Identification of Home Maintenance Risk in Reverse Mortgages:

An Empirical Examination of Home Price Appreciation among HECM Borrowers

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Abstract

This study provides an empirical estimation of rates of moral hazard from insufficient property maintenance in the collateral for a pool of reverse mortgages. Following Shiller and Weiss (2000), the associated valuation problem can be described in terms of basis risk in the spread between a market-level property-appreciation rate and the mean appreciation rate in a portfolio of reverse mortgages. Using historical data on terminations of FHA-insured reverse mortgages we are able both to identify that basis risk, and to verify that it increases with the age of a surviving pool of loans. Following Rodda and Patrabansh (2005), one can then subset reverse-mortgage borrowers into "movers" and "stayers," based upon their expected tenure in the home. We find that the basis risk of stayers with long expected tenures is in the neighborhood of 160 basis points, on an annual basis. However, there is actually negative basis risk for the fastest movers, whereby their homes appreciate at rates in excess of market rates. This work has direct implications for the valuation of loan guarantees on reverse mortgage pools.

Introduction

For 20 years, the Federal Housing Administration (FHA) has insured reverse mortgages for senior citizens under its Home Equity Conversion Mortgage (HECM) program. While a private market for reverse mortgages started to take shape in 2006, it disappeared by 2008 when private capital was no longer available for nonstandard mortgage instruments. At the same time, HECM became an even more valuable program for seniors because of the erosion of retirement savings in 2008, and because job layoffs led to earlier retirement than many seniors might have planned for. HECM permits homeowners 62 years or age and older to access equity in their homes without the burden of monthly mortgage payments, and without having to sell their home. The "reverse" nature of the program is that loan balances grow over time with cash draws and from interest and fee accruals, rather than shrinking with amortizing loan payments. The actuarial risk of a reverse mortgage is often expressed as a horse race between property value appreciation and the growing loan balance. These are non-recourse loans, so the maximum amount the investor or insurer can expect to recover is the value of the home at termination. Thus, underwriting is principally a matter of limiting allowable cash take-outs based upon an expected nexus between property value appreciation and interest rates in the future.[1]

[1] Two studies that have described the HECM program in detail are Case and Schnare (1994) and Szymanoski, et al (2007).

Because reverse mortgages are only offered to senior citizens, mobility termination patterns differ from those of younger households. Also, as loans season, mobility is primarily driven by mortality, rather than relocation, and conditional mortality rates increase over time. With forward loans, downpayment and leverage are functions of borrower wealth constraints and portfolio diversification decisions. With reverse mortgages, initial leverage is limited by maximum allowable cash draws that consider the imbedded credit risks. Chosen leverage within the lender's permissible upper bound is then determined by a household's immediate need for cash, and its risk aversity with respect to having equity available either for a tenure transition in the future or else a bequest.

Reverse mortgages pose unique challenges for understanding and modeling credit risk. Borrower incentives for obtaining these loans and their motivations for termination differ from those on standard forward-loans, and credit risk only increases over time, rather than decreasing. Previous authors have recognized that different paradigms must be developed for measuring and modeling credit risk on reverse mortgages. Three particular areas of concern have been identified in the literature. They are:

Longetivity or "cross-over" risk (DiVenti and Herzog (1991); Chinloy and Megbolugbe (1994); Wang, et al (2007)): This is the basic actuarial risk of a reverse mortgage. Borrowers are senior citizens, many of who will remain in the home until death. Cross-over risk is simply the chance that the borrower will live long enough for the accruing loan balance to exceed the home value at time of death. Because mortgage interest rates can be expected to exceed house price growth rates in the long run, at some point every surviving loan will produce losses for the investor or insurer. Thus, it is important to model baseline termination speeds as a function of mortality rates.[2]

Interest rate risk (Boehm and Ehrhardt (1994)): Historically, reverse mortgage products have tended to be adjustable, as opposed to fixed-rate products. Upward shocks to interest rates increase the rate of loan balance accruals and thus accelerate the cross-over point at which expected losses become positive. Such shocks also increase the loss rate on terminations for loans that continue to season beyond the cross-over point. An added effect here is that house price growth rates tend to be negatively correlated with movements in interest rates. Boehm and Ehrhardt (1994) analyze the interest-rate risk of a tenure-plan, fixed-rate reverse mortgage, comparing it to coupon bonds and to forward mortgages, and find that the risk of loss on reverse mortgages due to interest rate movements over time is many multiples of the risk on those other financial instruments. This makes it imperative to do portfolio valuations based upon interest rate simulations because the basic price convexity of reverse mortgages with

[2] We speak of mortality in a general way to include mobility caused by an inability to continue independent living.

respect to interest rate movements is much higher than for other standard financial instruments.

Moral hazard or property-maintenance risk (Miceli and Sirmans (1994); Shiller and Weiss (2000)): When a homeowner takes out a reverse mortgage with an expected tenure that exceeds the expected cross-over point, utility may be maximized by extracting service flows from the housing asset without full re-investment. That is, if they expect zero equity from the property upon mortgage termination, then owners have less incentive to invest in the property over time. Any investment that would have been for enhanced resale value will not be undertaken. In the Shiller and Weiss (2000) paradigm, the homeowner places weights on the consumption and home-equity values of each investment decision, where those weights must add to one. As the weight on the equity value declines, so too does the optimal level of property investment. Shiller and Weiss (2000) define this as a basis-risk problem in modeling: house price growth rates for reverse-mortgage borrowers will be systematically lower than market-level growth rates to the extent that borrowers have less incentive to invest in their properties over time. These authors argue that, because residential properties depreciate in value with age, any lack of new investment and/or routine maintenance can cause a serious acceleration of that depreciation.

In this paper we focus on an empirical determination of measuring the extent of moral hazard from insufficient property maintenance for properties serving as collateral for a pool of reverse mortgages. The presence and extent of this type of moral hazard may ultimately depend on the motivations of homeowners to take out equity via this financial instrument, and reverse-mortgage borrowers have a variety of reasons for doing so.[3] We use actual loan termination and loss data from FHA's HECM portfolio to assess whether the homes of seniors who use reverse mortgages exhibit negative net investment and, if so, at what rate. This is done with a statistical analysis comparing actual frequencies of loss events to expected frequencies under different levels of house-price-appreciation basis risk. Lacking an analytic solution, we rather search for the empirically-based discounts to market appreciation rates that bring expected and actual loss event rates in line with each other.

Our results support the grouping of reverse-mortgage borrowers into "movers" and "stayers" as defined by Rodda and Patrabansh (2005), and thus expected tenure in the home is a primary determinant of expected home investment and moral hazard. That is, borrowers act rationally

[3] HUD has never collected from lenders the reasons borrowers say they are taking HECM loans. One major lender posts this on their website: "Common uses include paying monthly bills, fixing up your home, paying for prescriptions and health care, making a major purchase, traveling, helping children or grandchildren, and planning for the unexpected." Less than 10 percent of borrowers chose monthly payment plans, while the rest choose a line-of-credit facility. Properties undergo physical inspections as part of the underwriting process and HECM proceeds must first be used to remove any property deficiencies.

to maximize the present value of the service and equity value of their home. If they expect to live in the home to the cross-over point, then they reduce their investment in the home to below-average levels and create positive basis risk. However, when their expected tenure is short, they actually have negative basis risk, implying above-average levels of home investment.

Previous Studies of Moral Hazard

Two studies have attempted to assess the presence of moral hazard in a reverse mortgage program. Rodda and Patrabansh (2005) use the Health and Retirement Survey to compare property values of homeowners above age 75 to those of owners aged 50-74. [4] They find that the homes of owners 75 years and older appear to appreciate at a rates 1.0 to 1.2 percentage points lower than those of owners aged 50 to 74. However, Rodda and Patrabansh admit that these results may not be valid because it is quite possible that elderly homeowners who have experienced long tenures in their homes do not have a good grasp of current market values. Also, in FHA's HECM program, approximately half of all borrowers fall into the 50 to 74 (or 62-74) age bracket, rather than the 75-and-over bracket. Thus, it is also important to study appreciation of their homes, relative to area market rates. If, for some reason borrowers in the 62-74 age bracket have accelerated home investment when compared to overall homeowner averages, there could be appreciation-rate discounts on the 75+ age group properties and still no net discount be required for valuing the entire, combined portfolio. Basis risk ultimately must be measured by comparing reverse-mortgage borrowers to market price indices that represent home sales from owners of all ages.

Rodda and Patrabansh (2005) also perform statistical analysis with the Census Public Use Microdata Sample (PUMS), another survey, and there find an even larger possible negative effect on price appreciation on the homes of the over-75 age group.[5] However, because this is again survey data, they conclude, "The "poor memory" explanation of low house value appreciation remains viable, in our view, and requires more direct evidence before it can be refuted in favor of alternative explanations" (p. 33).

Davidoff and Welke (2005) hypothesize that moral hazard may arise from a different source: low rates of market-level home-price appreciation. Their hypothesis is that losses on HECM properties are most likely to come from areas with slow or negative house-price appreciation, which leads owners to stay in place even longer than they would otherwise choose to do. In the slow-growth areas, the loan-balance cross-over point occurs sooner and losses occur more often and with higher severities than in stronger markets. These authors show, theoretically, and based on actual HECM experience, that the preponderance of evidence is toward "advantageous" selection, whereby HECM has been attractive to homeowners with

[4] This survey is managed by the University of Michigan and funded by the National Institute on Aging. See http://hrsonline.isr.umich.edu/ for more detail.
[5] See, http://www.census.gov/main/www/pums.html for information this survey.

expectations of higher rates of property value appreciation, and who have high rates of early mobility. These homeowners are more financially savvy, using HECM for short-term cash needs and the full residual property equity (via property sale) for more permanent needs. Davidoff and Welke say that their theoretical model "suggests that maintenance moral hazard may not be an equilibrium outcome in this market, because the inflow of cash generated by a reverse mortgage should increase the willingness of homeowners to invest in projects that pay off in part after they leave their home" (page 31). They test their theoretical model by analyzing the speed of homeowner mobility among the elderly population as a whole, and comparing that to HECM borrowers.[6] They find evidence of advantageous selection via faster mobility even in low-growth markets and conclude that HECM attracts borrowers who expect to have short tenures. However, some of their results suggest that slower overall mobility rates in low-growth markets may erase any benefits from intra-market advantageous selection, when valuing the entire portfolio.

Applying the Shiller and Weiss (2000) theorem to Davidoff-Welke, housing investment is more valuable in fast-growth markets because overall property value growth increases the chance of a full return on the investment. But that faster growth must increase the weight given by the homeowner to the equity value of the home improvement, as opposed to the consumption value, before it will lead to any additional net investment in the property. That is, the pure investment value of home maintenance and improvement involves an expectation and desire for net equity in the property at the time of expected termination. While faster market rates of appreciation may delay the mortgage cross-over point, it is still true that borrowers with long expected tenures should primarily focus on the consumption flows from any housing investment, rather than potential capital gains.

In this study we estimate basis risk using actual HECM claim and termination information to assess whether the homes of reverse-mortgage borrowers appreciate at market rates or not. We have the advantage of six more years of actual program data than was available to Davidoff and Welke. Our findings indicate that there are, generally speaking, two types of HECM borrowers, distinguishable by the length of time the loan remains active. The first type consists of borrowers that have relatively short expected tenures and who expect to have positive equity available at the time of property sale. These are experienced homeowners who likely have a history of maintaining their homes very well and who are willing to continue making investments in the property. Their home values tend to appreciate at above market rates. The second type of borrower consists of owners who expect to age in place, keeping their HECM for relatively long periods of time before passing away or moving to other living arrangements. Their expectations are to extract consumption flows from their homes, but not necessarily to have any net equity available upon property sale.

[6] Their population data comes from the American Housing Survey, various years.

This dichotomy between the so-called movers and stayers is consistent with the theoretical work of Shiller and Weiss (2000) and the survey data findings of Rodda and Patrabansh (2005). Without knowing the expected housing tenure for individual borrowers, we rely upon what is revealed in loss event rates upon loan termination. As surviving loan pools age, the preponderance of terminations switch from being from movers to stayers, and the revealed basis risk increases accordingly. Our study shows that the basis risk for stayers is approximately 160 basis points.

Measuring Home Maintenance Basis Risk

We start with an available price appreciation index as a benchmark for determining the existence and extent of basis risk in a reverse-mortgage portfolio. The most convenient is the series of weighted repeat sales/transactions indices developed by the Federal Housing Finance Agency (FHFA), which uses data from Fannie Mae and Freddie Mac mortgage portfolios. The theory underlying the FHFA house-price index (HPI) comes from Case and Shiller (1989) and suggests that home prices follow a log-normal diffusion process. This implies that property-level cumulative house price growth in a given geographic area, and over a defined period of time, is normally distributed around the mean value underlying the index.[7] The FHFA HPI values are calculated by taking the exponential of the mean cumulative growth rate.[8] Diffusion or dispersion parameters are produced as part of the house-price-index generating process. Those parameters are used to measure the variance of the cumulative-growth diffusion process as a second-order function of time.

If $\bar{P}_t$ represents the mean house price at time *t*, and $P_{i,t}$ is an individual property price/value, then,

$$\frac{\ln\left(P_{i,t}/P_{i.0}\right) - \ln\left(\bar{P}_t/\bar{P}_0\right)}{\sigma_t} \sim N(0,1) \tag{1}$$

That is, the cumulative growth rates of individual properties, *i*, over some length of time, *t*, are normally distributed around the mean-value rate, with standard deviation, σ_t, where σ_t is calculated as

$$\sigma_t = \sqrt{\alpha t + \beta t^2} \tag{2}$$

[7] See, Charles Calhoun, "OFHEO House Price Indexes: HPI Technical Description," working paper, March 1996, available at http://www.fhfa.gov/webfiles/896/hpi_tech.pdf.
[8] The FHFA does not add the so-called Goetzman correction to calculate a mean-value index. Thus, the simple exponentiation of the mean-value growth rate (or one plus the mean-value growth rate) yields an index that identifies the median home value.

And α and β are parameters estimated from the house price data used to generate the market-level house-price index, $HPI_t = \left(\bar{P}_t / \bar{P}_0 \right)$.[9]

In the presence of basis risk for a reverse-mortgage portfolio, the true relationship is rather

$$\frac{\ln\left(\frac{P_{i,t}}{P_{i,0}}\right) - \ln\left(\frac{\bar{P}_t - S_t}{\bar{P}_0}\right)}{\sigma_t} \sim N(0,1) \tag{3}$$

Where S_t is the cumulative dollar spread between market-average price appreciation and the reverse-mortgage portfolio average price appreciation.[10] A finding of $S_t \gg 0$ would represent the existence of basis risk, inferring that the reverse-mortgage portfolio represents a non-random sample of properties within a given market. Our need is then to design an empirical test for $S_t \gg 0$. We would also like to test for possible advantageous selection in this property portfolio, which would be identified by $S_t \ll 0$. So, ultimately, we are simply testing for $S_t <> 0$.

Our test construct is to use the cumulative distribution function for (1) to calculate theoretical, market-level expectations of the rate of loss events upon loan termination. The expected rate can then be compared to the actual rate of loss events, across time and geography. If expectations are statistically different from actual, across all geographies and time periods, then we will have found evidence for $S_t <> 0$.

Upon loan termination, we know both the outstanding loan balance and the property value, so we know whether or not an insurance loss has occurred on an individual loan. By substituting the outstanding loan balance, $L_{i,t}$, for $P_{i,t}$ in equation (1), we compute the expected probability of a loss-event (where $P_{i,t} < L_{i,t}$) with $S_t = 0$ using the cumulative normal distribution function evaluated at:

$$x = \frac{\ln\left(L_{i,t}/P_{i,0}\right) - \ln(HPI_t)}{\sigma_t} \tag{4}$$

We then compute this probability for every loan at time of termination, and sum the results to achieve an expected number of loss events with $S_t = 0$. That expectation is compared to the actual number and of rate of loss events. If expected/predicted rate of loss events is

[9] In the weighted-repeat-sales methodology, index values are created based on the sum of growth rates between each two consecutive points in time, where the growth rate for each individual period of time uses information from all matched-pairs of sale transactions for which the time interval of interest is between the first and second transaction of the pair. For simplicity, we simply define the price index as representing cumulative growth between time 0 and time *t*, where *t* is measured in calendar quarters.

[10] For simplicity, and without having information to the contrary, we assume that the variance of the reverse-mortgage portfolio price appreciation process is the same as that for the overall market.

systematically less than the actual rate across all times and markets, then we discount all house price growth rates until the expected rate matches the actual rate in order to measure S_t.

Data and Empirical Tests

The data used in this study include all historical HECM terminations through September 30, 2009, on loans that were originally purchased by Fannie Mae for its retained portfolio.[11] Many of these loans were subsequently "assigned" to FHA, at which point HUD became the investor of record. Assignment is the process whereby, due to maximum claim payment caps, lenders effectively sell loans to HUD in order to avoid any liability for possible losses due to cross-over risk.[12]

Though the FHA HECM program began in 1989, volumes were small throughout the 1990s. Originations reached 10,000 loans in 2001 and 100,000 in 2007. Thus, the absolute numbers of loan terminations are more heavily weighted toward the early policy years. Table 1 shows a juxtaposition of originations and terminations in the Fannie Mae HECM portfolio by fiscal year. Table 2 defines our dataset of interest, numbers of terminations and numbers of loss events among those terminations, by loan age. For ease of exposition, we group together all terminations occurring in years 12-20. Because the program is just 20 years old, there are no termination events yet for ages greater than 20 years.

We define a loss event as a situation where, at time of termination, t,

$$L_{i,t} > P_{i,t}(1 - \varepsilon_{i,t}) \qquad (5)$$

Where $\varepsilon_{i,t}$ represents selling expenses, as a percent of property value. The reason for this definition is to establish the trigger price for an owner or property estate to effectively turn over the keys rather than sell the property itself. If the estate fails to sell the property, for whatever reason, and either the loan servicer or FHA manages the property sale, there are other (deadweight) costs associated with property management. However, the "put" decision

[11] Until 2006, nearly all HECMs were purchased by Fannie Mae (see Table 1). While Fannie Mae was the principal investor in HECM loans, FHA was still insuring against credit risk. Our analysis is restricted to the Fannie Mae portfolio because of the availability of detailed records concerning loan balances and expenses at the time of loan termination.

[12] At time of origination, FHA establishes the Maximum Claim Amount (MCA), which is the initial house value, up to the area-specific loan limit for FHA. Once the loan balance reaches that level, loan servicers can either sell ("assign") the loans to FHA, or else take the risk that, upon final loan termination, losses could be larger than the MCA. Fannie Mae and Ginnie Mae investor rules both require that servicers complete assignment at the point where the loan balances reaches the MCA. Thus, FHA becomes the investor for all loans that are still active at this point.

by the owner can be defined solely by equation (7).[13] This results in a slight modification to equation (4), the limit of integration when establishing the theoretical probability of a loss event:

$$x = \frac{\ln\left(L_{i,t}/P_{i,0}\right) - \ln\left(HPI_t(1-\epsilon_j)\right)}{\sigma_t} \tag{6}$$

where the *j* subscript represents jurisdiction. We use actual selling expense rates by State for sales from FHA's entire single-family REO inventory, 2005-2009, to calculate the ε_j. Using the loss-event definition of equation (5), only 3.1 percent of historical HECM terminations have been in an actual negative equity position.

Market-level price appreciation is measured by house price indices (HPI) published by the Federal Housing Finance Agency (FHFA). We rely primarily upon the HPI for metropolitan areas, but use state-level indices for properties in non-metro areas.[14] We also leverage the HPI volatility parameters, which are generated by the FHFA as part of the house price index calculation process, to obtain measures of the size of the distribution of property values around market index value vectors.[15]

Table 3 compares actual to expected loss-event rates under a null hypothesis of $S_t = 0$. We use a standard chi-squared goodness-of-fit test, after grouping observations by events and non-events, and bucketing them by ranges of probabilities of loss event (0.05 % ranges). The null hypothesis of no difference is rejected at the 0.001 level. From the two panels of Table 3 (Loss Events and non-Loss Events) one sees that a model with the assumption of no basis risk assigns too many loss events to the low-probability buckets and too many non-events to the high-probability buckets. The upshot for our database is that the total number of loss events is under-predicted by the model with $S_t = 0$.

[13] This means that our definition of a loss event for purposes of testing the presence of basis risk does not include all loan terminations for which FHA will incur a loss. If the deadweight losses associated with managing a vacant property are defined as some percentage of the property value, δ, then there will be situations for which $P_{i,t}(1 - \varepsilon_{i,t} - \delta_{i,t}) < L_{i,t} < P_{i,t}(1 - \varepsilon_{i,t})$. In such cases, FHA will incur a net loss on the property, but not because of insufficient property value from any basis-risk problem.

[14] Metropolitan area HPI are primarily for Core Based Statistical Areas (CBSA), but are for subdivisions within those CBSAs for the 13 areas where OMB defines Metropolitan Statistical Divisions.

[15] FHFA does not make the metropolitan area volatility parameters publicly available, but has provided them to FHA for purposes of its internal forecasts and portfolio valuations.

Solving for the Rate of Basis Risk

We have defined S_t in dollar terms (equation (3)), and need to redefine it as an index value in order to insert it into our limit of integration for computing the expected rate of loss-event in the presence of basis risk.

Let, $\theta_t = e^{ts}$ be that index, where *s* is the basis risk adjustment to the market rate of house price growth, and -1 < *s* < 0, so that 0 < θ_t < 1.

Then, equation (6) with basis risk becomes:

$$x = \frac{\ln\left(L_{i,t}/P_{i,0}\right) - \ln(HPI_t\,(1-\epsilon_t)\theta_t)}{\sigma_t} \qquad (7)$$

In theory, on a portfolio of loans we should see larger values of *s* as *t* increases. As time passes, a greater share of terminations will be from households that expected to stay in the home past the cross-over point and thus limited their housing investments accordingly. Once that cross-over point is reached, then there is a reasonable expectation of a steady-state situation where *s* has reached an equilibrium point. We are not suggesting that θ_t should be built from a vector of values of s_t, but rather that, when estimating the probability of loss-event at any given point in time *t*, the underlying value of *s* used for all time periods, {1,…, *t*}, will change because surviving loans in the portfolio will have had a different historical pattern of home investments than would have prior terminations.

We do not have an analytic solution to finding the unknown values of s for terminations in each time period and so we use an empirical approach. Table 4 shows actual loss-event rates among terminations in each policy year, and contrasts those with expected rates under various values values of *s*. Figure 1 provides the same information in graphical form. That figure shows that there is actually *negative* basis risk on terminations that occur in the first five years, meaning that loan terminations reflect better-than-market rates of property-value appreciation. All terminations prior to year 6 exhibit less-than-expected rates of loss events under the null hypothesis of *s* = 0. Borrowers that have quick terminations thus tend to have better-than-average housing investments as shown by their properties outperforming standard market indices.

The largest *negative* basis risk is in the first two years, which suggests that early terminations are dominated by borrowers who use their initial cash proceeds to invest in the home. Only some of these early-terminations (27%) are for refinancing into a new, larger reverse mortgage, which would allow homeowners to repay themselves for their home investments.[16] The rest represent owners moving out of homes, suggesting that they may be using HECM to make home improvements and upgrades to improve salability. There are two principal benefits of HECM over a standard HELOC, with respect to financing short-run property investments. First is that HECM can also be used to pay-off any existing property liens (and those liens must be paid off), and second is that there is no credit qualification for a HECM.[17]

When one defines (positive) basis risk as a negative adjustment to market rates of home price appreciation, then basis risk appears to be an increasing function of loan age. There is an appearance of an equilibrium rate of around -160 basis points after year ten. Because the cross-over point for HECM loans is typically within some range of year 15, it would make sense that, by year 12, remaining borrowers overwhelmingly started out at time of origination with long expected tenures, and had little or no expectation of any net wealth remaining in the property at time of moving from the home. Thus few terminations after year 10 would be for borrowers who were fully maintaining their properties at rates comparable to younger homeowners.

We further define basis-risk regimes by estimating the implied basis-risk values of *s* for couplets of policy-year terminations. This is done with a simple OLS regression, where the left-hand side variable is a 0/1 indicator of a loss event upon termination, and the constant term is replaced with the probability of negative equity from equation (7), using various values for *s* and θ_t. The other right-hand-side variables are 0/1 indicators of each regime couplet, so that the regression is used to estimate the implied values of *s* required to match the actual probability of a termination loss event to the theoretical at the loan level. Results of this regression are found in Table 5. The values of *s* that create parameter estimates of effective zero for each of the age-couplet indicator dummies provide the final solution for mapping out the basis risk trajectory for our reverse-mortgage portfolio.

Holding to our hypothesis that the distribution of home value appreciation for reverse-mortgage borrowers can be understood by adjusting market-level appreciation rates, while still using market-level measures of the standard deviation of individual appreciation rates, we can interpret the findings of Table 5 as giving insights into the effects of reduced incentives for home investment for these households. Terminations in years one and two are marked by average home appreciate rates that are more than eight percentage points better than market. Thus, terminations at the end of year two are systematically beating the market by 17 percent,

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[16] The use of fixed-rate mortgages for HECM did not amount to any material business until the summer of 2009. At that time, rates on fixed-rate product were comparable to those on adjustable rate product, and so there was no typical interest rate incentive to refinance.

[17] We do not mention the lack of monthly payments as a benefit for HECM because one could ostensible make monthly payments on a short-term loan from HELOC proceeds, and accruing interest on the HECM will be due-and-payable upon property sale.

which represents a return on initial home investments. At the other end, for terminations after year 10, the annualized house-price appreciation rate discount is around 160 basis points. Thus, the household that takes out a reverse mortgage and stays in the home for 15 years has a cumulative loss of value, vis-à-vis their local market, of nearly 22 percent.

Summary and Conclusions

The early theoretical literature on reverse mortgages identified home maintenance risk as one of the primary credit risk concerns of such a lending program. Two empirical studies have attempted to discern whether or not such risk does exist. Here we confirm that it exists and show how to model its effects. Following Shiller and Weiss (2000), we understand that reverse-mortgage borrowers make decisions about property investment activities based on a balance of expected service-flow and investment return-upon-sale. Owners who expect to stay in the home until the cross-over point at which the loan balance exceeds the property value will invest less in their homes because all they have is the consumption value. What one should expect, then, is a shifting of the balance of loan terminations over time from borrowers with expectations of early/faster mobility and positive investment returns to those with expectations of later/slower mobility and zero investment returns. Any basis risk in the housing returns of a reverse mortgage portfolio will then reveal itself over time through loss-event rates on terminations from surviving loans. Our data suggest that the underlying basis risk from borrowers with long expected tenures is around 160 basis points. However, borrowers with early mobility (first two years) exhibit negative basis risk on the order of 825 basis points.

Our analysis of HECM termination data supports the notion that reverse-mortgage borrowers can be broadly grouped, in Rodda and Patrabansh (2005) terms, into movers and the stayers. Movers have better-than-average house price growth and so appear to be using at least some of their HECM proceeds to make upgrades to their homes, and are expecting to have net equity available to them at loan termination. The stayers plan on aging in place and holding their HECM until passing away. These borrowers have a smaller vested interest in maintaining the value of their home. It may also be that some "stayers" could start out as owners whose home-maintenance activities are strong early on, but then those activities and investments decline with borrower age. Such a hypothesis was part of the Rodda Pantrabansh (2005) study. As a part of this study we tested for any borrower-age-specific basis risk in the FHA data on reverse mortgage terminations and found none.

Empirically-based models of reverse-mortgage performance and valuation have tended to ignore home-maintenance basis risk in their assessments of credit risk (e.g., Rodda, Lan, and Youn (2004), IBM (2009)). Some theoretical/simulation models have included provisions for possible basis risk, but had no empirical basis for choosing a specific level and so simply ran their simulations with a number of alternative values (Diventi and Herzog (1991)). Another approach has been to simply use zero price appreciation in the valuation simulations so that basis risk becomes market specific (Chinloy and Megbolugbe (1994)).

Our research has direct implications for all models of reverse-mortgage portfolio valuation and credit risk. The existence of home-maintenance basis risk means that use of standard market indices of home value appreciation will not fit the historical data well and, thus, forecasting models will likely over-predict loss-upon-termination in the early years of loan life, and under-predict loss event rates in the later years. What level of basis risk applies to any individual loan is unknown, as it depends upon initial property investments from the mortgage proceeds and the borrower's expected tenure in the home. Yet, if one approaches portfolio credit risk as a two-step estimation process –termination event and then loss-event upon termination—one can build basis risk into the empirical/historical and predictive models, as outlined here. Borrowers essentially reveal themselves as movers or stayers through their termination speeds. Predicting which borrowers will fall into one group or the other then becomes an important additional research topic.

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Table 1. FHA Home Equity Conversion Mortgage Insurance Endorsements and Loan Terminations			
	Fannie Mae Investment Portfolio		
Fiscal Year	Endorsements	Terminations	Fannie Mae Share of All Endorsements
1990	2		1 %
1991	3		1
1992	5		0
1993	978		50
1994	3,162	1	94
1995	3,965	126	95
1996	3,477	718	97
1997	4,979	1,127	96
1998	7,540	1,689	96
1999	7,566	2,425	95
2000	6,521	2,600	98
2001	7,624	3,021	98
2002	12,831	3,700	98
2003	17,923	4,680	99
2004	37,484	6,978	99
2005	42,840	9,973	99
2006	65,091	15,379	85
2007	75,447	17,210	70
2008	99,457	13,188	89
2009	90,877	18,237	79
Total	487,772	101,052	85%

Source: US Department of HUD/FHA.

Table 2. HECM Terminations and Loss Events by Loan Age		
Loan Age in years	All Terminations	Loss Events
1-2	47,555	579
3	17,478	632
4	11,781	488
5	7,965	360
6	5,380	258
7	3,682	179
8	2,675	153
9	1,741	137
10	1,205	90
11	725	92
12+	865	134
All	101,052	3,102

Source: US Department of HUD/FHA; representing loans in the Fannie Mae investment portfolio.

Table 3. Baseline Chi-Squared Test of no Basis Risk							
Expected probability Range (max values)	Number of Terminations	Loss Events			Non-Loss Events		
		Actual	Expected	Chi-Sqrd Element	Actual	Expected	Chi-Sqrd Element
0.05	87,770	773	243	1,152	86,997	87,527	3
0.10	3,343	296	243	12	3,047	3,100	1
0.15	2,028	247	251	0	1,781	1,777	0
0.20	1,540	202	268	16	1,338	1,272	3
0.25	1,392	169	312	66	1,223	1,080	19
0.30	1,136	177	312	58	959	824	22
0.35	865	135	280	75	730	585	36
0.40	713	153	267	48	560	446	29
0.45	494	119	210	39	375	284	29
0.50	304	116	144	5	188	160	5
0.55	228	105	120	2	123	108	2
0.60	158	76	91	2	82	67	3
0.65	163	72	102	9	91	61	15
0.70	134	78	90	2	56	44	4
0.75	127	61	92	11	66	35	28
0.80	110	55	85	11	55	25	37
0.85	110	60	91	10	50	19	48
0.90	104	66	91	7	38	13	49
0.95	132	64	122	28	68	10	335
1.00	200	77	196	72	123	4	3,452
Summary Test Statistic = 5,746 (dof=29), p-value = .0000							

Table 4. Loss-Event Rates Upon Loan Termination, Actual versus Expected under Various Levels of Basis Risk												
	Loan Age at time of termination (years)											
	1-2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12+**	**Total**
Actual Rates	1.22%	3.62%	4.14%	4.52%	4.80%	4.86%	5.72%	7.87%	7.47%	12.69%	15.49%	3.07%
Basis Risk Regimes												
+ 100 bps	2.10	3.64	4.03	4.03	3.58	3.00	2.94	3.23	3.42	3.96	5.60	2.96
0 bps	2.31	4.23	4.88	5.12	4.76	4.14	4.27	4.82	5.17	6.33	8.62	3.57
- 50 bps	2.43	4.57	5.37	5.76	5.48	4.85	5.13	5.85	6.34	7.89	10.49	3.94
- 100 bps	2.55	4.93	5.91	6.47	6.30	5.67	6.15	7.07	7.74	9.73	12.63	4.35
- 125 bps	2.62	5.12	6.19	6.85	6.74	6.12	6.71	7.75	8.55	10.76	13.82	4.57
- 150 bps	2.68	5.32	6.49	7.25	7.21	6.61	7.32	8.49	9.42	11.87	15.08	4.80
- 175 bps	2.75	5.53	6.80	7.67	7.71	7.13	7.97	9.28	10.37	13.07	16.44	5.05

Note: basis risk is defined as an annualized rate adjustment to quarterly house price growth rates. The annualized rate adjustment is defined as s, as explained in the discussion of equation (7) in the text. A positive value represents an addition to market house price growth rates.

Table 5. Least Squares Regressions Results Solving for Basis-Risk Adjustment Factors, by Termination-Age Couplets					
Variable[1]	Basis Risk Adjustment	Coefficient Estimate	Standard Error	t-value	Pr > |t|
Initial Test of H_0: S_t = 0					
HPI-Computed Probability of a Loss Event – no adjustments[2]	N/A	1.000	0.000	0.00	<.0001
Dummy for Years 1 - 2	0 bps	(0.011)	0.001	-14.63	<.0001
Dummy for Years 3 - 4	0 bps	(0.007)	0.001	-7.00	<.0001
Dummy for Years 7 - 8	0 bps	0.010	0.002	5.02	<.0001
Dummy for Years 9 - 10	0 bps	0.027	0.003	9.13	<.0001
Dummy for Years 11+	0 bps	0.066	0.004	16.23	<.0001
With Basis-Risk Adjustments that Match Expected to Actual Loss Event Rates					
HPI-Computed Probability of a Loss Event – with adjustments[2,3]	N/A	1.000	0.000	0.00	<.0001
Dummy for Years 1 - 2	+825 bps	0.000	0.001	0.10	0.92
Dummy for Years 3 - 4	100 bps	0.000	0.001	0.36	0.72
Dummy for Years 7 - 8	- 50 bps	0.003	0.002	1.26	0.21
Dummy for Years 9 - 10	- 100 bps	0.004	0.003	1.22	0.22
Dummy for Years 11+	- 160 bps	0.001	0.004	0.23	0.82

[1] The omitted class for the series of age-couplet dummy variables is years 5-6. That is the group for which expected outcomes match the actual loss-event outcomes, without any adjustments to market price indices.

[2] This variable replaces the intercept and its coefficient is restricted to equal 1.0.

[3] For this second regression, the probabilities attached to each loan observation are based upon house price growth rates with the associated basis risk adjustments shown here in column 2. The basis-risk adjustments are chosen so that the series of dummy-variable coefficients are not statistically different from zero.

Figure 1: Loss Event Rates upon Termination, Actual versus Expected with different levels of Basis Risk