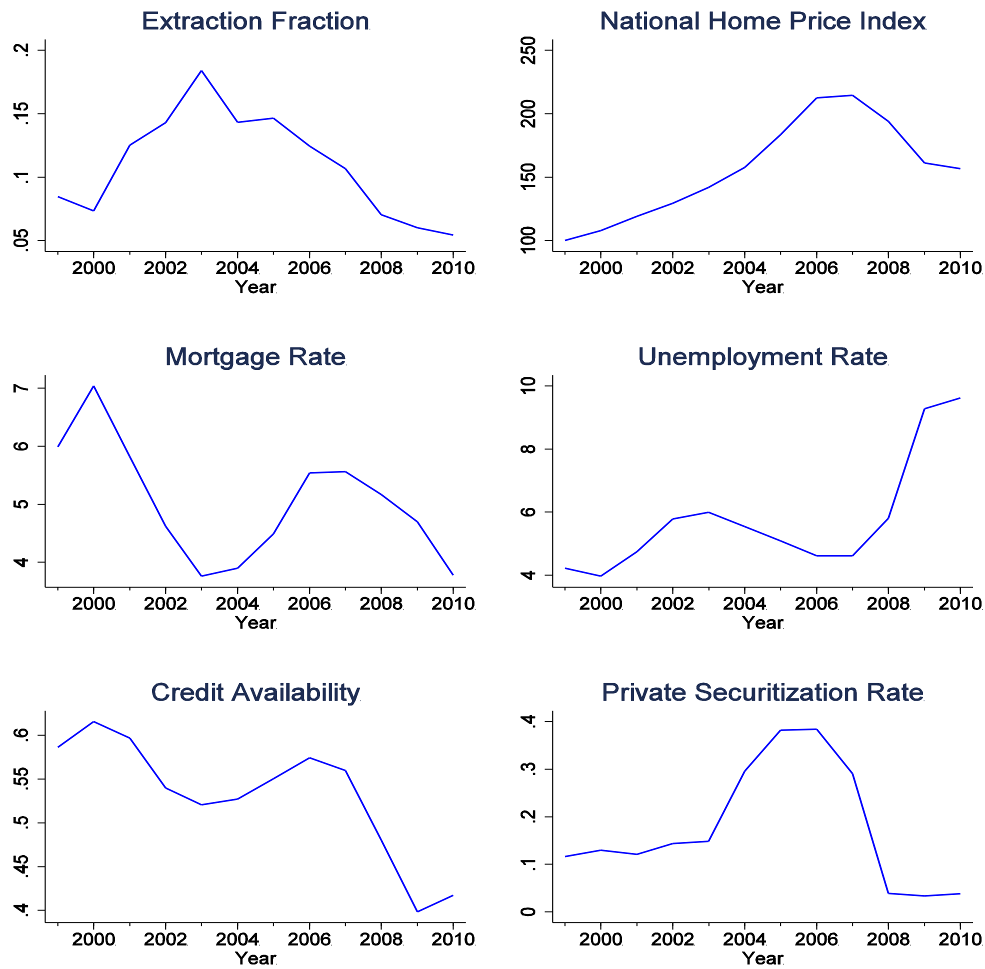
Appendix Figure 1: Heterogeneity across cities in house price growth




Source: Zillow monthly house price data.

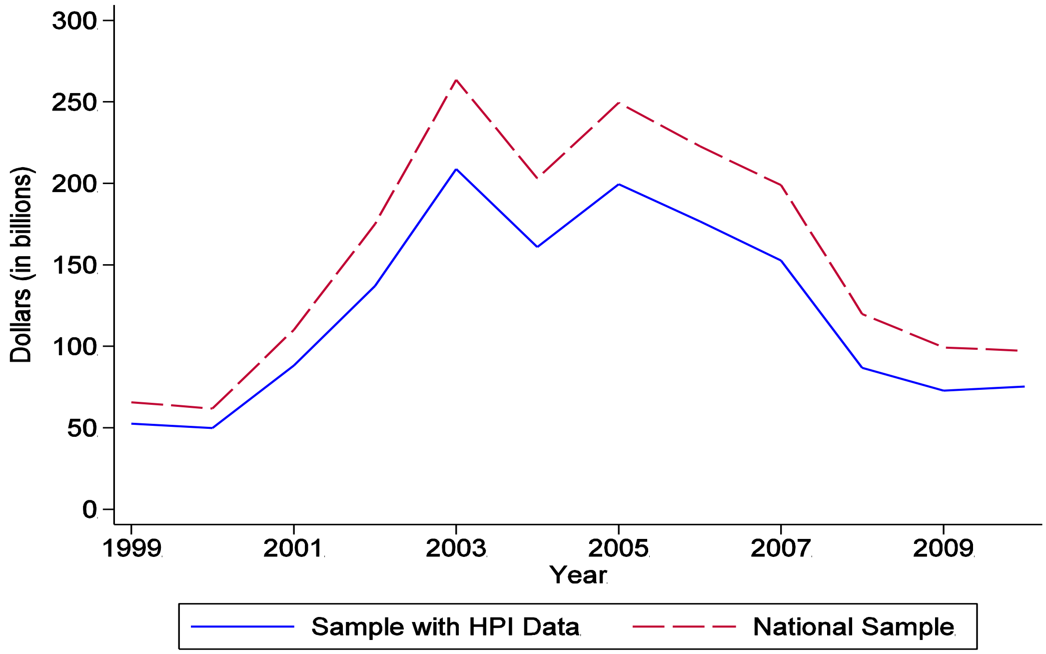
Notes: Figure shows year-over-year growth rates in home prices each month from January, 1999 through December, 2006 for 80 major cities.

Appendix Figure 2. Equity extraction versus other macroeconomic indicators




Sources: FRBNY CCP/Equifax, Freddie Mac PMMS, BLS, CoreLogic, Inside Mortgage Finance.
Notes: Extraction is defined as increasing one's 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.

Appendix Figure 3. 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.

Appendix Table 1. 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 | -$1,859.96 | -28.0% |
| Change in amount extracted given a one standard deviation increase in 3-year annual HPI growth | $2,633.30 | 39.6% |

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 $6,653, 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.

Appendix Table 2. Estimates of the effect of equity extraction on future mortgage delinquency

| Outcome variable | Mortgage debt | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 60+ days late 1 or 2 years later | | | | 60+ days late 1,2,3 or 4 years later | | | |
| Extract*1[t=1999] | 0.0090** | 0.0032 | 0.0060** | 0.0059** | 0.0163** | 0.0086** | 0.0123** | 0.0114** |
| | (0.0017) | (0.0018) | (0.0018) | (0.0018) | (0.0019) | (0.0021) | (0.0021) | (0.0022) |
| Extract*1[t=2000] | 0.0191** | 0.0091** | 0.0122** | 0.0121** | 0.0331** | 0.0202** | 0.0234** | 0.0236** |
| | (0.0033) | (0.0020) | (0.0020) | (0.0021) | (0.0054) | (0.0026) | (0.0026) | (0.0026) |
| Extract*1[t=2001] | 0.0009 | 0.0023 | 0.0036** | 0.0040** | 0.0059** | 0.0070** | 0.0090** | 0.0097** |
| | (0.0015) | (0.0013) | (0.0013) | (0.0014) | (0.0022) | (0.0018) | (0.0018) | (0.0017) |
| Extract*1[t=2002] | -0.0068** | -0.0020 | -0.0014 | -0.0015 | -0.0019 | 0.0033* | 0.0050** | 0.0048** |
| | (0.0011) | (0.0011) | (0.0011) | (0.0011) | (0.0018) | (0.0015) | (0.0015) | (0.0014) |
| Extract*1[t=2003] | -0.0073** | -0.0004 | 0.0010 | 0.0009 | 0.0007 | 0.0076** | 0.0097** | 0.0094** |
| | (0.0014) | (0.0010) | (0.0011) | (0.0010) | (0.0025) | (0.0014) | (0.0014) | (0.0014) |
| Extract*1[t=2004] | 0.0056** | 0.0002 | 0.0011 | 0.0012 | 0.0466** | 0.0350** | 0.0353** | 0.0350** |
| | (0.0021) | (0.0013) | (0.0013) | (0.0012) | (0.0080) | (0.0026) | (0.0024) | (0.0020) |
| Extract*1[t=2005] | 0.0200** | 0.0131** | 0.0124** | 0.0125** | 0.0845** | 0.0693** | 0.0668** | 0.0654** |
| | (0.0039) | (0.0017) | (0.0017) | (0.0014) | (0.0161) | (0.0047) | (0.0042) | (0.0022) |
| Extract*1[t=2006] | 0.0738** | 0.0587** | 0.0543** | 0.0534** | 0.1428** | 0.1192** | 0.1113** | 0.1094** |
| | (0.0136) | (0.0044) | (0.0038) | (0.0021) | (0.0216) | (0.0067) | (0.0057) | (0.0027) |
| Extract*1[t=2007] | 0.0680** | 0.0570** | 0.0532** | 0.0521** | | | | |
| | (0.0118) | (0.0044) | (0.0037) | (0.0025) | | | | |
| Extract*1[t=2008] | 0.0147 | 0.0132** | 0.0193** | 0.0196** | | | | |
| | (0.0074) | (0.0031) | (0.0029) | (0.0026) | | | | |
| Credit Score at start of year of potential extraction (< 520 omitted)[a] | | | | | | | | |
| 520-579 | | -0.0437** | -0.0384** | -0.0378** | | -0.0483** | -0.0446** | -0.0446** |
| | | (0.0024) | (0.0024) | (0.0021) | | (0.0031) | (0.0031) | (0.0026) |
| 580-659 | | -0.1143** | -0.1040** | -0.1036** | | -0.1331** | -0.1257** | -0.1255** |
| | | (0.0030) | (0.0030) | (0.0020) | | (0.0040) | (0.0037) | (0.0025) |
| 660-739 | | -0.1787** | -0.1595** | -0.1591** | | -0.2217** | -0.2048** | -0.2041** |
| | | (0.0035) | (0.0034) | (0.0020) | | (0.0049) | (0.0044) | (0.0025) |
| 740-800 | | -0.2075** | -0.1794** | -0.1788** | | -0.2614** | -0.2342** | -0.2333** |
| | | (0.0032) | (0.0032) | (0.0021) | | (0.0048) | (0.0044) | (0.0026) |
| 800+ | | -0.2213** | -0.1841** | -0.1830** | | -0.2731** | -0.2357** | -0.2345** |
| | | (0.0030) | (0.0031) | (0.0021) | | (0.0047) | (0.0044) | (0.0026) |
| Credit card utilization (zero balance omitted)[b] | | | | | | | | |
| 0 < utilization =< .5 | | | -0.0028** | -0.0030** | | | -0.0036** | -0.0037** |
| | | | (0.0006) | (0.0006) | | | (0.0008) | (0.0008) |
| .5 < utilization =< .75 | | | 0.0015 | 0.0014 | | | 0.0002 | 0.0003 |
| | | | (0.0009) | (0.0009) | | | (0.0012) | (0.0011) |
| .75 < utilization =< 1 | | | 0.0074** | 0.0074** | | | 0.0077** | 0.0079** |
| | | | (0.0011) | (0.0009) | | | (0.0015) | (0.0012) |
| utilization > 1 | | | 0.0235** | 0.0234** | | | 0.0252** | 0.0248** |
| | | | (0.0023) | (0.0018) | | | (0.0028) | (0.0023) |
| Has a 60+ days late mortgage at start of year | | 0.1212** | 0.1205** | 0.1191** | | 0.1002** | 0.1019** | 0.1014** |
| of potential extraction | | (0.0036) | (0.0037) | (0.0027) | | (0.0041) | (0.0041) | (0.0033) |
| Has a 60+ days late non-mortgage at start of year of potential extraction | | | | | | | | |
| Has any 30+ days late accounts at start of year | | | 0.0045** | 0.0045** | | | -0.0018 | -0.0020 |
| of potential extraction | | | (0.0012) | (0.0011) | | | (0.0016) | (0.0014) |
| Extract next year[c] | | | -0.0047** | -0.0044** | | | 0.0177** | 0.0176** |
| | | | (0.0006) | (0.0006) | | | (0.0012) | (0.0008) |
| ZIP HPI growth last 3 years | | | -0.0004* | | | | 0.0005* | |
| | | | (0.0002) | | | | (0.0002) | |
| ZIP HPI growth next 3 years | | | -0.0022** | | | | -0.0021** | |
| | | | (0.0002) | | | | (0.0003) | |
| County by year fixed effects | | Y | Y | | | Y | Y | |
| Zip by year fixed effects | | | | Y | | | | Y |
| Other credit and demographic controls | | | Y | Y | | | Y | Y |
| R-squared | 0.0198 | 0.1338 | 0.1493 | 0.182 | 0.0169 | 0.1393 | 0.1508 | 0.1843 |
| N | 1,651,203 | 1,651,203 | 1,651,073 | 1,651,073 | 1,276,183 | 1,276,183 | 1,276,092 | 1,276,092 |

Notes: * p < 0.05; ** p < 0.01. Robust standard errors in parentheses, clustered at the county level in regressions with county by year fixed effects. Other credit and demographic controls 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.

Appendix Table 3. Estimates of the effect of equity extraction on future non-mortgage delinquency

| Outcome variable | Non-mortgage debt | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 60+ days late 1 or 2 years later | | | | 60+ days late 1,2,3 or 4 years later | | | |
| Extract*1[t=1999] | 0.0065* | -0.0040 | -0.0073** | -0.0073* | 0.0206** | 0.0038 | 0.0023 | 0.0023 |
| | (0.0030) | (0.0028) | (0.0028) | (0.0029) | (0.0046) | (0.0034) | (0.0034) | (0.0033) |
| Extract*1[t=2000] | 0.0334** | 0.0097** | 0.0058 | 0.0071* | 0.0495** | 0.0173** | 0.0147** | 0.0159** |
| | (0.0044) | (0.0033) | (0.0032) | (0.0032) | (0.0073) | (0.0038) | (0.0037) | (0.0036) |
| Extract*1[t=2001] | -0.0154** | -0.0062** | -0.0097** | -0.0092** | -0.0100** | -0.0040 | -0.0062* | -0.0054* |
| | (0.0029) | (0.0021) | (0.0022) | (0.0023) | (0.0038) | (0.0027) | (0.0026) | (0.0026) |
| Extract*1[t=2002] | -0.0332** | -0.0158** | -0.0186** | -0.0185** | -0.0247** | -0.0092** | -0.0103** | -0.0100** |
| | (0.0038) | (0.0020) | (0.0020) | (0.0019) | (0.0047) | (0.0022) | (0.0022) | (0.0022) |
| Extract*1[t=2003] | -0.0428** | -0.0208** | -0.0236** | -0.0233** | -0.0288** | -0.0086** | -0.0100** | -0.0096** |
| | (0.0036) | (0.0019) | (0.0019) | (0.0017) | (0.0047) | (0.0022) | (0.0023) | (0.0020) |
| Extract*1[t=2004] | -0.0038 | -0.0172** | -0.0197** | -0.0193** | 0.0426** | 0.0186** | 0.0161** | 0.0164** |
| | (0.0040) | (0.0021) | (0.0021) | (0.0020) | (0.0078) | (0.0026) | (0.0026) | (0.0025) |
| Extract*1[t=2005] | 0.0125* | -0.0005 | -0.0032 | -0.0026 | 0.0733** | 0.0483** | 0.0448** | 0.0441** |
| | (0.0060) | (0.0025) | (0.0025) | (0.0020) | (0.0139) | (0.0037) | (0.0034) | (0.0025) |
| Extract*1[t=2006] | 0.0640** | 0.0359** | 0.0304** | 0.0297** | 0.1225** | 0.0801** | 0.0725** | 0.0713** |
| | (0.0102) | (0.0028) | (0.0026) | (0.0025) | (0.0140) | (0.0038) | (0.0033) | (0.0029) |
| Extract*1[t=2007] | 0.0507** | 0.0364** | 0.0307** | 0.0312** | | | | |
| | (0.0091) | (0.0040) | (0.0036) | (0.0027) | | | | |
| Extract*1[t=2008] | -0.0047 | -0.0022 | 0.0009 | 0.0015 | | | | |
| | (0.0036) | (0.0027) | (0.0026) | (0.0028) | | | | |
| Credit Score at start of year of potential extraction (< 520 omitted)[a] | | | | | | | | |
| 520-579 | | -0.1105** | -0.0898** | -0.0899** | | -0.0967** | -0.0757** | -0.0758** |
| | | (0.0028) | (0.0028) | (0.0025) | | (0.0031) | (0.0032) | (0.0027) |
| 580-659 | | -0.2514** | -0.2190** | -0.2183** | | -0.2500** | -0.2188** | -0.2176** |
| | | (0.0029) | (0.0032) | (0.0024) | | (0.0032) | (0.0036) | (0.0027) |
| 660-739 | | -0.4226** | -0.3715** | -0.3702** | | -0.4768** | -0.4244** | -0.4227** |
| | | (0.0033) | (0.0038) | (0.0025) | | (0.0039) | (0.0046) | (0.0028) |
| 740-800 | | -0.4951** | -0.4245** | -0.4232** | | -0.5829** | -0.5084** | -0.5068** |
| | | (0.0032) | (0.0037) | (0.0026) | | (0.0038) | (0.0045) | (0.0029) |
| 800+ | | -0.5122** | -0.4274** | -0.4262** | | -0.6059** | -0.5153** | -0.5140** |
| | | (0.0031) | (0.0036) | (0.0026) | | (0.0038) | (0.0045) | (0.0030) |
| Credit card utilization (zero balance omitted)[b] | | | | | | | | |
| 0 < utilization =< .5 | | | -0.0070** | -0.0067** | | | -0.0089** | -0.0083** |
| | | | (0.0010) | (0.0008) | | | (0.0013) | (0.0011) |
| .5 < utilization =< .75 | | | 0.0219** | 0.0223** | | | 0.0231** | 0.0235** |
| | | | (0.0015) | (0.0012) | | | (0.0018) | (0.0016) |
| .75 < utilization =< 1 | | | 0.0447** | 0.0452** | | | 0.0436** | 0.0443** |
| | | | (0.0016) | (0.0013) | | | (0.0020) | (0.0016) |
| utilization > 1 | | | 0.1108** | 0.1108** | | | 0.1104** | 0.1103** |
| | | | (0.0029) | (0.0023) | | | (0.0032) | (0.0026) |
| Has a 60+ days late mortgage at start of year of potential extraction | | | | | | | | |
| Has a 60+ days late non-mortgage at start of year of potential extraction | | 0.2186** | 0.2097** | 0.2101** | | 0.1888** | 0.1904** | 0.1909** |
| | | (0.0024) | (0.0027) | (0.0023) | | (0.0027) | (0.0031) | (0.0026) |
| Has any 30+ days late accounts at start of year of potential extraction | | | -0.0038 | -0.0040 | | | -0.0167** | -0.0170** |
| | | | (0.0023) | (0.0020) | | | (0.0027) | (0.0025) |
| Extract next year[c] | | | -0.0281** | -0.0276** | | | -0.0044** | -0.0040** |
| | | | (0.0009) | (0.0008) | | | (0.0011) | (0.0010) |
| ZIP HPI growth last 3 years | | | -0.0002 | | | | -0.0003 | |
| | | | (0.0002) | | | | (0.0002) | |
| ZIP HPI growth next 3 years | | | -0.0010** | | | | -0.0011** | |
| | | | (0.0002) | | | | (0.0002) | |
| County by year fixed effects | | Y | Y | | | Y | Y | |
| Zip by year fixed effects | | | | Y | | | | Y |
| Other credit and demographic controls | | | Y | Y | | | Y | Y |
| R-squared | 0.0028 | 0.3179 | 0.3277 | 0.3518 | 0.0037 | 0.3293 | 0.3383 | 0.3631 |
| N | 1,651,203 | 1,651,203 | 1,651,073 | 1,651,073 | 1,276,183 | 1,276,183 | 1,276,092 | 1,276,092 |

Notes: * p < 0.05; ** p < 0.01. Robust standard errors in parentheses, clustered at the county level in regressions with county by year fixed effects. Other credit and demographic controls 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.