# Do Reverse Mortgage Borrowers Use Credit Ruthlessly?

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July 28, 2013

**Abstract**

Home Equity Conversion Mortgage ("HECM") rules concerning repayment, limited liability, and credit line growth provide older homeowners with put options that are "in the money" when available credit exceeds mortgaged homes' resale value. Federal Housing Administration (FHA) mortgage insurance pricing and credit rules do not reflect geographic or cyclical risk, and HECMs were disproportionately originated near the home price cycle peak in markets with large subsequent busts. Federal reverse mortgage insurance has thus lost money, contrary to legislative goals. Was selection on geography and timing adverse because borrowers consciously exploited unpriced information? This appears unlikely because borrowers have not used credit "ruthlessly." Borrowers whose loans have terminated with credit limits greater than property value have not been likelier to exhaust credit lines than similar borrowers with put options "out of the money."

JEL Codes: Mortgages (G21), Housing Demand (R21), Social Security and Pensions (H55), Portfolio Choice (G11), Insurance (G22)

## 1 Introduction

Home Equity Conversion Mortgages ("HECMs") are available to US homeowners over age 62. The Federal Housing Administration ("FHA"), part of the Department of Housing and Urban Development, both defines available credit terms and, in exchange for fees, provides guarantees to lenders that they will be repaid principal and interest due. Congress authorized HECM in 1987, with the stated purpose of providing home equity liquidity to senior citizens with low income who wish to remain in their homes while meeting expenditure needs.[1] With

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[1]See Section 255 of the National Housing Act.

roughly 800,000 loans issued to date, HECM represents a small part of a very large federal commitment to mortgage insurance.[2]

Lines of credit, historically the most common form of HECM loans, let borrowers choose the timing and amount of withdrawals up to a maximum balance that grows with time. Borrowers may defer repayment of any credit used until death or extended absence from the home, and lenders cannot force early termination or reduce available credit in response to declining collateral value. Borrowers' liability at termination is the lesser of accumulated principal and interest or net resale value of the home. FHA thus effectively sells borrowers put options on mortgaged homes, with an exercise price equal to the evolving maximum allowable balance. When the allowable balance exceeds collateral value near an anticipated termination, the put option is "in the money," and any remaining available credit in excess of net resale value is close to free money.[3]

This paper asks how "ruthlessly" HECM line of credit borrowers have exploited embedded put options. In particular, we ask if borrowers are likelier to exhaust available credit before termination when their homes are worth less than available credit. The question is motivated by the fact that HECM loans were disproportionately originated near the recent home price cycle peak in markets where prices subsequently fell most. Sharp price declines in over-represented markets have rendered the limited liability terms valuable to borrowers and costly to the federal government as mortgage insurer. 2014 Federal budget estimates indicate that FHA faces insurance liabilities roughly $5 billion dollars greater in present value than income taken in from premiums described below on loans insured to date. FHA's HECM insurance was meant to be subsidy-free in expectation, and program goals do not specifically include providing seniors with a way to bet against future price declines.

Figures 1 and 2 illustrate the extent of adverse selection on the dimensions of timing and geography faced by FHA as HECM guarantor.[4] The top panel of Figure 1 takes metropolitan area ($m$) $\times$ year-quarter ($t$) combinations as the unit of observation. The horizontal axis provides a measure of the magnitude of the recent home price bust: the ratio of real Federal Housing Finance Agency ("FHFA") repeated home price index for $m$ at date $t$ to the value for $m$ in 2010, quarter 4. The vertical axis plots the ratio of HECM loans originated at $mt$ to US Census estimates of number of homeowners over 65 in $m$ as of 2010. Data run from

[2]Since the federal takeover in 2008, Fannie Mae and Freddie Mac have required $187 billion in taxpayer investment and have turned over $65 billion in dividends, according to the Congressional Budget Office.

[3]Below, we address the possibility of credit score damage and show that demand for bequests or precautionary savings do not affect the analysis of incentives meaningfully.

[4]It is generally difficult to distinguish between moral hazard and adverse selection in actuarial markets, but it is difficult to believe that average market home prices fell in response to HECM volume. Indeed, if HECM is an alternative to selling a home, HECMs should add to, rather than subtract from, market prices. Any effect would be small, as HECMs have small market share everywhere.

1992 through 2010. The unconditional correlation between HECM market penetration and *ex-post* price declines is .56.

The top panel of Figure 2 plots a measure of FHA liability for all HECM loans as of the last observation (the earlier of loan termination or quarter 4, 2011). This measure equals the greater of zero or the ratio of maximum allowable balance to home value (based on initial appraised value and FHFA metropolitan price index growth) minus one. This is an estimate of the "moneyness" of the borrower's put option. The circles plot unweighted means by quarter of origination. The line plots mean moneyness for loans by quarter, with metropolitan area weights governed by the area's share of all loans originated through the first quarter of 2000, rather than by time-varying shares.[5] Shifts in metropolitan area origination shares across time account for a strikingly large fraction of FHA insurance obligations.

The bottom panel of Figure 2 plots by year the number of HECM loans originated in all states (in thousands, circles) and the percentage originated in the "Sand States" of Arizona, California, Florida, and Nevada (line). Sand State markets uniformly witnessed larger price increases and more severe housing busts than other states, and their HECM originations share jumped during the price and origination boom between 2004 and 2007.

The extent of geographic and temporal adverse selection suggests that borrowers may have consciously selected into HECM based on the embedded put option value. That is, demand may have been more intense in markets in which prices subsequently fell because some fraction of older homeowners both correctly anticipated the geographic distribution of price declines and recognized the value of HECM's implicit put options.

Such selection is plausible given that (a) credit terms set by the government did not reflect rising risk as prices rose across time or locations during the home price boom of the 2000s and (b) the worst price declines and largest increases in HECM demand occurred in housing markets that *ex-post* seem to have been clearly overpriced near the peak. Selection into an actuarial market based on unpriced information would be consistent with the standard Akerlof (1970) model, and is proposed in the HECM context by Shan (2011) and Haurin et al. (2013).[6] As discussed in Davidoff (2012*a*) and Davidoff (2012*b*), it is plausible that a significant number of older homeowners in historically elastically supplied Sand State markets such as Bakersfield, Las Vegas, Orlando, and Phoenix around 2007 might have believed prices were likely to decline sharply after roughly doubling over the five prior years. The possibility

[5]The circles measure $\sum_m \sum_{i \in mt} \frac{z_{it}}{N_{mt}} \frac{N_{mt}}{N_t}$, whereas the line calculates $\sum_m \sum_{i \in mt} \frac{z_{it}}{N_{mt}} \frac{N_{m2000}}{N_{2000}}$, where $i \in mt$ is a loan originated in metropolitan area $m$ at date $t$, $z_{it}$ is the moneyness measure, and $N$ is a sum of originated loans.

[6]The latter two papers do not emphasize put option value, but suggest that the negative correlation between originations and subsequent price changes may have been a result of borrowers seeking to lock in formulaically available proceeds from HECM at high levels.

of continuing large price declines were certainly widely appreciated by HECM's origination peak in 2008.

We are unaware of any survey evidence concerning borrowers' intent to use HECM as a put option.[7] We thus employ data on credit use to ask indirectly whether selection into HECM on *ex-post* realizations of put option value was plausibly driven by a combination of potential borrowers intent to use HECM as a put option and correct expectations of relative home price busts across markets. We view a reasonable assumption to be that borrowers intending to use HECM as a put option, as opposed to for liquidity or other purposes, would seek to fully exercise their option by exhausting available credit prior to any termination with collateral worth substantially less than available credit.

Ours is a one-way test of intentions. A finding that there are negligible effects of put option moneyness on the propensity to exhaust available credit makes it difficult to believe that put option value was an important driver of relatively high demand in markets where *ex-post* put value has been high. However, a finding that a large number of borrowers do use credit ruthlessly could arise from a combination of borrowers' luck and opportunism.

Identifying opportunistic borrower behavior alone would not be uninteresting. Such behavior would contrast with recent findings concerning financial literacy, particularly among the elderly. Brown et al. (2008) and Chalmers and Reuter (2009) suggest that retirees have difficulty correctly valuing life annuities, and HECM put options, like life annuities, typically grow in value with expected longevity. Lusardi, Mitchell and Curto (2009) find a low level of general financial literacy among surveyed retirees. Absence of sophistication among the elderly would not rule out exploitation of underpriced put options as a source of HECM demand growth in Sand State markets: financially literate children might encourage parents to exploit HECM's embedded put option, since total wealth available for bequests or nursing home use increase if HECM increases available home equity.

Generally, consumers' ability and willingness to maximize the value of options embedded in mortgages and other financial products has been called into question. Mortgage default and prepayment options are difficult to value for consumers (Deng and Quigley (2004), Deng, Quigley and Van Order (2000)), and even econometricians (Foster and Van Order (1984) and Vandell (1995)). Lucas and Moore (2007) show that just as HECM provides incidental put options, the federal student loan program provides incidental and valuable refinance options. They judge that borrowers do consolidate loans at fixed rates in a way that costs the government money, but less money than if borrowers maximized option value. Foote, Gerardi and Willen (2012) argue that most market participants, including professional

[7]Redfoot, Scholen and Brown (2007) does not list home price hedging among actual and potential borrowers' stated reasons for considering HECM.

investors, did not believe that home prices were likely to fall substantially from peak levels around 2006. While it is true that HECM was *relatively* popular in elastically supplied markets that experienced large price busts, the fraction of old homeowners using HECM was low everywhere. Davidoff (2012*a*) observes that more than 90% of Sand State borrowers found the *ex-post* apparently underpriced put options either unattractive or incomprehensible *ex-ante*. HECM is an appealing market in which to measure the "ruthlessness" of borrower behavior in part because the only knowledge required of borrowers or econometricians is whether the loan will terminate soon and whether the principal limit exceeds collateral value. Unlike with conventional mortgages, conditional on termination, exploiting default does not extinguish a call option. Credit costs of default are likely small and often zero.

Adverse selection on geography could have arisen without borrowers knowingly exploiting unpriced information. Borrower and market characteristics likely correlated with future price declines were likely also correlated with HECM demand through other channels.[8] For example, capital gains that homeowners enjoyed between 2000 and 2007 are very highly correlated with price busts after 2007, and might themselves have caused demand for the home equity extraction, even with no expectation of default on the part of borrowers. Alternatively, if differently aggressive lending was a cause of geographic differences in the magnitude of the home price cycle, then the same group of intermediaries responsible for fueling risky, highly leveraged home purchases might also have fueled demand for HECM loans. HECM loans have not proven highly popular, with roughly 2% of the eligible population participating despite a view held by many economists that they would be welfare improving (e.g.Artle and Varaiya (1978), Mayer and Simons (1994), and to a lesser extent Nakajima and Telyukova (2011). Aggressive lending may have been necessary to generate widespread demand.

Consistent with these alternative explanations for adverse selection, much of the correlation between *ex-post* price declines and HECM demand disappears conditional on lagged price appreciation.[9] This fact alone does not imply that put value was not central to HECM demand, though, since expected price declines around the cycle peak were presumably very highly correlated with lagged appreciation. The bottom panel of Figure 1 shows a high degree of correlation among all of past price appreciation, future price declines, and HECM market penetration in the panel of metropolitan areas across time. That figure plots the magnitude of the post-peak price crash on the horizontal axis, with peak price to 2000, quarter 1 price on the vertical axis. Circle diameters are proportional to the ratio of HECM

[8]Pursuant to Finkelstein and Poterba (2004), the simple "positive correlation" between price declines and HECM demand thus does not imply exploitation of unpriced information.

[9]We have found this result in unreported regressions. The extent to which controlling for lagged appreciation reduces the impact of forward-looking price declines depends on regression specification, and we believe such a regression to be poorly identified.

originations in a market in 2006-2007 to 1989-2002.

HECM design is subject to problems of hidden action and unpriced information on dimensions other than credit use. Shiller and Weiss (2000) and Miceli and Sirmans (1994) observe that when default is feasible, homeowners will have an incentive to undermaintain their homes. Davidoff and Welke (2006) observe that in the same situation, borrowers have an incentive to remain in their homes longer than would otherwise be optimal. Both of these contractual problems have been borne out in the current downturn: HECM terminations have slowed down considerably from the peak, and market participants report that a surprisingly large number of borrowers have defaulted on property tax or insurance obligations.

Our approach to indirectly identifying borrower intent to exploit underpriced options relies on a form of dynamic adverse selection. While it is not irrational for borrowers impatient to consume to draw down their lines of credit at any time, we would expect rational (and "ruthless") borrowers to use all credit available before termination when the used credit does not have to be repaid. As longevity, interest rates, and home prices evolve, borrowers learn over time whether credit used will likely be repaid at termination or not. Borrowers learning that their put options are likely to expire in the money will have an incentive to use more credit than other borrowers.

If borrower credit use is greater when collateral value is less than available credit, then to break even, FHA insurance premiums must be raised, or relatively heavily loaded up-front rather than on used credit. Prepayment by borrowers with rising incomes or collateral value generates a similar problem in forward mortgage markets, as observed by Mayer, Piskorski and Tchistyi (2012). Likewise, the exit of healthy borrowers from long-term care insurance contracts with prices that do not reflect changing health of the insured over time creates an actuarial problem in the long-term care insurance market. Finkelstein, McGarry and Sufi (2005) find evidence of this theoretically problematic exit of healthy borrowers in US data.

Throughout the discussion that follows, we highlight our approach to three related challenges to identifying borrower intent to exploit mispriced put options through use of credit. First, a large fraction of HECM borrowers use all available credit in an initial draw, such that a large number of borrowers are necessarily close to exhaustion of credit at termination, regardless of incentives. Second, HECM demand on both the "extensive margin" of participation in the program and the "intensive margin" of initial credit use conditional on participation, may be correlated with *ex-post* price declines through *ex-ante* home price increases. These correlations could reflect anticipated price declines or simple capital gains pressure on home equity liquidation demand. We may thus wish to condition on low initial credit use, but low initial credit use could itself be correlated with expectations or realizations of *ex-post* price performance. Our preferred approach is thus to compare credit use

among borrowers who experienced similar price growth *ex-ante*, but very different price declines after loan closing. We also show that there is theoretical justification for considering credit use among borrowers who choose not to take large initial draws.

A third challenge to identification may arise from sample selection. It is not easy to characterize ruthless put value maximization other than that it requires exhaustion of credit prior to termination when in-the-money. Davidoff (2012*a*) observes that patient borrowers aiming to exploit the embedded put option will not use credit until near termination, and Davidoff and Welke (2006) show that borrowers with no equity have less incentive to move while alive than other borrowers; empirically, terminations are slower where current loan to value ratios are greater. Borrowers whose loans have terminated may thus not be representative of borrowers whose loans are active, particularly on the dimension of collateral value, and may thus be less prone to use credit. We show that the Sand State borrowers we consider generally hold put options so deep into the money by termination that there is little risk that those who terminate are doing so voluntarily in part because their homes are still worth more than available credit. We also consider credit use among borrowers demographically likely to have terminated their loans.

# 2 The Home Equity Conversion Mortgage ("HECM")

To be eligible for HECM loans, homeowners must be able to retire any outstanding mortgage debt with available proceeds. Before 2008, the large majority of borrowers took adjustable rate lines of credit, although other payment plans such as regular monthly payments were available. Fixed rate loans, which require that the full balance be withdrawn immediately, were introduced in 2008 and have proven popular since. For married borrowers, the younger borrower's age governs eligibility and credit terms.[10]

HECM lines of credit offer an initial principal limit that grows with borrower age and falls with the 10-year LIBOR or US Treasury yield (the notch in realized put value in 2006 shown in Figure 2 came from a movements in 10-year interest rates). Among all HECM lines of credit in our sample, the median loan to value ratio at origination was 65%. In expensive housing markets, some loans hit a time- and market-varying cap on insurable value, such that loan-to-value ratios are smaller than available to borrowers with less valuable homes.

Each month, the outstanding balance on the credit line grows at the 1-year index rate plus a lender's margin (typically 1.5% in our data), plus an FHA guarantee fee (.5% per year

[10]Anecdotally, there appear to be problems of older borrowers dropping younger borrowers from title to take on larger loans, then spending the money, dying, and leaving widowed partners with no home equity and a need to repay the loan. See " A Risky Lifeline for the Elderly Is Costing Some Their Homes", Jessica Silver-Greenberg Ackerman for *New York Times*, October 14, 2012.

for loans originated through mid-2010). The maximum allowable outstanding balance grows at the same rate as the actual outstanding balance, so at any date up to loan termination, borrowers may draw on the credit line up to the point at which the balance is equal to the outstanding balance if all available credit had been drawn at loan origination. Loan servicers must respond quickly to credit requests from borrowers; HUD staff have indicated that there is no administrative obstacle to exploiting a HECM as a put option by waiting until near termination to draw credit. Borrowers may prepay part or all of their HECM loans without penalty, but partial prepayment is rare in practice. Starting in 2004, low-cost HECM refinancing became available,[11] and a large number of borrowers exploited low interest rates and rising home prices to extract further home equity.

At origination, borrowers owe lenders closing costs and fees plus an FHA mortgage insurance premium equal to 2% of a "maximum claim amount," equal to the lesser of the area cap on insured value or the appraised value of the home. Caplin (2002) suggests a total liability of 5% of property value at closing would not be out of the ordinary, but lender origination fees and closing costs vary considerably. Initial credit draws are almost always much larger than total closing costs, so that borrowers effectively finance these costs.

Borrowers need not make any payments until they vacate the home for more than six months, sell the home, or die. Couples can defer termination as long as one of the borrowers remains alive in the home. At termination, borrowers owe the accumulated principal and interest balance. However, lenders have no recourse to any borrower assets other than the mortgaged home, and the language in HECM marketing materials emphasizes this limited liability.[12] An open question is whether there are any adverse credit consequences of a "short sale" while alive. Asked informally about such consequences, several mortgage lenders, FHA-approved HECM counselors (counseling is mandatory prior to closing), FHA and Fannie Mae staff, and a credit bureau executive gave us conflicting responses, with most indicating uncertainty and that the question had never been posed to them before. The fact that a small sample of HECM counselors uniformly reported never having been asked about the consequences of short sales itself casts some doubt on borrowers' interest in using HECM for its put option value.

Just before termination, ignoring slight interest accumulation and assuming home prices

[11] The FHA guarantee fee applied only to the increase in insured value, not the entire insured value.

[12] Frequently Asked Question 2 regarding HECM loans found in a search of FHA's web site is as follows: "Can a borrower on a Home Equity Conversion Mortgage (HECM or reverse mortgage) ever owe more than the value of the home? No, the borrower's total debt on a Home Equity Conversion Mortgage (HECM or reverse mortgage) can never exceed the value of the home. The borrower can never owe more than the home is worth. The HECM is a 'non-recourse' loan. This means that the HECM borrower (or his or her estate) will never owe more than the loan balance or the value of the property, whichever is less; and no assets other than the home can be used to repay the debt."

do not jump suddenly, the direct cost in dollars at termination of dollars borrowed is equal to one dollar for balances less than collateral value and zero for balances in excess of collateral.[13] If the loan terminates with the death of the borrower (or both borrowers if a couple), the estate owes no debt beyond the property value, and there is no question of damage to credit. This calculation is not different if borrowers intend to use home equity for bequests or to fund long-term care, frequently cited reasons why HECM demand might be low.[14] Since borrowers do not need to terminate the loan until they have moved elsewhere, fear of exclusion from a nursing home due to such an event does not seem plausible.[15] If the loan terminates in death (as most "underwater" terminations are likely to), there is no possibility of any credit damage to children.

The limited liability feature of HECM loans makes lines of credit similar to put options on the mortgaged home, as described in Davidoff (2012*a*). If the borrower does not touch the line of credit until just before sale or death (putting aside for the now the possibility of sudden incapacity), they have spent closing costs and fees that may be thought of as a purchase price for the option. If the home is worth more than available credit at termination, the put option expires "out of the money," although drawing the line would generate only small interest costs. If the home is worth less than available credit, the borrower can draw the full line, sell the home (at arm's length), and pay the lender the resale price less allowable selling costs in a short sale. The option's payoff is thus the positive difference between available credit and collateral value at termination minus the future value of closing costs. If $r_t$ is the index yield, $\delta$ the borrower's discount rate, $s$ the interest rate spread, $l$ the initial loan to value ratio, $F$ initial fees and closing costs, $h_0$ the initial home price, and $h_T$ the value at termination net of selling costs, then the borrower's total discounted home equity under this HECM strategy for a loan originated at date 0 and terminated at $T$ will be:

$$V(T) = -Fh_0 + \max\left(h_T, lh_0\Pi_{t=1}^{T}\left[1 + r_t + s\right]\right)e^{-\delta T}. \tag{1}$$

HECM borrowers almost never use credit in a way consistent with valuation (1). The number of borrowers who draw less than 25% of available credit in the first year of the loan's life and then more than 50% of remaining credit in any subsequent year is 8,411 out of 583,937 lines of credit in our sample. Of these, only 1,799 are in the Sand States where in-the-money options have been concentrated. This fact alone does not imply a lack of interest in the embedded put option among borrowers, but it strongly suggests that adverse selection

[13] Any cost of damage to credit for selling the property short if there is a surviving borrower is presumably constant in the gap between collateral value and mortgage debt conditional on a "short" sale.

[14] See Skinner (1996), Nakajima and Telyukova (2011).

[15] Medicaid eligibility rules impose a very large tax on assets, so if borrowers terminated into a Medicaid-funded nursing home stay, it might not be worthwhile to exercise the put.

was not the product of borrowers with no interest in consuming or investing home equity prior to sale exploiting put options.

If a borrower discounts at a rate greater than the current loan index rate, or if they wish to smooth consumption between the illiquid period before the home is sold and the more liquid (or dead) state after, then early draws may be welfare enhancing. Older and single borrowers who are not impatient to consume might still draw before termination but after collateral is deemed less valuable than the allowable balance, if they believe they will die or become incapacitated in the near future with sufficiently high probability. That pattern of credit use, though, is difficult to reconcile with the empirical absence of small draws at origination followed by large draws after the principal limit has "crossed over" (Chinloy and Megbolugbe (1994)).[16]

For borrowers who wish to maximize the present value of some weakly concave function of periodic home equity proceeds (to the borrower(s) or heirs), when contemplating whether to draw funds at a given date prior to termination, the opportunity cost of funds borrowed prior to the last possible opportunity to borrow is equal to the loan interest rate up until the date of termination. The probability that the loan will not be repaid does not enter this cost. The borrower effectively repays principal and interest on prior draws upon termination whether they receive: (a) the resale value of the home net of selling costs and accumulated principal and interest on prior draws, or (b) the maximum allowable balance on the line of credit less accumulated principal and interest on prior draws. To see that for borrowers with linear utility, whether or not to draw credit early should only depend on discount rate $\delta$ versus the current loan interest rate (prepayment is allowed without penalty), note that if a draw in amount $x$ on the line is extracted at some date $A$ and not repaid until termination, then the value to the borrower in (1) is modified to:

$$\begin{aligned} V(T) =& - Fh_0 + xe^{-\delta A} \\ &+ \max\left(h_T - x\Pi_{t=A}^{T}\left[1+r_t+s\right], lh_0\Pi_{t=1}^{T}\left[1+r_t+s\right] - x\Pi_{t=A}^{T}\left[1+r_t+s\right]\right)e^{-\delta T} \end{aligned} \tag{2}$$

$$\text{and: } \frac{\partial V}{\partial x} = e^{-\delta A} - \Pi_{t=A}^{T}\left[1+r_t+s\right]e^{-\delta T}. \tag{3}$$

For borrowers with strictly concave utility over periodic expenditures, the expected resale value of the home will affect optimal draws between origination and termination. Changes in resale value associated with macroeconomic conditions might also affect demand for liquidity, for example to help unemployed children. Holding constant initial value, home price

[16]Conceivably, borrowers might take large initial draws anticipating that incapacity to make sound decisions, but not death or exit from the home, is likely to occur prior to the put options arrival in the money.

appreciation prior to origination, and other resources, we would expect to see less credit use on origination when expected resale value is lower. However, we know that price declines after origination near the cycle peak were correlated with nonlinear functions of prior appreciation, and prior price appreciation should increase demand for credit at origination.[17] We thus do not have a strong prior belief on whether borrowers whose loans have terminated in-the-money should have used more or less credit relative to other borrowers around loan origination, but before price uncertainty was resolved than other loans.

We conclude that:

1. Put option value is maximized by using all credit prior to termination if the net resale value of the mortgaged home plus any cost of damaged credit is less than the maximum allowable balance at loan termination;

2. Put value maximization *per se* does not imply a correlation between the size of credit use near origination (when collateral value exceeds the maximum principal limit) and any expected positive gap between maximum allowable balance and collateral value;

3. If death or incapacity can arrive with insufficient warning to withdraw available credit:

   (a) it may be optimal even for patient borrowers to withdraw the full credit line before termination, and,

   (b) borrowers who believe surprise termination occurs with probability smaller than the loan interest rate or whose homes are not worth too much less than the allowable credit may optimally fail to withdraw credit before termination with positive probability.

# 3 Empirical Analysis of Home Equity Conversion Mortgage Lines of Credit

## 3.1 Estimation Framework

Figures 1 and 2, described above, show that HECM loans were disproportionately originated in markets where home prices fell farthest *ex-post*. We wish to explore whether borrower behavior is consistent with this adverse geographic selection having been driven by borrower intent to exploit the put options embedded in HECM loans. Because FHA guarantee fees

[17] Unfortunately, we do not observe borrowers' non-housing wealth. Nakajima and Telyukova (2011) address the role of expectations in demand for HECM loans as consumption smoothing mechanisms.

are constant across locations, and because they did not rise with home prices through 2007, such intent seems like a plausible source of selection. Statement 1 suggests that we can learn about intent by asking whether borrowers appear to use all credit before termination when credit available is far in excess of collateral value.

In light of the fact described above that there are close to zero borrowers who use HECM as a pure put option, we may expect that even if put value played a role for some borrowers, many other borrowers may have had no intent to use HECM as a put option. Denote by $\mu$ the fraction of borrowers in a high cycle amplitude market $m$ featuring procyclical HECM demand, who participated in HECM with the expectation that they would exploit an in-the-money put option at or before loan termination. Suppose that of this fraction $\mu$, a fraction $\alpha$ exhaust credit well before termination in anticipation of price declines and through a combination of impatience and concern about incapacity. A fraction $k$ both observes their loans terminate with a principal limit in excess of collateral value plus any perceived credit costs of default and does not die or become incapacitated without warning prior to loan termination. We would then expect to see at least $[\alpha + [1-\alpha]\,k]\,\mu$ of borrowers in these high HECM growth markets to terminate with balances close to available credit.

The fraction of borrowers we expect to see use all credit prior to termination conditional on having a principal limit in excess of collateral value at termination is weakly greater than $[\alpha + [1-\alpha]\,k]\,\mu$, since some borrowers using HECM for its "intended" consumption smoothing use would also use all available credit at or before termination. Let $Y_{mT}$ be the observed fraction of HECM borrowers with loans observed at termination at date $T$ who use all available credit in market $m$. Let $\hat{Y}_{mT}$ represent the predicted fraction of borrowers using all credit based on the behavior of borrowers in markets with no *ex-post* put option value and the distribution across markets of observable borrower characteristics and changes in equity available from sale or refinance across markets. Let $\psi\,[1-\mu]\,k\left[1-\hat{Y}_{mT}\right]$ represent the fraction of borrowers exhibiting moral hazard but not adverse selection, that is those not intending to use HECM for put option purposes at origination, not using all available credit for liquidity reasons, but ruthlessly exploiting a put option they stumbled upon.

If the fraction of borrowers who would use all credit for liquidity purposes prior to termination at some date is identical between the put option-driven borrowers and other borrowers, we would then have:

$$Y_{mT} = [\alpha + [1-\alpha]\,k]\,\mu + [1-\mu]\left[\hat{Y}_{mT} + \left[1-\hat{Y}_{mT}\right]\psi\,[1-k]\right], \tag{4}$$

We cannot directly observe $\mu$ and are unaware of prior attempts to elicit that parameter. We also are unaware of medical evidence on the fraction of seniors that would have at least the few days warning necessary before loan termination to exercise an option. $\hat{Y}_m$

can be estimated, subject to identification problems discussed below. Recognizing that the differently ruthless sources of credit use $\psi$ and $\mu$ are indistinguishable from each other in available data, the fact that $\psi$ cannot be negative implies that if $\alpha$, $k$ and $\hat{Y}_m$ were observed, then we could estimate:

$$\hat{\mu} = \frac{Y_{mT} - \hat{Y}_{mT}}{[\alpha + [1-\alpha]\,k]\left[1 - \hat{Y}_{mT}\right]} \tag{5}$$

$$\geq \frac{Y_{mT} - \hat{Y}_{mT} - \left[1 - \hat{Y}_{mT}\right]\psi\,[1-k]}{[\alpha + [1-\alpha]\,k]\left[1 - \hat{Y}_{mT} - \left[1 - \hat{Y}_{mT}\right]\psi\,[1-k]\right]} \tag{6}$$

$$= \mu. \tag{7}$$

Assuming that all borrowers with ruthless intent behave ruthlessly given the opportunity, and that some borrowers without ruthless intent still behave ruthlessly given the opportunity, we will overstate the fraction of borrowers with ruthless intent if we attribute all ruthlessness to the intent parameter $\mu$. However, we may understate $\mu$ if we understate $k$ or $\alpha$.

Before describing our approach to bounding $\mu$ above by estimating $Y_m$ and $\hat{Y}_m$ and to treating the hypothesized parameters $\alpha$ and $k$, we turn to a description of available data.

## 3.2 HECM Loan Microdata

FHA has made public (with no warranty as to accuracy) data on HECMs originated between 1992 and mid-2011.[18] This data includes the state, metropolitan area, and zip code of origination, age and marital status of borrowers, gender of single borrowers, initial loan amount and appraised value of the home, and month of origination. For terminated loans, we observe an indicator for whether the loan terminated as an FHA repurchase (lenders may force this before termination if the outstanding balance is close to or above initial property appraised value), an FHA insurance claim (available to servicers after termination, if collateral value is less than the outstanding balance), or neither. We observe credit draws for each year of the loan's life; these draws are infrequently negative, consistent with infrequent partial prepayments.

We are interested in the behavior of lines of credit with available credit in excess of property value and similar lines of credit with no such moneyness. We thus confine consideration to loans originated prior to 2008. Loans originated thereafter were less likely to have "crossed over" into moneyness (see Figure 4) and involved borrowers rejecting a now-popular choice

[18] `portal.hud.gov/hudportal/HUD?src=/program_offices/housing/rmra/oe/rpts/hecmdata/`.

of a fixed rate loan that required 100% credit use at origination. Lump-sum fixed rate loans were made available in mid-2008. Borrowers originating after 2008 would thus have limited time before the sample period ends and motive to use all available credit. Also, the Sand State share of originations declined after 2007. We confine attention to 2006 and 2007, when just over half of all HECM lines of credit or fixed rate loans that were last observed with available credit exceeding resale value. Loans taken earlier than 2006 are unlikely to have crossed over into moneyness, and generally experienced large price increases after origination, which may have generated pressure for increased liquidity demand after closing and for rapid termination through refinance or sale. We thus view loans with earlier origination within the sample metropolitan areas to be a less than optimal control group. While our approach does not permit estimation of metropolitan area fixed effects, we suspect that loans originated in the Sand States while home prices were rapidly rising might make a uniquely poor comparison group for the later vintage Sand State loans we consider.

To estimate the ratio of outstanding balance to property value at a given date, we accumulate interest on draws monthly as if the draws occur at loan closing for year 1, and at the anniversary of loan closing for subsequent years. This choice is motivated by anecdotal evidence that credit draws are not only heavily loaded on the first year of the loan, but also at closing within the first year. We accumulate credit line draws at the monthly 1-year treasury rate (taken from the St. Louis Federal Reserve Bank) plus the loan's margin rate plus the 0.5% mortgage insurance premium. We cap a very small number of outlier loan margin rates at 3.5%. We find that the distribution of outstanding balance to credit available appears most plausibly correct when two items are excluded from the balance available for cash draws: the initial mortgage insurance premium of 2% of the maximum claim amount and a formulaic servicing fee set-aside.[19]

Our estimate of property resale value is the original appraised value of the home increased by the ratio of the FHFA home price index for the loan's metropolitan area in the quarter in question divided by the FHFA index at the quarter of origination, less 5% of value in approximate selling costs.[20] Data for the full FHA sample, narrowed to include only loans originated before the end of 2008, with an observable metropolitan area home price series back at least as far as 1989, with borrower age between 62 and 100, with initial credit use below zero and above 100% recoded to those bounds, and confined to credit line mortgages with gender or marital status reported, are summarized in Table 1.

We want to know if borrowers use more credit when their homes are worth less than

[19]These assumptions generate a large spike at 100% credit use at origination and borrowers drawing 100% at origination under this calculation are very unlikely to make subsequent draws.

[20]The amount suggested in Mortgagee Letter 2008-38.

available credit, so it is important that we approximate both credit use and resale value closely. The distribution of credit use close to 100% is consistent with good approximation. Of 340,273 lines of credit originated between 1989 and 2008 with data fields described below populated, we find that fewer than 200 report negative first-year credit use, and fewer than 1.5% report first-year use of more than 102% of initial credit. A strikingly large 30% feature initial credit use within 2% of 100% of available credit. Of these, roughly 75% report no further credit use. By contrast, only 30% of loans between 95% and 96% of initial credit used in year 1 report no subsequent credit use, and fewer than 20% of those with between 90% and 91% report no subsequent use.

Unfortunately, FHA does not report the insurable difference between collateral value and outstanding balance, but we do observe the insurance claims mentioned above. Among loans originated in 2006 and 2007, under 800 of roughly 48,000 that have terminated involve a repurchase, but 4,903 report a shortfall insurance claim.[21] It would be encouraging to find that loans that we estimate eligible for insurance coverage because collateral is worth less than the outstanding balance do, in fact, report insurance claims, and that other loans do not. False positives (no claim, but we estimate "underwater") could arise through lenders' choices, FHA rejection of claims, classical measurement error, or worse, classical measurement error combined with selection. A selection problem would arise if loans we estimate to have a principal limit in excess of resale value are more likely to terminate when the principal limit is, in fact, less than true resale value. This would be consistent with incentives: per Davidoff and Welke (2006) there is no opportunity cost of debt once the loan has "crossed over."

Figure 3 suggests that some measurement error in debt outstanding or resale value is present, but that lender behavior is also important. The top panel plots the fraction of loans that report a claim by rounded (10% bins) estimated outstanding loan balance to resale value at termination. We see a generally increasing relationship, but a seeming upper bound on claim rates around 60%.

Consideration of lender behavior leads to the middle panel of Figure 3. Financial Freedom had a very large market share of HECM loans around the price cycle peak.[22] Financial Freedom was a subsidiary of IndyMac, which was taken over by FDIC in 2008. We find that Financial Freedom was far less likely than other lenders to make claims, and becomes decreasingly likely to successfully claim as the gap between outstanding debt at termination

[21] This difference comes from the facts that repurchases (flags 5 and 9 in the data) are triggered by long durations and high interest rates, whereas insurance claims without repurchase (flag 10) come from short durations, low interest rates and steep price declines. The latter have been more common than the former in the sample period.

[22] These Financial Freedom HECM loans are different from the proprietary loans Financial Freedom made. Private label reverse mortgages are not in our data.

and collateral value rises. We do not know why this is so, but one possibility is suspicion on the part of FHA or the lender that loans were not adequately screened (e.g. appraisal was inflated to generate a larger loan amount). Conceivably, collateral backing Financial Freedom's loans could have outperformed other lenders' collateral, but we think this is very unlikely: Financial Freedom was one of only a small number of originators that purchased loans from other originators and IndyMac became insolvent. Exclusive of Financial Freedom loans and those loans reporting a different originator and sponsor, we find a significantly tighter relationship between estimated insurable value and insurance claims. More than 75% of non-Financial Freedom loans report claims when the outstanding balance exceeds 125%. Presumably some lenders, like Financial Freedom fail to make claims despite an outstanding balance greater than available credit. The very steep rise near but less than 100% balance to collateral value suggests that we are more likely to incorrectly deem a property as out of the money than to falsely deem a property in the money.

While reliable sub-metropolitan area price indexes are not available, the Local Initiative Support Coalition ("LISC") has created zip-code level measures of foreclosure activity relative to metropolitan area averages. These measures are taken with respect to the conventional mortgage market, and so HECM loans will not affect this measure. We may presume that price appreciation has been weaker in the high foreclosure zip codes than low foreclosure zip codes during the price bust. The bottom panel of Figure 3 plots the insurance claim rate (for non-Financial Freedom and non-third party loans) by rounded outstanding balance to FHFA-updated collateral ratio separately for HECM loans in zip codes with LISC foreclosure rates greater than and less than the metropolitan HECM sample mean. We see that while the rate of FHA insurance payments is somewhat higher on average for loans in high-foreclosure zip codes, this difference explains only a very small part of the distance between observed insurance rates and 100%. The small difference in claim rates based on an observable source of differences in collateral performance within metropolitan areas suggests that unobservable differences are not likely to be so large as to cause large errors in estimated put option moneyness. We address the possibility with instrumental variables described below.

## 3.3 Samples of loans with and without in-the-money put options

We wish to compare credit use among borrowers in metropolitan areas that saw large price busts to otherwise similar borrowers who did not experience such a bust. In terms of equation (4), we wish to compare metropolitan areas with similar levels of $\hat{Y}$ for borrowers originating and last observed at given dates. The bottom panel of Figure 1 shows that originations were highest (plotting bubbles largest) in metropolitan areas and at times that saw high past

appreciation and large subsequent price declines. These loans are represented in the upper right of the plot. The most suitable comparison metropolitan areas appear to be those plotted in the upper left corner, where there were large past price increases, but relatively modest price declines after 2006. As it turns out, the upper right quadrant is entirely composed of borrowers in the Sand States, and the majority of loans in the (mid-) upper left are within the "Northeastern Corridor" between Washington, D.C., and Boston.

To attain both reasonable sample size and a "treated group" in which almost all borrowers have been exposed to in-the-money put options and a comparison group in which very few have, we confine the analysis of credit use to metropolitan areas that experienced home price increases between 2000 and their all-time high in FHFA repeated sale data in the top 20% of all US metropolitan areas. We define the treated group as having also experienced a price decline (peak to 2010, quarter 4) greater in magnitude than the 95th percentile among all metropolitan areas. The comparison group must have experienced price declines less severe than the 75th percentile. Reducing tolerated price crash severity among comparison loans sharply reduces sample size: few metropolitan areas had large price increases that presumably generated liquidity demand $\hat{Y}$, but did not see large price declines.

Tables 2 and 3 list metropolitan areas and provide certain descriptive characteristics of the loans originated in the treated and control metropolitan area sets in 2006 and 2007. Most importantly, among the loans terminated after 2009 that we consider, the median principal limit to estimated resale value ratio was .77 in the comparison and 1.47 in the treated areas.

A striking feature of the comparison is the relationship among price growth between 2000 and metropolitan-specific peak prices; price declines from the peak to 2010, quarter 4; and HECM origination growth over time. The ratio of HECM loans originated in the peak years of 2006 to 2007 to pre-price spike originations between 1989 and 2002 is 2.4 for the treated group, 9.1 for the comparison group, and 3.18 for all other metropolitan areas with any HECM originations in 2006-2007. By contrast, across metropolitan areas by group, the mean ratio of FHFA index to its level in 2000, quarter 1 was 2.55 in the treated group, 2.16 in the comparison group, and 1.5 in other metropolitan areas. The median ratio of peak price to price in 2010 quarter 4 is 2.12 in the treated group, 1.2 in the comparison group, and 1.1 among other metropolitan areas.

The differential growth in HECM demand in metropolitan areas with comparable booms but very different bust magnitudes supports the notion of prescient borrowers put forward by Shan (2011) and Haurin et al. (2013). That the larger price declines in the comparison group might plausibly have been anticipated by potential borrowers is suggested by the ratio of total housing units (based on census counts) in 2009 to 2000 across the three areas: 1.27 in the treated Sand State markets, 1.06 in the comparison group, (and 1.13 among all other

metropolitan areas).[23]

We would like to assume that borrowers in the comparison group, in which very few held in-the-money options at or before the end of our sample period, use credit only due to liquidity demand. Borrowers there generally have not had collateral fall below credit available, so we should not see almost any opportunistically ruthless credit use. However, it may not be safe to attribute all credit use in the comparison group to liquidity demand. Some of the many borrowers drawing all or almost all credit near origination may have been impatient to consume equity, but also may have selected into HECM anticipating price declines. Indeed, several prominent economists have argued that it was inelastically supplied markets were at greatest risk for a price drop. Thus, in the language of equation (5), some of the initial credit exhaustion in comparison markets may have been attributable to positive $\mu$ and $\alpha$ in these markets, but we will attribute this below to $\hat{Y}$. We address this concern in three ways. First, we can think of the adverse selection intent parameter $\mu$ as truly reflecting all of ruthlessness, intent to use an underpriced put option, and correct expectations about price movements. Second, if borrowers had similar price expectations regarding the comparison and treatment markets, then selection on anticipated put option value can not explain the very large difference in origination growth between the two sets of markets. Third, we can examine the behavior of borrowers who did not take large credit draws in the first year of the loan's life. Subsequent credit draws were largely made after observing the relative magnitude of price declines.

If put value calculation explained all of the difference in HECM originations across markets, then pursuant to equation (5) we would expect to see very large differences in credit use across markets. If price growth can only explain roughly a tripling of originations in the treated markets (per Table 3), then the ruthless $\mu$ fraction of treated peak borrowers should not be approximately two-thirds.[24]

The age composition of borrowers in the treated and comparison groups are similar, with means of 73 in the comparison group and 72 in the treated group. The treated metropolitan areas have fewer single female borrowers and more single men and couples. Appraised property values are higher among the comparison group, and a larger fraction of those borrowers have loan to value ratios constrained by time- and location-varying caps on insurable value. Unfortunately, among the treated group, the caps are close enough to appraised value that only a small fraction of treated but capped borrowers terminate with credit less than estimated net resale value. Also, high property values are associated with limited credit use

[23]Coastal California markets did not have large enough price declines to be in the treatment group.

[24]If *ex-ante* price growth led to demand three times a base rate based on the comparison and other markets, but actual growth was nine times the base in the treated markets, we have six-ninths of base demand that are not explained by capital gains pressure on liquidity demand.

even among borrowers not facing caps. It is thus not feasible to compare credit behavior among borrowers in areas that observed large price declines who did and did not see credit exceed property value before an actual or likely termination.

Given the difference in the magnitude of price declines, it is not surprising that loan terminations are less common among the Sand State "treated" borrowers than in the comparison group. In both groups, terminations were much more rapid in the years of rapid price appreciation. Of loans originated in 2002-2003 in the comparison metropolitan areas, 40 percent had terminated by mid-2007; in the treatment metropolitan areas, 62% of earlier borrowers had terminated by mid-2007.[25] Of the 89% of loans in the treated metropolitan areas that were last observed with a principal limit greater than estimated property value, roughly 8% terminated prior to the end of our sample period.

Differential termination on put option value would threaten identification if termination were correlated with small put option value *within* the treated group. While we see clear evidence of selection *across* groups into terminations, it is not clear that those whose loans terminated within the treated group saw smaller price declines than those whose loans did not terminate. Consistent with evidence in Figure 3, among treated market borrowers taking a very large initial draw (greater than 95% of initial value), outside of borrowers excluded from the middle panel of Figure 3, 76% terminated with a shortfall claim. A lender's shortfall claim is a sufficient, but not necessary condition for no remaining equity. We thus have reason to believe that a very large majority of borrowers terminating with estimated credit available greater than resale value actually did hold in-the-money put options. Not all borrowers stood to lose put option value by terminating their loans before the end of the FHA sample period. Since the end of our sample, home prices have risen considerably faster in some of the treated metropolitan areas than HECM loan balances have grown. A borrower in Phoenix who wished to trade up in home quality, for example, would have been better off purchasing and moving into a new home in 2011 than 2012 (prolonged exit requires a termination). Terminations are likely involuntary and related to mortality or severe disability among those we deem to have more available credit than property value, since there is little financial incentive to leave (beyond defaulting on property tax obligations). Neither group of borrowers saw much increase over the course of their loans in available proceeds from refinance: the mean maximal ratio (including at origination) of HECM proceeds at any date after originations to the principal limit at that date was 1.03 among the comparison group and 1.01 for the treated group.

Recognizing concerns about endogenous termination, we also consider both the possibility that borrowers whose loans terminated were less ruthless than other in-the-money borrowers

[25]These termination differences are discussed in more detail in Davidoff and Welke (2006).

and that surprise death or incapacity (low $\alpha k$) might have reduced the number of borrowers with intent to exploit put options who actually did so. We consider borrowers who were demographically very likely to terminate their loans. In particular, we identify the age and gender combinations that terminated loans at a rate of more than 10% per year among borrowers with loans originated in 2006 and 2007, but not living in either of our sample sets of metropolitan areas. We select 10% because interest rates were uniformly less than 5% above the riskless rate on loans. Thus, assuming a loan balance outstanding equal to or greater than appraised value, a 10% probability of death arriving fifty percent of the time without warning would then make early withdrawal of all remaining credit profitable even for patient borrowers. If surprise death is a common phenomenon, most of these borrowers should have found early withdrawal profitable. These ages start at 84 for single men, 88 for single women, and 89 for couples. These groups represent a trivial 2% of all borrowers in the treated metropolitan areas, but a larger 9.5% of treated borrowers who terminated their loans prior to the end of the sample period.

A strength and weakness of considering credit use among extremely old borrowers is that these borrowers obtain large initial loan-to-value ratios. Thus we can be quite confident that older borrowers in the treated Sand State markets would have held in the money put options as long as termination occurred after 2008. However, while only 16% of all comparison group borrowers are estimated to have been in-the-money if unterminated through 2011, a significant majority of such borrowers in the selected age categories would have been in-the-money (although only a minority of those estimated to have borrowed more than available credit are observed with an insurance claim). We thus do not wish to compare credit use exhaustion among the elderly across markets. Rather, we ask if the borrowers demographically likeliest to terminate exhausted credit more frequently than borrowers who actually terminated their loans in the treated metropolitan areas.

We are unaware of any medical evidence on the correct value of $k$, the fraction of borrowers who would be capable of exhausting credit at nearly the last minute if they found it optimal to do so.[26] We regard 50% as a plausible upper-bound value for the product $[1-\alpha][1-k]$, which represents those who become dead or incapacitated without arriving first at a belief that such an event was sufficiently likely as to make the cost of failing to exercise a put option at all greater than the capital cost of failing to wait an additional period.

[26] Causes of death do not seem like a promising source of calibration. Death from heart disease, the leading cause of death, for example, need not arrive as a result of an unanticipated heart attack.

## 3.4 Credit Use Among Selected Borrowers

The top panel of Figure 5 plots the cumulative distribution of ratios of first year credit draws to available credit for loans in the comparison (line) and treated (circles) metropolitan areas. Both groups exhibit a large mass above 98%, with 34% among the comparison group and 43% among those treated with a large *ex-post* price decline.

The bottom panel of Figure 5 plots for each set of metropolitan areas the fraction of borrowers whose loans terminated between 2009 and the end of our sample that use at least 95% of credit prior to termination, by rounded (5% bins) initial credit use. Given statement 2, it is not unreasonable to consider terminal credit use conditional on initial credit use to measure ruthlessness. It is not clear theoretically that initially high credit use should be a signal of intent to use HECM as a put option. Indeed, relatively weak demand for HECM's liquidity features might be taken as a signal interest in put option value conditional on participation. On the other hand, borrowers perceiving high put option value might have believed themselves to have investment opportunities with rates of return greater than loan interest rates (with foresight, long-maturity treasuries would have been a very good use of HECM credit in 2006 and 2007). It is also useful to consider low initial credit use borrowers to avoid the problem that some of the large initial use among comparison group borrowers may have reflected incorrect expectations that their loans would wind up deep in the money.

Empirically, the growth in the treated metropolitan area's share of HECM loans with initial credit use less than 50% was comparable to growth among loans with larger initial draws. Specifically, the share of loans with less than 50% initial credit use that were originated in the treated areas was 7.5% prior to 2004. For low initial credit loans originated in 2006 and 2007, the treated metropolitan areas held 14.1% market share. For loans with greater than 50% initial use, the treated metropolitan areas' share was 8.2% pre-2004 and 16.1% in 2006-2007. For the comparison metropolitan areas, the low initial draw share fell slightly from 16% to 13%. The higher initial draw share was relatively constant, moving from 10.4% to 9.5%. An intricate story would be required to explain why similar increases in HECM origination share growth for the treated areas reflected a difference in put valuation at higher initial credit use, but not at the lower end of initial credit use.

It is difficult to find evidence in Figure 5 that borrowers who failed to use all available credit at loan origination were likelier to use credit prior to termination in the treated than comparison markets. Of particular interest in the bottom panel of Figure 5 is the very low level of credit exhaustion at low levels of initial credit use. For those borrowing less than 50% in the first year of the loan's life, while a very large majority of those in the treated group (88%, identical to the fraction of all treated borrowers) held in-the-money options, just 12% exhausted credit prior to termination. Assuming a very high strategic failure rate

$[1-\alpha]\,[1-k]$ value of 50%, even if the counterfactual $\hat{Y}$ liquidity demand for exhaustion were 0, we would estimate $\hat{\mu}$ at only $\frac{.12}{.5} = 24\%$. 24% is small relative to the disproportionate origination growth in these markets. In fact, recognizing that credit exhaustion among borrowers in the comparison metropolitan areas, a value of $\hat{\mu}$ around zero appears correct among low initial credit use borrowers. Among borrowers with loans terminating after 2009 in the comparison metropolitan areas using less than 50% of available credit in the first year of the loan's life, fewer than 8% are estimated to have terminated in the money. Of this group, over 22% used all credit prior to termination.[27]

Regression Table 4 presents regression estimates of terminal credit use in excess of 95% (results are similar for other cutoff definitions of credit use exhaustion, the coefficient of interest is also displayed for 90% as defining exhaustion). Given a large number of dummy variables, including the regressor of interest, we use a linear probability model rather than a probit or logit specification. We cluster standard errors at the metropolitan level, finding minimal effects on standard errors of clustering also or separately on the date of origination.

All of specifications (1) through (5) presented in Table 4 confine the analysis to the treated and comparison metropolitan areas and consider only borrowers whose loans terminated between 2009 (when loans mostly start coming into the money) and the end of the sample period in mid-2011. The right hand side variable of interest is an indicator for whether or not the loan terminated with a principal limit in excess of estimated value (appraisal at origination inflated by the FHFA index). The coefficient on that variable corresponds to the value $Y_{mT} - \hat{Y}_{mT}$ in (4) assuming that $\alpha\mu$ is zero among the comparison group borrowers. We are interested in the discrete indicator for moneyness, because theory does not provide a result of generally more credit use with a higher principal limit, conditional on being in or out of the money.

We include control dummy variables for age and gender/marital status, for whether Financial Freedom or a third party originated the loan, for the year and quarter of origination, and continuous controls for initial appraised value, initial credit to appraisal, home price growth between 2000 and origination. We cluster standard errors at the level of metropolitan area. We estimate $\hat{Y}$ as the mean fitted value of the dependent variable among the treated borrowers, minus the mean indicator for moneyness among those borrowers times the moneyness coefficient. That is, we estimate the rate of credit exhaustion for borrowers with similar characteristics to those with in the money put options, if they did not hold such options.

Specifications (3) through (5) acknowledge that we have an imprecise measure of money-

[27] Subtracting $22\% \times (1 - 8\%)$ for the comparison group from the 12% low initial credit use among treated borrowers implies a negative numerator in (5).

ness that is in part endogenously determined by the date of termination. We thus instrument for the indicator with two different variables. In specification (3), we instrument with membership in the treated set of metropolitan areas. In specifications (4) and (5), we instrument with a continuous variable: the metropolitan area-specific fraction of terminated loans with initial credit use greater than 95% that are not associated with Financial Freedom and are noted as featuring a shortfall insurance claim. These specifications recognize that some borrowers in the comparison group may have held in-the-money options and allow for the possibility that some in the treated group did not. Neither of these variables should be caused by endogenous borrower choices after observing put value. The treatment group variable may be correlated with measurement error, since the loan to value ratio in excess of unity indicator includes FHFA price growth, upon which the two groups are selected. The rate of insurance claims for loans with large initial balances will pick up differences in the extent of moneyness. The first stage regressions are extremely strong, with F-statistics greater than 300 and t-statistics on the instrumental variable above 30, so there is no problem of weak instruments. We do not interact our instrumental variables with loan to value ratio, because loan to value ratio is highly correlated with age, and we do not believe it makes sense to assume stronger effects for older, deeper in-the-money borrowers. Indeed, we check for such a difference in Table 5 and find no significant difference.

Specification (2) is unique in that it excludes the significant minority of borrowers who faced market-specific loan limits imposed by FHA, such that loan to value ratios are low. We might expect these borrowers to behave less ruthlessly than others; their existence in significant numbers should arguably inform our estimate of the role of put value calculation as a driver of the Sand State surge in HECM originations, though, so we exclude them from only one specification. We find no difference in the estimated relationship between holding an in the money put option and credit exhaustion whether these loans are excluded or not.

In each of specifications (1) through (5) we find a small difference in the prevalence of credit exhaustion prior to loan termination that is indistinguishable from zero. The IV coefficients are not significantly different from each other, from zero, or from the OLS estimates, with a maximum value of .057 in specification (4). In that specification, we find a fitted $\hat{Y}$ of 52% credit exhaustion based on characteristics other than put value. Because characteristics are similar across the sets of metropolitan areas, and because the coefficient on high terminal credit limit to value is close to zero, this is close to actual mean credit exhaustion among terminated loans in the treated group. The characteristics that appear to eliminate the unconditional difference in credit use (driven by use at origination) are initial appraised value (which drives down use in the higher priced comparison markets), and the higher capital gains since 2000 in the treated markets.

Taking the largest IV point estimate of .057, assuming ability to exercise $k$ is equal to .5, and using $\hat{Y} = .52$, we obtain an implied measure of intent to put $\mu$ of $\frac{.057}{.5[1-.52]} = .24\%$. Given large standard errors, we can reject neither zero nor a much larger share. The approximately zero estimate in the other specifications implies a $\mu$ of zero. If capacity to ruthlessly put $[\alpha + [1-\alpha]\, k]$ is .8, even at the highest point estimate, our estimate of $\mu$ falls below .15.

Specification (5) conditions on initial credit use by excluding loans with initial credit use greater than 95% of initial balance, and then controlling for indicators for 5% bins of first year credit use along with a linear term in first year use. We estimate zero tendency for exhausting credit after origination when the principal limit exceeds property value using the insurance claim rate instrument. This is a particularly significant finding in light of the possibility that large initial credit use in the comparison group may have reflected intent to exploit an underpriced put option that *ex-post* did not turn out to be underpriced.

Summarizing, among terminated loans, we can not reject zero effect of high terminal loan to value ratios on the propensity to exhaust available credit prior to termination. Point estimates remain close to zero when we instrument with the treated or untreated status of borrowers metropolitan areas, or with a metropolitan measure of shortfall insurance claims among loans with intense credit use before price changes were observed. Using the largest point estimate and assuming only 50% of borrowers who terminate their loans are able to exercise their put option by drawing remaining credit before death or incapacity occurs, we would estimate that fewer than a quarter of borrowers, or approximately one-third of the excess originations in the treated metropolitan areas are opportunistic and hence may have selected into HECM for the put value. The near absence of credit exhaustion among borrowers with low initial credit use facing in-the-money put options, and the similarity of their exhaustion to out-of-the-money borrowers casts severe doubt on intent to put as a cause for selection. Conditional on credit use, the standard error of the estimated coefficient on the moneyness indicator is small enough that we can reject a large difference and hence a large estimated $\hat{mu}$ with high confidence.

## 3.5 Older Borrowers

Figure 6 plots the cumulative distribution of initial credit use in the top panel and exhaustion of credit conditional on initial use in the bottom panel. Here, we separately plot use for all borrowers in the treated metropolitan areas whose loans originated between 2006 and 2007 (circles), those whose loans have terminated (solid line), and those most likely to terminate due to demographics (dashed line). There are not clear differences between those borrowers whose loans have terminated and those that are statistically relatively likely to terminate.

Table 5 presents two regressions asking if older borrowers demographically predicted to terminate at a rate greater than 10% per year use more credit than borrowers than the entire set of treated borrowers whose loans terminate. The sample is confined to the "treated" Sand State loans originated in 2006-2007 that either terminated prior to mid-2011 or had an older borrower. We find no significant difference in credit use between actual and likely terminating borrowers, either unconditionally, specification (1), or conditioning on initial credit use in specification (2). We conclude that it is unlikely to be the case that all of: a large fraction of terminations occur with insufficient warning to allow withdrawal of remaining credit, older borrowers recognize this risk and calculate that early withdrawal will be profitable despite the additional capital cost, and older borrowers seek to ruthlessly exploit embedded put options by exhausting credit available when this exceeds collateral value.

# 4 Conclusion

FHA has faced costly geographic adverse selection in the HECM program. Among metropolitan areas witnessing extremely high price growth between 2000 and 2006, demand growth was more than three times as high in the Sand State markets that saw extreme subsequent price declines than in the mostly Northeastern and inelastically supplied markets where price increases were relatively sustained.

We find no evidence of the ruthless use of credit that we hypothesize would characterize borrowers who selected into HECM to exploit underpriced embedded home price insurance. Close to zero percent of borrowers used HECM as a pure put option, drawing no credit until after price uncertainty played out, and then exhausting available credit prior to termination. Among the borrowers using little credit in the first year of the loan's life, only a small minority exhaust credit prior to origination, even in markets where loan to value ratios at termination averaged roughly 150%. The stakes associated with credit use were high for loans originated near the cycle peak and terminated prior to the end of our sample period. Among terminated loans in the treated metropolitan areas on which borrowers withdrew less than 50% of available credit, the median gap between available credit and the greater of credit used or property value was approximately $39,000. The mean "money left on the table" among all borrowers in the treated metropolitan areas whose loans originated near the peak and terminated prior to the end of our sample was over $22,500.

Among borrowers experiencing large price increases through 2006, borrowers in markets that saw large subsequent price crashes are absolutely and relatively likely to have exhausted credit in the first year of origination. The difference between this behavior across market types, though, disappears conditional on regression covariates and is not large enough un-

conditionally to explain the relative tripling of market share in the markets where prices crashed most violently. It is difficult to distinguish ruthless behavior from simple demand for credit when initial credit use is large, but assuming borrowers in high price growth - modest price crash markets used credit only due to liquidity demand, we describe a way to place an upper-bound estimate on the degree of ruthlessness among borrowers selecting into the large price crash markets. We find that our largest point estimate is insignificantly different from zero and implies ruthlessness among less than one-quarter of the borrowers in large crash Sand State markets. Conditional on small initial credit use, there is a tightly estimated zero relationship between moneyness and subsequent credit exhaustion.

The apparent lack of ruthlessness among borrowers terminating with in the money put options suggests that something other than conscious lemon selling drove adverse selection. A natural conjecture is that differently aggressive lending environments across markets played an important role. We leave empirical verification of that conjecture to future research, but the different behavior of Financial Freedom loans in terms of greater credit use and less frequent insurance claims is interesting, but Financial Freedom had a slightly smaller market share in the extreme crash Sand State markets than in the comparison markets. HECM growth was much greater in markets experiencing large crashes conditional on rapid price growth between 2000 and 2004, but capital gains may have been relatively unanticipated in those markets, such that a modified Artle and Varaiya (1978) consumption smoothing story may be a satisfactory explanation for the relative surge in the Sand States.

A natural direction for future research would be to distinguish among a lack of understanding of HECM incentives, fear of credit damage, reluctance to behave unethically, Medicaid incentives, and sudden incapacity as sources of borrowers' failure to "ruthlessly" maximize home equity under HECM rules. Unlike in the forward market, among borrowers terminating their loans, future call option value on the home cannot explain a failure to exploit the put option. The structure of incentives also rule out precautionary savings or demand for bequests as compelling explanations. Borrowers have not had a very long time to adapt to declining collateral values, but some will likely never see gaps between collateral value and available credit as large as near the end of our sample period. Price increases much greater than accumulation of loan balances and principal limits have reduced the moneyness of many implicit put options on the majority of in the money loans that remain active.

Credit use stands out as one dimension of borrower behavior in which incentive problems have not arisen as a problem in HECM design. Loan durations have been longer in worse performing loans, which is a problem when insurance fees are charged periodically rather than all up-front. Liquidity constrained, and perhaps opportunistic, borrowers appear to have defaulted in some cases on property tax and insurance obligations, and one expects

maintenance on these properties has suffered, too.

The fact that credit use is not highly responsive to put value calculation suggests that retaining a line of credit option in HECM, as FHA has recently done while eliminating other payment options, would be desirable. If credit use were elastic with respect to put value, then charging interest on draws and allowing the loan balance to grow at the loan interest rate would almost guarantee insurance losses. With credit use apparently reflecting liquidity demand, the benefits of the flexibility inherent in a line of credit, relative to loans that require immediate lump sum, presumably outweigh any dynamic contracting cost. However, losses due to selection suggest that federal mortgage insurance pricing and limits should incorporate deviations from historical local price-rent ratios.

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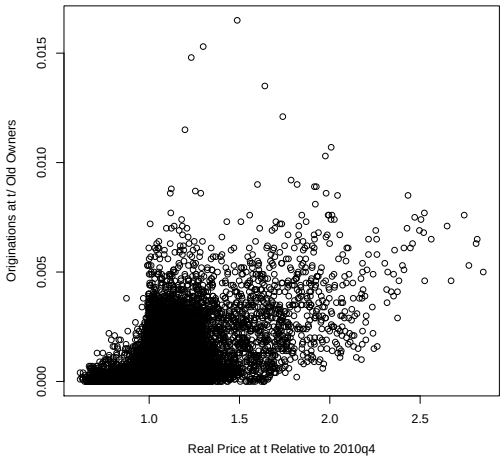
Figure 1: HECM originations and subsequent real home price declines. Top panel: Observations are metropolitan area by year-quarter, 2000 through 2010. Horizontal axis: real home price change from quarter plotted to 2010, quarter 4, from FHFA repeated sale data. Vertical axis: HECM originations by metropolitan area and quarter divided by household head homeowners over age 65 in the 2010 census. Bottom panel: Observations are metropolitan areas. Horizontal axis is price ratio of: peak to 2010, quarter 4. Vertical axis is price ratio, peak to 2000, quarter 1. Bubbles are proportional to total originations 2006-2007 divided by originations 1989-2004.



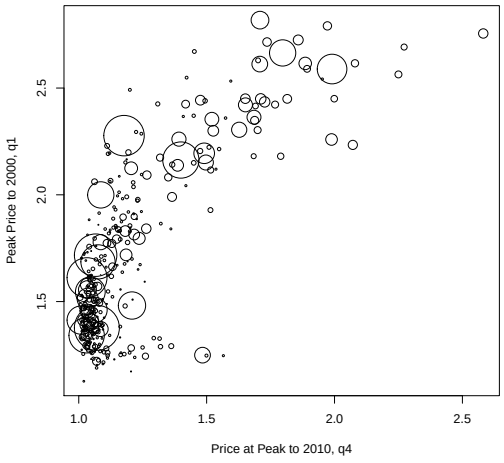
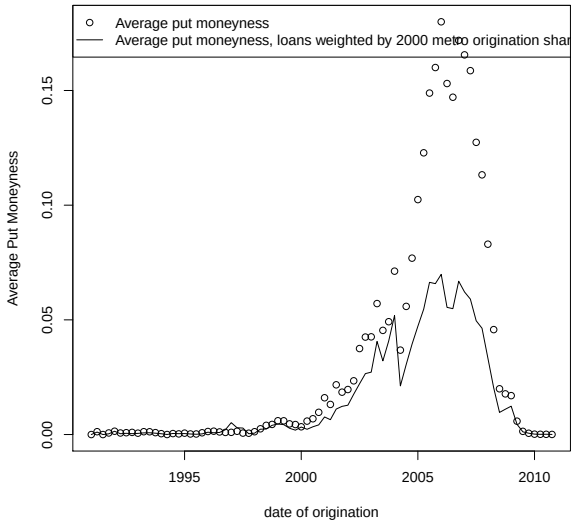



Figure 2: Top panel: mean of the greater of zero or the ratio of allowable balance to home value minus one as of loan termination or last observation in 2011 (appraised home value at origination inflated by metropolitan area nominal FHFA repeated sale index); unweighted mean (points), mean weighted by metropolitan share of originations in 2000 to metropolitan share of originations in the plotted quarter on the horizontal axis (solid line). Bottom panel: HECM loans originated by year, all loans (points, in thousands) and loans originated in the "Sand States of Arizona, California, Florida, and Nevada" (percentage share of all originations by year, line).



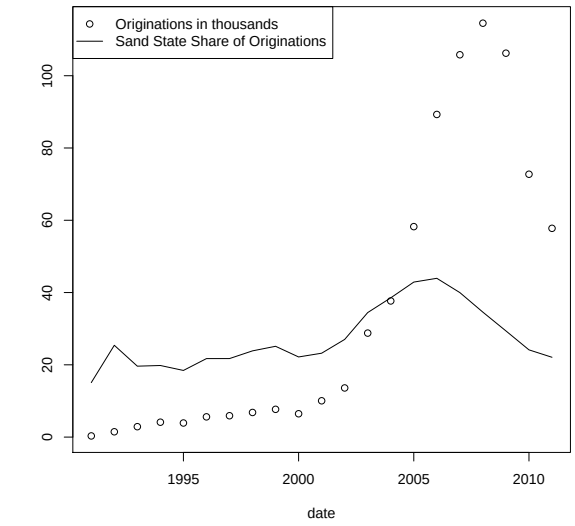
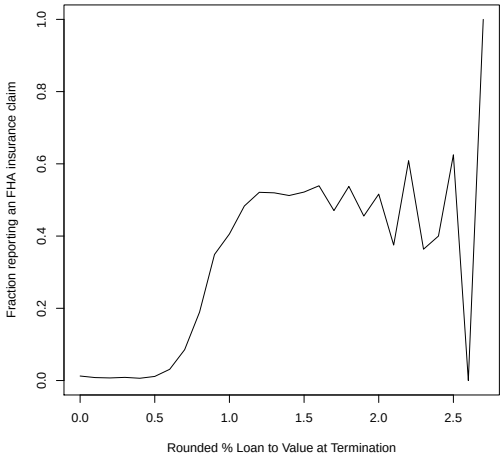
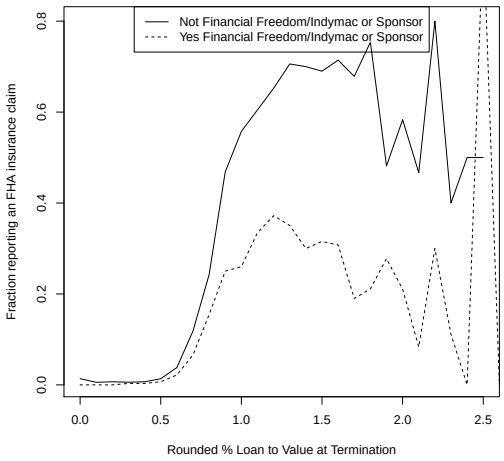



Figure 3: Fraction of terminated loans not designated as insurance claims that were assigned to HUD at or before termination, by rounded ratio of outstanding balance to initial appraised value or area cap on claim amount. Universe: all terminated HECM loans.



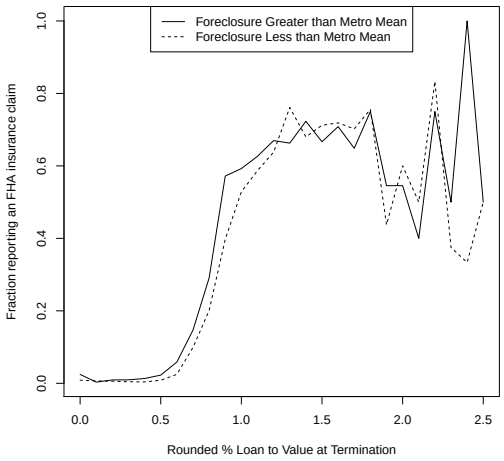



Figure 4: Cumulative distribution of loans terminating with estimated principal limit greater than estimated home value by quarter of origination

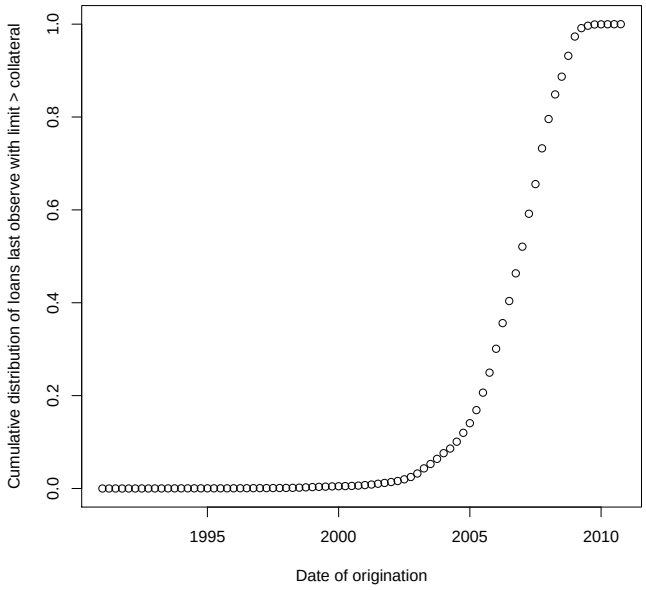
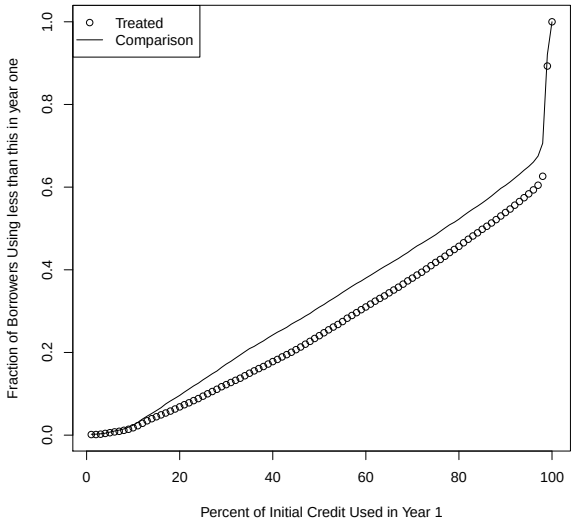


Figure 5: Distribution of credit use: treated (circles) and comparison (lines) metropolitan areas for loans originated 2006-2007. Data points are means by rounded hundredths. Top panel: first year credit use divided by available credit. Bottom panel: fraction of borrowers whose loans subsequently terminated at each rounded five percent initial credit use interval that are last observed with credit use in excess of 95% of available credit at termination



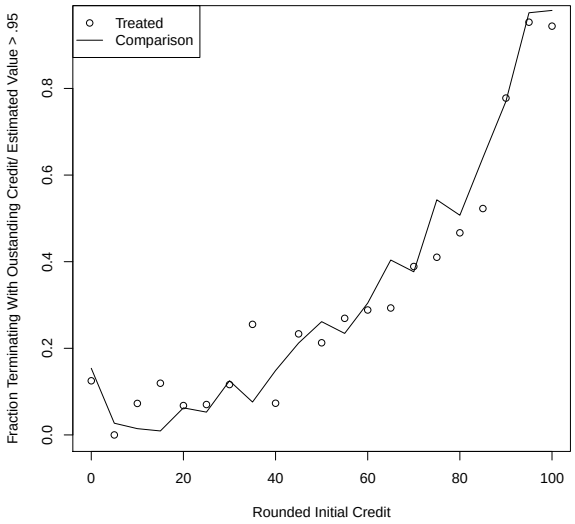
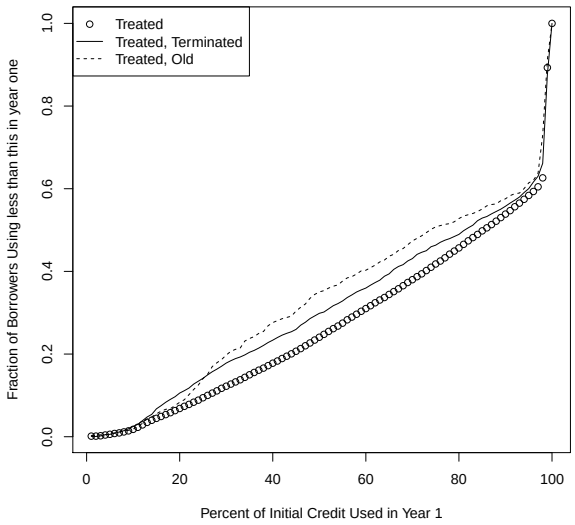



Figure 6: Distribution of credit use among borrowers in the "treated" metropolitan areas: all loans (circles), terminated loans (line) and borrowers demographically likely to terminate at more than 10% rate per year (dashed line). Data points are means by rounded hundredths. Top panel: cdf of initial credit use. Bottom panel, fraction using 95%+ of available credit at last observation of the loan (termination or end of the panel in late 2011) by rounded five percent bin of first-year credit use.



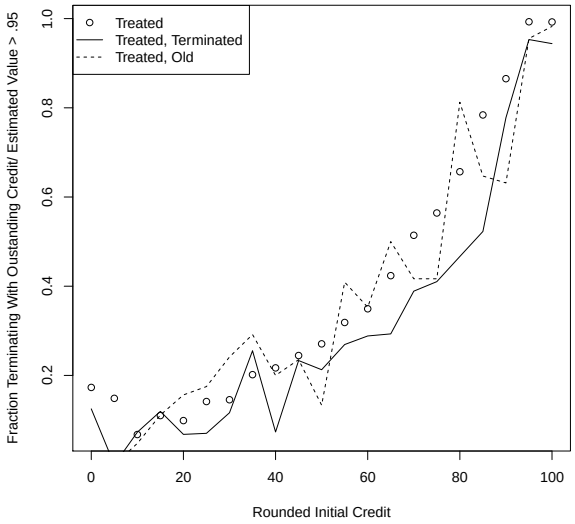



Table 1: Summary statistics for HECM individual loan data. Lines of credit originated prior to 2008

| Variable | Obs | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|
| Origination quarter | 340,273 | 2004.74 | 3.247 | 1991 | 2007.75 |
| Borrower age | 340,273 | 73.494 | 7.266 | 62 | 124 |
| Initial credit to appraised value | 340,273 | 0.632 | 0.138 | 0 | 1 |
| Estimated credit to value at last obs. | 340,273 | 0.909 | 0.363 | -0.126 | 3.04 |
| First year credit use to initial year limit | 340,273 | 0.685 | 15.351 | -7876 | 3545 |
| Second year credit use to second year total limit | 340,273 | 0.05 | 1.111 | -636 | 40 |
| Third year credit use to third year total limit | 340,273 | 0.033 | 1.441 | -831 | 38 |
| Fourth year credit use to fourth year total limit | 340,273 | 0.023 | 1.75 | -1017 | 25 |
| Fifth year credit use to fifth year total limit | 340,273 | 0.013 | 1.806 | -997 | 16 |
| Credit to use at last observation | 340,273 | 0.825 | 21.968 | -11945 | 3772 |
| Maximum available refinance over loan's life | 340,273 | 1.149 | 0.352 | 1 | 81.48 |
| Appraisal at closing | 340,273 | 232621.399 | 147936.164 | 13300 | 950,000 |
| Financial Freedom originator or sponsor? | 340,273 | 0.375 | 0.484 | 0 | 1 |

Table 2: Treatment (Top 20% of price increase through peak and top 5% of price crash through 2010) and Comparison (Top 20% and bottom 75%)metropolitan areas: names

**List of Metropolitan Area Names**

| Comparison Metropolitan Areas | Treatment Metropolitan Areas |
|---|---|
| Baltimore-Towson, MD | Bakersfield-Delano, CA |
| Barnstable Town, MA | Cape Coral-Fort Myers, FL |
| Bellingham, WA | Carson City, NV |
| Bethesda-Rockville-Frederick, MD (MSAD) | El Centro, CA |
| Casper, WY | Las Vegas-Paradise, NV |
| Charlottesville, VA | Madera-Chowchilla, CA |
| Edison-New Brunswick, NJ (MSAD) | Merced, CA |
| Glens Falls, NY | Modesto, CA |
| Honolulu, HI | Naples-Marco Island, FL |
| Kingston, NY | North Port-Bradenton-Sarasota, FL |
| Midland, TX | Palm Bay-Melbourne-Titusville, FL |
| Nassau-Suffolk, NY (MSAD) | Phoenix-Mesa-Glendale, AZ |
| New York-White Plains-Wayne, NY-NJ (MSAD) | Port St. Lucie, FL |
| Ocean City, NJ | Punta Gorda, FL |
| Poughkeepsie-Newburgh-Middletown, NY | Reno-Sparks, NV |
| Virginia Beach-Norfolk-Newport News, VA-NC | Riverside-San Bernardino-Ontario, CA |
| | Salinas, CA |
| | Stockton, CA |
| | Vallejo-Fairfield, CA |
| | Yuba City, CA |

Table 3: Treatment and Comparison metropolitan areas: characteristics

| Variable | Comparison | Treatment |
|---|---|---|
| Originations with available data 2006-2007 | 15,721 | 24,871 |
| Ratio of originations 2006-2007 to 1989-2002 | 2.40 | 9.07 |
| Median nominal $\frac{\text{FHFA Price 2000s peak}}{\text{Price 2000,q1}}$ | 2.16 | 2.55 |
| Median nominal $\frac{\text{FHFA Price 2000s peak}}{\text{Price 2010,q4}}$ | 1.20 | 2.12 |
| Mean Appraised Value at origination | 335,300 | 275,700 |
| Loan to value capped by metro-time maximum | .43 | .35 |
| Ratio of Housing Supply 2009 to 2000 (US Census) | 1.06 | 1.28 |
| Median Age of borrowers 2006-2007 | 73 | 72 |
| Fraction single men | .17 | .19 |
| Fraction single women | .49 | .40 |
| Loans originated 2006-2007 terminated prior to 2011,q4 | .24 | .13 |
| Certain loans* with shortfall claim | .76 | .16 |
| Median terminal principal limit to value among terminated loans | .77 | 1.47 |
| Mean maximal refinance to initial credit over loan's life | 1.03 | 1.01 |
| 2006-2007 loans with $\frac{\text{available credit}}{\text{estimated value}} > 1$ at last observation | .16 | .89 |
| 2006-2007 loans with year 1 credit use $> .95$ | .35 | .43 |
| 2006-2007 loans terminated post-2009 with terminal credit use $> .95$ | .47 | .55 |
| Financial Freedom originator or sponsor? | .39 | .44 |

**Note:** * indicates Originated 2006-2007, with initial balance $> .95$ of available credit, not originated by Financial Freedom or IndyMac or through a third party originator.

Table 4: Regressions of an indicator for near exhaustion of credit (95%+ use) by last observation. Loans terminated after 2009 in treatment or comparison metropolitan areas, loans originated 2006-2007.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Credit limit > Collateral at Termination? | -0.004 | -0.001 | 0.005 | 0.057 | -0.033 |
| | (0.054) | (0.075) | (0.112) | (0.111) | (0.034) |
| Loan to value at origination | -0.455 | -0.506 | -0.470 | -0.553 | -0.026 |
| | (0.211)* | (0.283) | (0.258) | (0.250)* | (0.148) |
| Financial Freedom? | 0.075 | 0.114 | 0.075 | 0.075 | 0.034 |
| | (0.024)** | (0.035)** | (0.023)** | (0.024)** | (0.015)* |
| third party? | -0.004 | 0.018 | -0.004 | -0.003 | 0.033 |
| | (0.022) | (0.025) | (0.022) | (0.022) | (0.010)** |
| Log appraised value at origination | -0.196 | -0.212 | -0.197 | -0.198 | -0.003 |
| | (0.048)** | (0.044)** | (0.047)** | (0.050)** | (0.022) |
| Log price growth since 2000 | 0.193 | 0.229 | 0.181 | 0.117 | 0.085 |
| | (0.094)* | (0.144) | (0.150) | (0.149) | (0.048) |
| $R^2$ | 0.08 | 0.09 | 0.08 | 0.07 | 0.29 |
| $N$ | 3,454 | 1,830 | 3,454 | 3,454 | 2,198 |
| Age and Gender Dummies | Yes | Yes | Yes | Yes | Yes |
| Initial balance controls | No | No | No | No | Yes |
| Quarter of origination dummies | Yes | Yes | Yes | Yes | Yes |
| Allow capped loans? | Yes | No | Yes | Yes | Yes |
| Instrument | None | None | Treated metro? | Claim rate | Claim rate |
| Approximate Implied $\hat{Y}$ (Mean fitted credit exhaustion - large $LTV$ effect) | | | | | |
| Among borrowers with large $LTV$: | .55 | .56 | .56 | .52 | .50 |
| Implicit $\hat{\mu}$ if $\alpha + [1-\alpha]\, k = .5$ | | | | | |
| per (5) | 0 | 0 | .02 | .24 | 0 |
| $\hat{\mu}$ if $\alpha + [1-\alpha]\, k = .8$ | 0 | 0 | .022 | .15 | 0 |
| Credit limit > Collateral | | | | | |
| If cutoff .95 → .9: | -0.019 | -0.012 | -0.011 | 0.014 | -0.039 |

* $p < 0.05$; ** $p < 0.01$

**Notes:** Credit limit and collateral value are calculated as described in the text. Initial balance controls include indicators for ranges of 5% first year credit ranges plus a linear control for first year balance. Capped loans are those with appraised values greater than time- and market-specific FHA caps on insured value. Robust standard errors clustered at the metropolitan area (CBSA) level in parentheses. Third party loans are those in which a "sponsor" different from the "originator" is identified. A large fraction of these loans involved Financial Freedom/ IndyMac. The treated metro instrument is an indicator for being in one of the treated metropolitan areas. The claim rate instrument is the percentage of loans in the borrower's metropolitan area with first year balances greater than 95% of initial credit that are flagged as having featured a shortfall claim, excluding loans originated by Financial Freedom or third parties. The credit limit > collateral coefficient at a cutoff for exhaustion at .9 rather than .95 is conditional on the same variables as in the main specification.

Table 5: OLS Regressions of an indicator for near exhaustion of credit (95%+ use) as of last observation. Universe is loans in the "treated" metropolitan areas originated 2006-2007 that terminated prior to the end of the sample or went to borrowers demographically likely to terminate. Likely demographic termination based on age and marital status rates of termination 10% or greater in excluded metropolitan areas. Both specifications include controls for gender and date of loan closing. Second column includes the controls for first-year credit use present in specification of Table 4.

| | (1) | (2) |
|---|---|---|
| Probable termination | -0.006 | 0.045 |
| | (0.030) | (0.028) |
| Log appraisal at origination | -0.229 | 0.001 |
| | (0.021)** | (0.024) |
| Loan to value at origination | -0.671 | -0.073 |
| | (0.080)** | (0.084) |
| Financial Freedom? | 0.074 | 0.035 |
| | (0.019)** | (0.019) |
| Not Third Party | -0.008 | 0.037 |
| | (0.019) | (0.019) |
| Log price growth since 2000 | 0.194 | 0.041 |
| | (0.045)** | (0.045) |
| Constant | 3.516 | 0.097 |
| | (0.308)** | (0.366) |
| $R^2$ | 0.06 | 0.27 |
| $N$ | 3,454 | 2,198 |

* $p < 0.05$; ** $p < 0.01$