A-1 Online Appendix to Neil Bhutta and Benjamin J. Keys "Interest Rates and Equity Extraction during the Housing Boom"

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.[1] 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.[2]

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

[1] 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)

[2] 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.

of the intensive margin (how much to extract).[3] 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 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. 2011, Case et al. 2013).

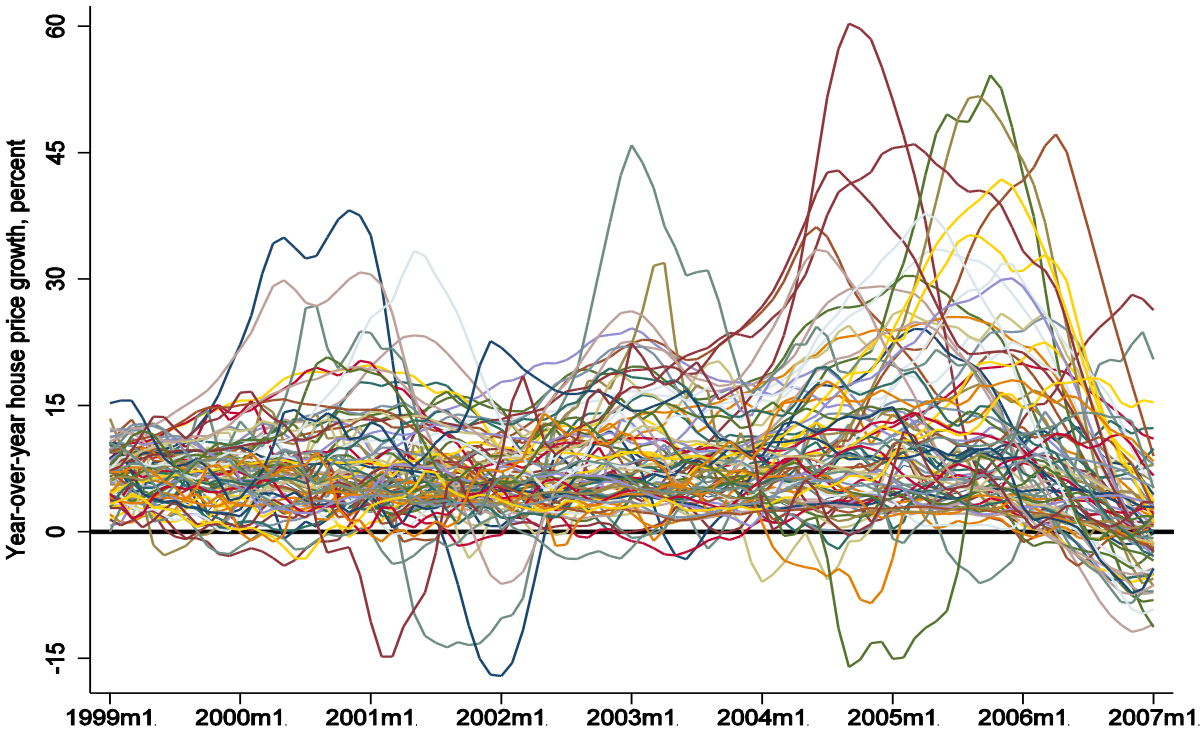
A-1.B Sensitivity of Default Results to Controls

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

[3]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.

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.

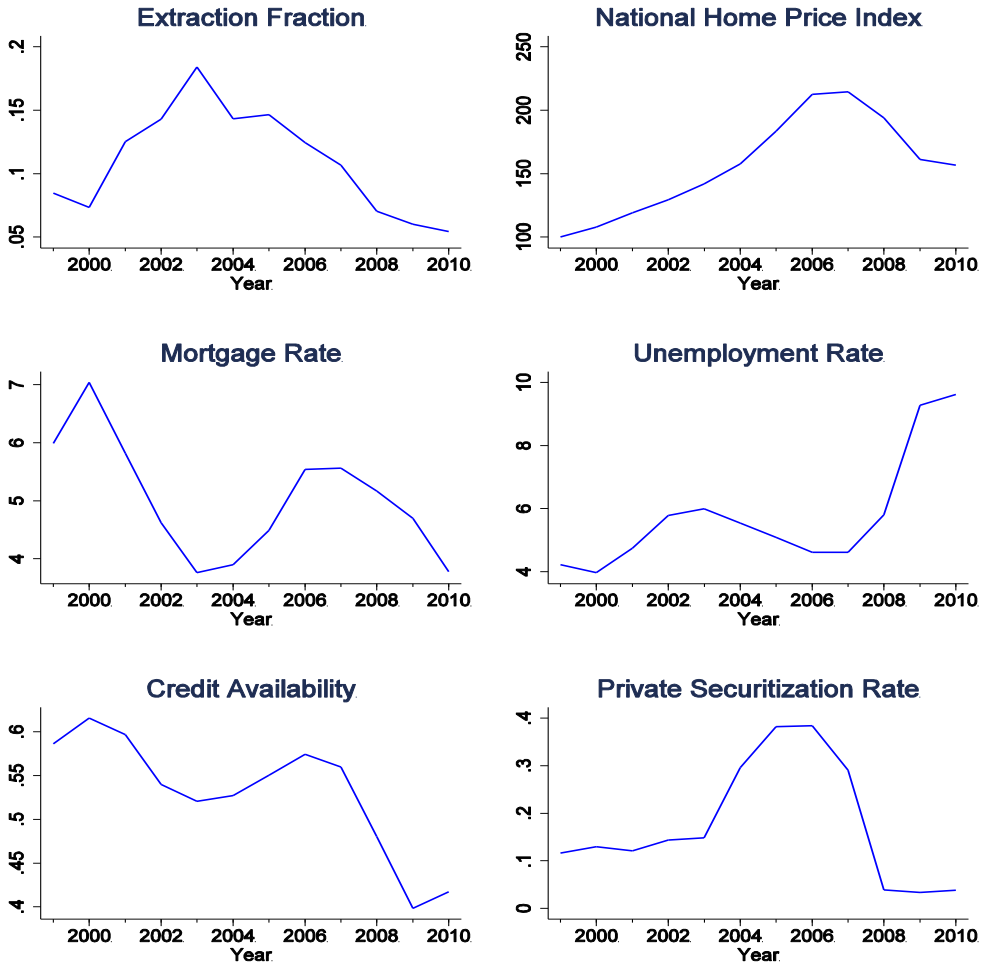
Appendix Figure 1: Heterogeneity across cities in house price growth



Source: Zillow monthly house price data.

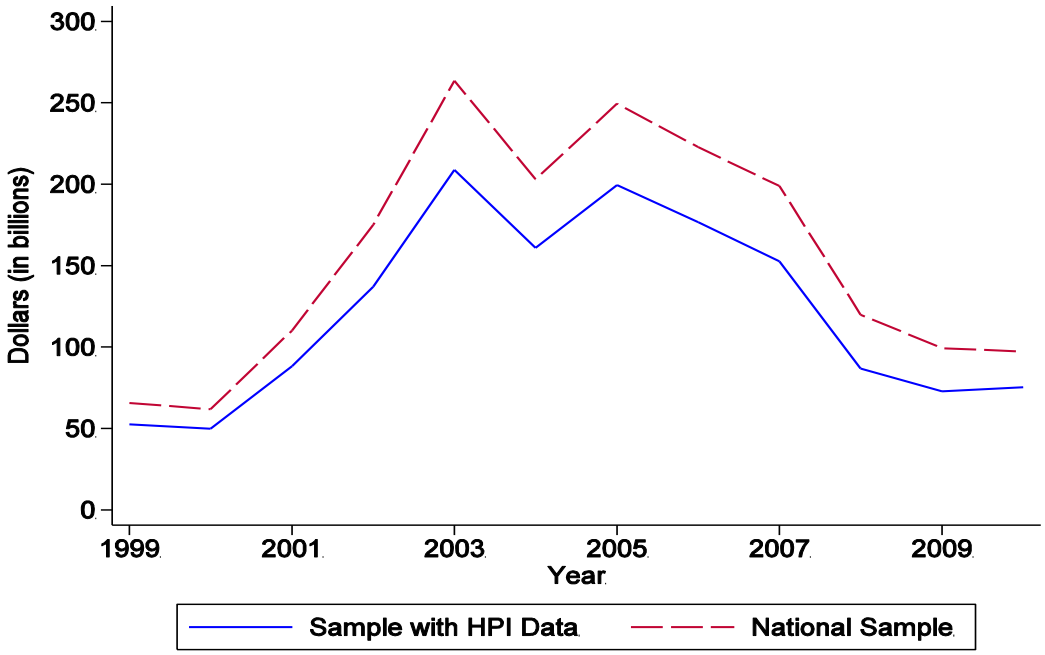
Notes: Figure shows year-over-year growth rates in home prices each month from January, 1999 through December, 2006 for 80 major cities.

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 of potential extraction		0.1212**	0.1205**	0.1191**		0.1002**	0.1019**	0.1014**
		(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 of potential extraction			0.0045**	0.0045**			-0.0018	-0.0020
			(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

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