# Actuarial Review of the Federal Housing Administration Mutual Mortgage Insurance Fund HECM Loans For Fiscal Year 2014

**November 17, 2014**

**Prepared for**

**U.S. Department of Housing and Urban Development**

**By**

**Integrated Financial Engineering, Inc.**

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November 17, 2014

The Honorable Biniam T. Gebre
Assistant Secretary for Housing – Federal Housing Commissioner
U.S. Department of Housing and Urban Development
451 Seventh Street, SW, Room 9100
Washington, DC 20410

Dear Mr. Gebre:

IFE Group has completed and, along with this letter, is submitting the fiscal year 2014 Actuarial Review of the Mutual Mortgage Insurance Fund Home Equity Conversion Mortgages (the HECM Fund).

We estimate that the HECM Fund's economic value as of the end of fiscal year 2014 was *negative* $1.17 billion and the insurance in force was $96.82 billion. We project that at the end of fiscal year 2021 the HECM Fund's economic value will be $1.04 billion and the insurance in force will be $170.00 billion.

The financial estimates presented in this Review require projections of events more than 70 years into the future. These projections are dependent upon the validity and robustness of the underlying model and assumptions about the future economic environment and loan characteristics. These assumptions include economic forecasted by Moody's Analytics and the assumptions concerning compositions of future endorsements projected by FHA. To the extent that actual events deviate from these or other assumptions, the actual results may differ, perhaps significantly, from our current projections. The models used for this Review are, by nature, large and complex. We applied an extensive validation process to assure that the results reported in this Review are accurate and reliable. The full actuarial report explains these projections and the reasons for the changes since last year's actuarial review.

Very truly yours,

Tyler T. Yang, Ph.D.
Chairman and CEO
Integrated Financial Engineering, Inc.

**Actuarial Review of the**
**Federal Housing Administration**
**Mutual Mortgage Insurance Fund**
**HECM Loans**
**for Fiscal Year 2014**

I have reviewed the "Actuarial Review of the Federal Housing Administration Mutual Mortgage Insurance Fund, HECM Loans, for Fiscal Year 2014". The purpose of my review was to determine the soundness of the methodology used, the appropriateness of the underlying assumptions applied, and the reasonableness of the resulting estimates derived in the Review.

The Review was based upon data and information prepared by the Federal Housing Administration (FHA). I have relied upon the FHA for the accuracy and completeness of this data. In addition, I also relied upon the reasonableness of the assumptions used in the economic projections prepared by Moody's Analytics, from which the base case used in the Review was derived.

It is my opinion that on an overall basis the methodology and underlying assumptions used in the Review are reasonable and appropriate in the circumstances. In my opinion the estimates in the Review lie within a reasonable range of probable values as of this time although the actual experience in the future will not unfold as projected.

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Fellow of the Institute of Actuaries (UK)
Fellow of the Canadian Institute of Actuaries
November 17, 2014

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## Executive Summary

The U.S. Department of Housing and Urban Development (HUD), Federal Housing Administration (FHA), provides reverse mortgage insurance through the Home Equity Conversion Mortgage (HECM) program. HECMs enable senior homeowners to obtain additional income by accessing the equity in their homes. The program began as a pilot program in 1989 and became permanent in 1998. Between 2003 and 2008, the number of HECM endorsements grew because of increasingly widespread product knowledge, lower interest rates, higher home values, and higher FHA loan limits. Prior to fiscal year (FY) 2009, the HECM program was part of the General Insurance (GI) Fund. The Federal Housing Administration Modernization Act within the Housing and Economic Recovery Act of 2008 (HERA)[1] moved all new HECM program endorsements into the Mutual Mortgage Insurance (MMI) Fund effective in FY 2009. Mortgage Letter 2013-27 eliminated the HECM Standard and HECM Saver programs and replaced them at the beginning of FY 2014 with HECMs that reduced the initial and total allowable drawdowns to strengthen the financial condition of the program.[2] HUD Mortgage Letter 2014-07 allowed a Non-Borrowing Spouse to be younger than 62.[3] Mortgagee Letter 2014-12 posted yet more conservative principal limit factors starting on August 4, 2014.[4]

The National Housing Act requires an independent annual actuarial study of FHA's MMI Fund.[5] Accordingly, an actuarial review must be conducted on HECM loans within the MMI Fund. This document reports the estimated economic values of the FY 2014 through FY 2021 MMI HECM portfolios. A fiscal year's MMI HECM portfolio is defined as the set of loans that survive to the end of the fiscal year and were endorsed in FY 2009 or later. In addition to the initial capital reserve, the economic value of the portfolio depends on the net present value of the future cash flows from the surviving portfolio of loans existing at the start of the valuation forecast (the end of the fiscal year under review). Our projections indicate that, as of the end of FY 2014, the HECM portion of the MMI fund has an economic value of *negative* $1,166 million. The primary source of this dramatic decrease from last year's estimate of $6,541 million was the updated discount factors from the Office of Management and Budget (OMB) which contributed a drop of $5,182 million in economic value.

### A. Status of the MMI HECM Portfolio

In order to assess the adequacy of the current and future capital resources to meet estimated future net liabilities, we analyzed all HECM historical terminations and associated recoveries using loan-level HECM data reported by FHA through March 31, 2014. We developed loan-level termination and recovery models using various economic and loan-specific factors. We then estimated the future loan performance of the FY 2014 through FY 2021 MMI HECM

[1] HERA was passed by the United States Congress on July 24, 2008 and signed by President George W. Bush on July 30, 2008.
[2] Mortgagee Letter 2013-27, September 3, 2013: Changes to the Home Equity Conversion Mortgage Program Requirements.
3 Mortgage Letter 2014-07, April 25th, 2014: Home Equity Conversion Mortgage (HECM) Program: Non-Borrowing Spouse.
[4] Principal Limit Factors following Mortgagee Letter 2014-12 provided PLFs for younger borrowers and also restricted PLFs for borrowers 62 and above.
[5] HERA moved the requirement from the 1990 National Affordable Housing Act (NAHA) to the Federal Housing Administration operations within the National Housing Act, 12 USC 1708(a)(4).

portfolios using various assumptions, including macroeconomic forecasts based on stochastic simulation of 100 possible future economic scenarios and the expected HECM portfolio characteristics provided by FHA.

Based on our evaluation of the HECM loans in the FY 2014 portfolio, we estimated the economic value of the HECM portion of the MMI fund to be *negative* $1,166 million. We also estimated that the economic value of the HECM portfolio will subsequently improve over time. Policy changes and forecasted improvement of future economic conditions are predicted to increase the estimated value of future endorsements as well as the existing books of business.[6] The estimated economic value of the fund as of the end of FY 2021 is $1,036 million.

The maximum claim amount (MCA) of a HECM loan serves as cap on the amount of insurance claims that FHA will pay the lender. The MCA is defined as the minimum of the appraised value and FHA's HECM loan limit at the time of origination. The insurance-in-force (IIF) is expressed as the sum of the MCAs in the active portfolio. As new endorsements are added to the portfolio, projected HECM IIF increases from $96,816 million in FY 2014 to $169,995 million in FY 2021. Exhibit ES-1 provides the baseline economic values of the HECM portfolio, IIF and new endorsements for FY 2014 through FY 2021.

**Exhibit ES-1. Economic Value, Insurance-in-Force, and Endorsements for FY 2014-FY 2021 ($ Million)**

| Fiscal Year* | Economic Value | Insurance in Force** | Volume of New Endorsements*** | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | -$1,166 | $96,816 | $13,729 | -$513 | |
| 2015 | -1,071 | 107,021 | 14,739 | 98 | -3 |
| 2016 | -794 | 112,942 | 16,381 | 290 | -13 |
| 2017 | -424 | 123,995 | 17,468 | 388 | -18 |
| 2018 | -121 | 135,241 | 18,581 | 317 | -13 |
| 2019 | 191 | 146,700 | 19,726 | 316 | -5 |
| 2020 | 591 | 158,253 | 20,869 | 393 | 8 |
| 2021 | 1,036 | 169,995 | 22,108 | 420 | 25 |

*All values, except the volume of new endorsements, are expressed as of the end of the fiscal year.
**Insurance-in-force is estimated as the sum of the MCAs of the remaining insured loans.
*** Projections are based on the HECM demand model in Appendix E times the average MCA. This volume number in FY 2014 reflects the outstanding loans at the end of the fiscal year, and excludes loans endorsed and terminated in the same fiscal year.

[6] Details of the policy changes are provided in Section I of this Review.

## B. Sources of Change in the Status of the Fund

The economic value of the HECM portfolio in the MMI fund decreased by $7,707 million from the estimated FY 2013 economic value of $6,541 million estimated in the FY 2013 review. This change was primarily driven by four main factors:[7]

- Fund transfer of $770 million to Single Family Financing Account.
- The portfolio data and policy update reduces the FY 2014 economic value by $886 million.
- Updating the economic scenario forecast reduces the FY 2014 economic value by $961 million.
- The 2014 model update lowers the FY 2014 economic value by $856 million.
- The discount factor update reduces the FY 2014 economic value by $5,812 million.

## C. Impact of Economic and Loan Factors

The projected economic value of the HECM portion of the MMI Fund depends on various economic and loan-specific factors. These include the following:

- House Price Appreciation Rates: HPA rates impact the recovery FHA receives upon loan terminations and the rate at which borrowers will refinance or move out of the property. HPA rates are generated by our stochastic simulation of economic variables. These rates for the Monte Carlo simulation are centered on Moody's July 2014 forecast.
- One-year and ten-year Treasury interest rates and one-year and ten-year LIBOR rates: Interest rates impact the growth rate of loan balances and the amount of equity available to borrowers at origination. Interest rate projections used in the stochastic simulation are also centered on the Moody's July 2014 forecast.
- Mortality Rates: Mortality rates are either directly obtained or derived from the U.S. Decennial Life Table for 1990-1991, 1999-2001 and 2009 populations, published by the Center for Disease Control and Prevention (CDC). Refer to Appendix A for the details of the calculation of mortality rates.
- Cash Drawdown Rates: These represent the speed at which borrowers access the equity in their homes over time, which impacts the growth of the loan balance. Borrower cash draw rates are derived from past HECM program experience with adjustments to account for the expected borrower characteristics of future books-of-business and the tighter drawdown limits starting in FY 2014.

The realized economic value will vary from the Review's estimate if the actual drivers of loan performance deviate from the baseline projections. Exhibit ES-2 presents the baseline economic value from the average of the Monte Carlo simulations, six alternative scenarios from our simulated paths, and two additional scenarios from Moody's Analytics. The baseline case of the Review is the mean of the economic values of the MMI HECM portfolio over the 100 simulated paths. Each alternative scenario estimates the performance of the Fund under the future interest rate and house price appreciation rates simulated for each path. The results indicate that there is

[7] Only the major driving factors are listed here. Details of the decomposition of changes of economic value are in Section II of this report.

approximately a 50 percent chance that the economic value would fall in the range of *negative* $8,908 million to positive $7,736 million, and an 80 percent chance to be within the range of *negative* $15,343 million to positive $11,998 million. Under the worst simulated scenario, the economic value could be *negative* $33,671 million. Based on our model and our assumptions, we estimate that this represents a 99.5 percent stress test for the Fund.

**Exhibit ES-2. Economic Values of the Fund under Different Economic Scenarios ($ Millions)**

| Fiscal Year | Mean Stochastic Simulation | 10th Best Path in Simulation | 25th Best Path in Simulation | 25th Worst Path in Simulation | 10th Worst Path in Simulation | The Worst Path in Simulation | Moody's Baseline Path | Moody's Protracted Slump Path |
|---|---|---|---|---|---|---|---|---|
| 2014 | -$1,166 | $11,998 | $7,736 | -$8,908 | -$15,343 | -$33,671 | -$189 | -$11,706 |
| 2021 | 1,036 | 24,435 | 19,240 | -5,902 | -28,222 | -59,277 | 5,943 | -10,109 |

*All values are expressed as of the end of the fiscal year.

We also test two of Moody's alternative scenarios in this Review. Moody's baseline scenario as a deterministic path produces economic value about $0.98 billion higher than the baseline Monte Carlo result, due to the asymmetric distribution of stochastic simulation results. Under the most stressful scenario projected by Moody's, the protracted slump scenario, the FY 2014 economic value of the Fund is *negative* $11,706 million. This is similar to the 20th worst path in our simulation. Thus, it is equivalent to about an 80 percentile stress test based on our simulation model and assumptions.

Note that the 10th or the 25th best and worst paths presented in Exhibit ES-2 may not correspond to the same paths that generate the 10th or the 25th best and worst economic values in the case of the forward loans in the MMI Fund. This is due to the substantial different risk drivers in the HECM loans causing differences in the sensitivity of the cash flows to economic conditions under the two programs as well as differences in the timing of these cash flows. As a result, the 25th worst scenario of the combined HECM and forward portfolios will not equal to the sum of the 25th worst HECM portfolio economic value and the 25th worst forward portfolio economic value that is reported in the separate Actuarial Review of the forward portfolio.

# Section I. Introduction

## A. Actuarial Reviews of the FHA Mutual Mortgage Insurance Fund

The National Housing Act requires an annual independent actuarial review of the Federal Housing Administration's (FHA) Mutual Mortgage Insurance (MMI) Fund.[8] FHA has conducted annual actuarial reviews of the MMI Fund since 1990.

The FHA Modernization Act within the Housing and Economic Recovery Act of 2008 (HERA)[9] moved all new endorsements for FHA's Home Equity Conversion Mortgage (HECM) program from the General Insurance Fund to the MMI Fund starting in fiscal year (FY) 2009. Therefore, an actuarial review must also be conducted on the HECM portfolio within the MMI Fund. This document reports the estimated economic value of the HECM MMI portfolios in FY 2014 and as projected through FY 2021. This review also provides the HECM portion of the insurance-in-force (IIF) used to compute the overall MMI Fund capital ratio.

## B. HECM Program Overview

The U.S. Department of Housing and Urban Development (HUD), Federal Housing Administration (FHA), provides reverse mortgage insurance through the HECM program, which enables senior homeowners to obtain additional funds by borrowing against the equity in their homes. Since the inception of the HECM program in 1989, FHA has insured more than 878,960 reverse mortgages. To be eligible for a HECM (a) at least one of the homeowners must be 62 years of age or older, (b) if they have a mortgage, the outstanding balance must be paid off with the HECM proceeds and (c) they must have received FHA-approved reverse mortgage counseling to learn about the program. HECM loans are available from FHA-approved lending institutions. These approved institutions provide homeowners with cash payments or credit lines secured by the equity in the underlying homes, and there is no required repayment as long as the borrowers continue to live in the home and meet HUD guidelines on meeting requirements for property taxes, homeowners insurance and property maintenance. Borrowers use reverse mortgages to access cash for various reasons, including home improvements, medical bills, paying off balances on existing traditional mortgages or for everyday living. A HECM terminates for reasons described in Section V. However, the existence of negative equity does not require borrowers to pay off the loan and it does not limit any payments to them as per their HECM contract.

The reverse mortgage insurance provided by FHA through the HECM program protects lenders from losses due to non-repayment of the loans. When a loan terminates and the loan balance is greater than the net value of the home, the lender can file a claim for the amount of loss up to the maximum claim amount (MCA). The MCA is defined as the minimum of the home's appraised

[8] HERA moved the requirement from the 1990 National Affordable Housing Act (NAHA) to the Federal Housing Administration operations within the National Housing Act, 12 USC 1708(a)(4).
[9] HERA was passed by the United States Congress on July 24, 2008 and signed by President George W. Bush on July 30, 2008.

value and the FHA HECM loan limit, both measured at origination. A lender can and usually does assign the mortgage note to FHA when the loan balance reaches 98 percent of the MCA and be reimbursed for the balance of the loan. When note assignment occurs, FHA switches from being the insurer to the holder of the note and services the loan until termination. At loan termination (post-assignment), FHA attempts to recover the loan balance including any accrued interest and insurance premiums.

In 2010, FHA introduced the "Saver" alternative to the Standard HECM product. The HECM Saver program charged a lower upfront mortgage insurance premium (MIP) but also reduced the amount of housing equity a borrower can access. Thus, the Saver's upfront mortgage insurance premium of one basis point attracted borrowers who can accept less funds in order to pay a lower mortgage insurance premium than the two percent premium charged by the Standard HECM program.

Starting at the beginning of FY 2014, the existing Standard and Saver programs were replaced by a more conservative program to improve the financial viability of the HECM program. The program had lower principal limit factors than the Standard program, and also had initial disbursement limitations. Furthermore, the initial MIP was based on the mortgagor's initial disbursement.

Starting from August 4, 2014, the HECM program was modified to allow non-borrowing spouses younger than 62. More conservative Principle Limit Factors (see below) are also imposed for borrowers 62 and above. Appendix E incorporates the impact of this new product on HECM demand and the future HECM endorsement composition.

The following are definitions of common HECM terms.

**1. Maximum Claim Amount (MCA)**

The MCA is the minimum of the appraised value of the home and the FHA HECM loan limit at the time of origination. It is the maximum HECM insurance claim a lender can receive. The MCA is also used together with the Principal Limit Factor (explained next) to calculate the maximum amount of initial equity available to the borrower. The MCA is determined at origination and does not change over the life of the loan. However, if the house value appreciates over time, borrowers may access additional equity by refinancing. In the event of termination, the entire net sales proceeds[10] can be used to pay off the outstanding loan balance, regardless of whether the size of the MCA was capped by the FHA HECM loan limit at origination.

**2. Principal Limits (PLs) and Principal Limit Factors (PLFs)**

FHA manages its insurance risk by limiting the percentage of the initial available equity that a HECM borrower can draw by use of a Principal Limit Factor (PLF). Conceptually, the PLF is similar to the loan-to-value ratio applied to a traditional mortgage. Exhibit I-1 presents a selected number of PLFs published in October 2010 and also from the new program started in FY 2014

[10] Net sales proceeds are the proceeds from selling the home minus transaction costs.

(FY 2014 Program) which replaced the Saver and Standard program.[11] From August 4, 2014, another program allowed a younger non-borrowing spouse (Current Program). This Current Program superseded the FY 2014 Program. It further restricted the PLFs for the borrowers.

For a given HECM applicant, a PLF is multiplied by the MCA according to the HECM program features and the borrower's age and gender. The result is the maximum HECM principal limit available to the applicant. The PLF increases with the borrower's age at origination[12] and decreases with the expected mortgage interest rate (with a floor of 3.0 percent).[13] The PLFs for the Saver program were lower than the Standard program, offering borrowers a tradeoff between the amount of accessible home equity and the rate of the upfront mortgage insurance premium. The PLFs for the FY 2014 program was 85 percent of those in comparable Standard program PLFs. Over the course of the loan, the principal limit grows at a rate equal to the sum of the mortgage interest rate, the mortgage insurance premium and the servicing fees. Once the HECM unpaid loan balance reaches the principal limit, no more cash advances are available to the borrower (except for the tenure plan, which acts as an annuity). As mentioned above, the Current program further restricted PLFs, as shown in the exhibit.

**Exhibit I-1. Selected Principal Limit Factors[14]**

| Expected Mortgage Interest Rate | Borrower Age at Origination | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 25 | 35 | 45 | 55 | 65 | | | |
| | Current Program | | | | Standard | Saver | Expired FY 2014 Program | Current Program |
| 5.50% | 0.302 | 0.341 | 0.381 | 0.419 | 0.569 | 0.468 | 0.483 | 0.478 |
| 7.00% | 0.146 | 0.187 | 0.228 | 0.270 | 0.428 | 0.316 | 0.363 | 0.332 |
| 8.50% | 0.042 | 0.087 | 0.133 | 0.171 | 0.326 | 0.192 | 0.277 | 0.227 |
| **Expected Mortgage Interest Rate** | **75** | | | | **85** | | | |
| | **Standard** | **Saver** | **Expired FY 2014 Program** | **Current Program** | **Standard** | **Saver** | **Expired FY 2014 Program** | **Current Program** |
| 5.50% | 0.636 | 0.508 | 0.540 | 0.553 | 0.703 | 0.554 | 0.597 | 0.644 |
| 7.00% | 0.516 | 0.376 | 0.438 | 0.410 | 0.606 | 0.443 | 0.515 | 0.513 |
| 8.50% | 0.425 | 0.264 | 0.361 | 0.304 | 0.531 | 0.341 | 0.451 | 0.414 |

* Or the age of younger Non-Borrowing Spouse.

[11] Mortgagee Letter 2013-27, September 3, 2013: Changes to the Home Equity Conversion Mortgage Program Requirements.
[12] For couples, the age of the younger borrower is used to determine the corresponding PLF.
[13] For adjustable rate mortgages, "expected" interest rates are calculated by the lender as the sum of an index rate (10-year LIBOR or Treasury) and the lender's index margin. The index margin is what will actually be charged on the loan as a mark-up over the index rate used for the loan (LIBOR or Constant-Maturity Treasury, either 1-month or 1-year). For fixed-rate loans, the "expected" rate is the note rate on the mortgage.
[14] The PLFs shown here are based on the 8/19/2014 values provided at:
http://portal.hud.gov/hudportal/HUD?src=/program_offices/housing/sfh/hecm/hecmhomelenders

### 3. Payment Plans

HECM borrowers access the equity available to them according to the payment plan they select. Borrowers can change their payment plan at any time during the course of the loan as long as they have not exhausted their principal limit. The payment plans are:

- Tenure plan: a fixed monthly cash payment as long as the borrowers stay in their home;
- Term plan: a fixed monthly cash payment over a specified number of years;
- Line of credit: the ability to draw on allowable funds at any time and
- Combinations of all of the above.

For the new program, the initial disbursement period limitation is applicable to all payment plans and subsequent payment plan changes that occur during the initial disbursement period.

### 4. Unpaid Principal Balance (UPB) and Loan Costs

HECMs differ from normal mortgage products as they require no repayment as long as the borrower continues to live in the home and follows FHA guidelines on property maintenance and real estate taxes and insurance. In general, the loan balance continues to grow with borrower cash draws, and accruals of interest, premiums and servicing fees until the loan terminates.[15] HECMs can have fixed or adjustable interest rates and the adjustable rate can be adjusted annually or monthly.

The initial cost of a HECM can be financed by adding it to the loan balance instead of paying cash; adding it to the loan reduces the remaining principal limit available to the borrower. These costs include origination fees, closing costs, upfront mortgage insurance premiums and pre-charged annual servicing fees. For all loans endorsed prior to October 4, 2010, the insurance premiums comprised an upfront premium of two percent of the MCA and an annual premium of half a percent of the unpaid principal balance. After October 4, 2010, the upfront premium remained at two percent for the Standard program but was set as one basis point of the MCA for the Saver program, whereas the annual insurance premium increased from 0.5 to 1.25 percent of the unpaid principal balance for both the Standard and Saver programs.

Starting from FY 2014[16], under the new policy the annual MIP rate of 1.25 percent remained the same, but the upfront MIP was determined based on the amount of the initial cash drawn at loan closing. An initial MIP of 0.50 percent of the MCA was charged if the initial draw amount is less than or equal to 60 percent of the available principal limit and 2.50 percent if the initial draw amount exceeds 60 percent of the available principal limit.

[15] The loan balance can also decrease or stay the same since borrowers have the option to make a partial or full repayment at any time.

[16] Mortgagee Letter 2013-27, September 3, 2013: Changes to the Home Equity Conversion Mortgage Program Requirements.

### 5. Loan Terminations

HECM loans typically terminate when borrowers die, move out of the home so that their primary residence changes, the HECM is refinanced or the house is sold. Loans can also terminate under foreclosure if borrowers fail to pay property taxes or homeowner's insurance. Appendix D describes how we model the tax and insurance defaults.

When a HECM loan terminates, the current loan balance becomes due. If the net sale proceeds from the home sale exceed the loan balance, the borrower or the estate is entitled to the difference. If the net proceeds from the home sale are insufficient to pay off the entire outstanding loan balance and the lender has not assigned the note, the lender can file a claim for the shortfall, up to the amount of the MCA. HECM loans are non-recourse, so the property is the only collateral for the loan; no other assets of the borrowers can be accessed to cover any shortfall.

### 6. Assignments and Recoveries

The assignment option is a unique feature of the HECM program. When the balance of a HECM reaches 98 percent of the MCA, the lender can choose to terminate the FHA insurance by redeeming the mortgage note with HUD at face value, a transaction referred to as loan assignment. HUD will pay an assignment claim in the full amount of the loan balance (up to the MCA) and will continue to hold and service the note until termination. During the note holding period, the loan balance will continue to grow by accruing interest, premiums and servicing fees. Borrowers can continue to draw cash as long as the loan balance is below the current principal limit. The only exception is that borrowers on the tenure plan are not constrained by the principal limit. At loan termination, the borrowers or their estates are required to repay HUD the minimum of the loan balance and the net sales proceeds of the home. These repayments are referred to as post-assignment recoveries.

## C. FHA Policy Changes

FHA periodically implements policy changes to the HECM program, including changes in insurance premiums, principal limit factors, FHA loan limits for HECMs and related program features. These changes generally do not affect outstanding HECM contracts. FHA publishes the policy changes in Mortgagee Letters with several examples listed in the references at the end of this report and in the above footnotes.

Exhibit I-2 indicates that the principal limit factors have become more conservative since FY 2009. The percentage decrease in the PLFs since 2009 varies based on the borrower's age at origination and expected interest rate. This reduction in PLFs reduces the amount of equity available to borrowers. This policy lowers the likelihood and size of claims and reduces FHA's financial risk accordingly, as it reduces the likelihood that the unpaid principal balance will exceed the net proceeds from the house sale. Exhibit I-2 also indicates that the FY 2014 program was more conservative than the current Standard program, because the principal limit factors for

the new program equaled 85 percent of the current Standard program. The most recent policy change[17] effective on August 14, 2014 further reduces the principal limit factors.

**Exhibit I-2. Selected Principal Limit Factors Changes for Standard HECMs, the Expired FY 2014 Program, and the Current Program**

| Borrower Age* at Origination | Expected Mortgage Interest Rate | PLFs for Standard Program | | | PLFs for Expired FY 2014 Program | PLFs for Current Program |
|---|---|---|---|---|---|---|
| | | FY 2009 and Prior | FY 2010 | FY 2011 to FY2013 | 9/30/2013 - 8/3/2014 | 8/4/2014 and onward |
| 35 | 5.50% | | | | | 0.341 |
| 35 | 7.00% | | | | | 0.187 |
| 35 | 8.50% | | | | | 0.087 |
| 45 | 5.50% | | | | | 0.381 |
| 45 | 7.00% | | | | | 0.228 |
| 45 | 8.50% | | | | | 0.133 |
| 55 | 5.50% | | | | | 0.419 |
| 55 | 7.00% | | | | | 0.270 |
| 55 | 8.50% | | | | | 0.171 |
| 65 | 5.50% | 0.649 | 0.584 | 0.569 | 0.483 | 0.478 |
| 65 | 7.00% | 0.489 | 0.44 | 0.428 | 0.363 | 0.332 |
| 65 | 8.50% | 0.369 | 0.332 | 0.326 | 0.277 | 0.227 |
| 75 | 5.50% | 0.732 | 0.659 | 0.636 | 0.54 | 0.553 |
| 75 | 7.00% | 0.609 | 0.548 | 0.516 | 0.438 | 0.410 |
| 75 | 8.50% | 0.503 | 0.453 | 0.425 | 0.361 | 0.304 |
| 85 | 5.50% | 0.819 | 0.737 | 0.703 | 0.597 | 0.644 |
| 85 | 7.00% | 0.738 | 0.664 | 0.606 | 0.515 | 0.513 |
| 85 | 8.50% | 0.66 | 0.594 | 0.531 | 0.451 | 0.414 |

* Or the age of younger Non-Borrowing Spouse.

In early 2009, the U.S. Congress passed the American Recovery and Reinvestment Act of 2009 (ARRA)[18] which mandated a temporary increase in the HECM loan limit to $625,500 nationwide, effective February 17, 2009 through December 31, 2009. The temporary loan limit increase was later extended to December 31, 2010 in the Department of the Interior,

[17] Mortgagee Letter 2014-12, June 27, 2014: Home Equity Conversion Mortgage (HECM) Program: New Principal Limit Factors.

[18] ARRA was passed by the U.S. Congress on February 13, 2009 and signed by President Barack Obama on February 17, 2009.

Environment, and Related Agencies Appropriations Act 2010.[19] Mortgagee Letters 2011-29 and 2011-39 further extended the $625,500 loan limit through December 31, 2012. Mortgage Letters 2012-26 and 2013-43 again extended the same loan limit to December 31, 2013, and December 31, 2014, respectively.

## D. Current and Future Market Environment

This section discusses the recent and projected market environment and the implications for the HECM program. In our projections of the cash flows associated with FHA insurance under the HECM program we used a set of 100 possible future economic scenarios, which were generated by our Monte Carlo simulation model. Each path produces a possible future scenario for house prices and unemployment and interest rates. This distribution is centered on Moody's July 2014 baseline forecasts in the sense that our projected values are just as likely to be above Moody's forecast values as below them. We discuss future house price growth and future interest rates in Section I in terms of Moody's forecasts since our simulated distribution is centered on these forecasts.

### 1. House Price Growth Rate

The house price growth rate trend forecasts for the nation, states and MSAs were obtained from Moody's July 2014 forecast of the FHFA Purchase-Only (PO) repeat-sales House Price Index (HPI). The Purchase-Only Index is based on repeat sales at market prices and does not involve any appraised values. As such it provides a more direct and accurate measure of housing market conditions. Moody's state and MSA house price forecasts take into consideration local area economic conditions including unemployment rates. Moody's July 2014 forecast provides estimates from FY 2014Q2 to the end of FY 2044. We derive the House Price Appreciation (HPA) rates from the local HPI, and use the HPA forecasts for FY 2044 as the basis for HPA beyond year 2044.

Exhibit I-3a presents a brief summary of the July 2014 Moody's baseline national HPA forecast as compared to the one used in the 2013 Review. According to this year's forecast, the annualized national house price growth rate is 6.80 percent through the fourth quarter of FY 2014. Then the rate drops to positive 0.54 percent per annum by the fourth quarter of FY 2016, representing a minor recession. After that, the house price growth rate gradually rises to a long-run average annual rate of around 3.50 percent.

Exhibit I-3b presents the HPI comparison between the July 2014 Moody's baseline national HPI forecast and that of the 2013 Review. Although the short-term HPI level is higher in the 2014 forecast, the long-term level is lower than that of the 2013 Review, as a result of lower HPA between 2021 and 2036.

[19] Department of the Interior, Environment, and Related Agencies Appropriations Act (H.R. 2996) was passed by the U.S. Congress on October 29, 2009 and signed by President Barrack Obama on October 30, 2009.

**Exhibit I-3a. House Price Appreciation Rates: Actuals and Forecasts from Year 2007 to 2044**

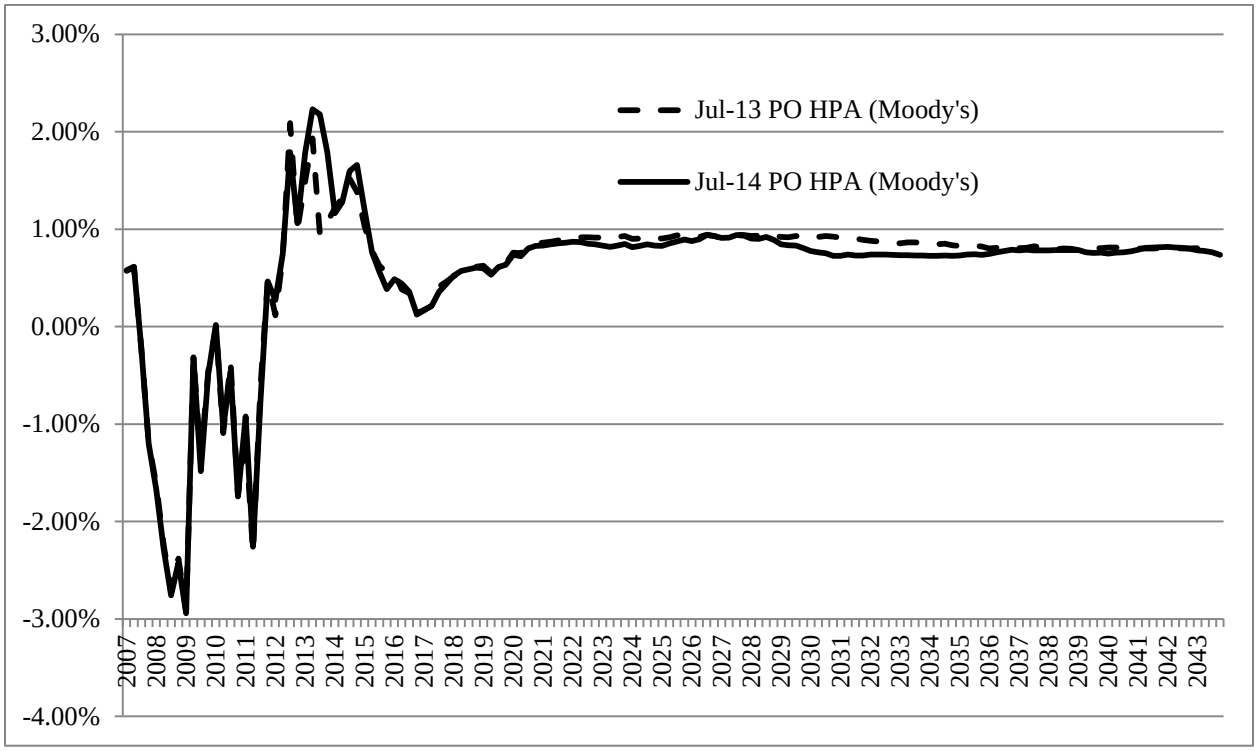
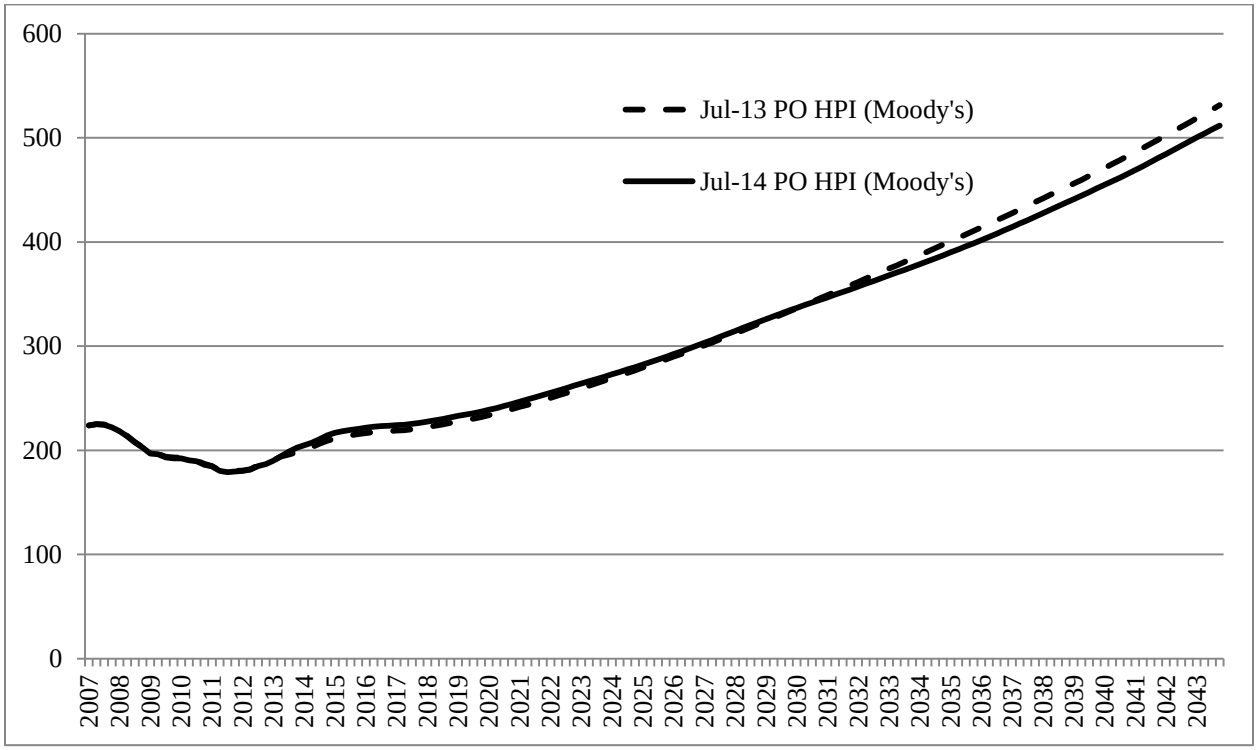



**Exhibit I-3b. House Price Indices: Actuals and Forecasts from Year 2007 to 2044**



The house price projections for individual states generally differ from the overall national level. The HECM portfolio active at the end of FY 2014 is concentrated in California, Florida, New York and Texas. A near-term strong recovery is forecasted for California, while a mild increase is forecasted for Texas and Florida. Except for Florida, the long-term trends of house price growth for these states remain similar to those in last year's Moody's forecast. The differences compared to last year's Review are shown below in Exhibit I-3c for these large states and nationally.

**Exhibit I-3c. Comparison of House Price Forecasts in Four States**

| State | Percent of FY 2013 Endorsements | House Price Growth Forecast | | | |
|---|---|---|---|---|---|
| | | Short-Term Trend [20] | | Long-Term Trend | |
| | | Forecast in FY 2014 Review | Forecast in FY 2013 Review | Forecast in FY 2014 Review | Forecast in FY 2013 Review |
| California | 17.52% | 7.58% | 2.67% | 2.88% | 3.13% |
| Texas | 6.48% | 6.70% | 2.55% | 2.73% | 2.62% |
| Florida | 10.47% | 7.11% | 3.24% | 3.26% | 3.26% |
| New York | 5.42% | 2.17% | 1.76% | 2.91% | 3.26% |
| National Average | | 5.86% | 5.59% | 3.04% | 3.27% |

The strong recovery in house price growth affects the HECM portfolio in two ways. First, we observe strong short-term recovery in states that suffered the most in the recent recession, such as California. A recovering housing market leads to more refinancing and lower claim payments. The positive house price growth rates in FYs 2013-2014 and the mild long-term house price growth projection increase the recovery revenue of HECM loans. Consequently, HECM insurance losses would be lowered.

Second, a near-term strong house price forecast and long-term positive growth rate increase the additional equity available to a borrower through refinancing. However, this benefit is offset by the lower principal limit factors imposed in the FY 2014 and the August 14, 2014 policy change allowing younger non-borrowing spouse. The net benefit would be the combined effect of house price appreciation and a lower percentage of allowed cash draws. Appendix A provides a detailed analysis of HECM refinancing.

Compared with last year's baseline scenario, house price growth forecast under this year's baseline scenario is more optimistic, which leads to larger recoveries at termination and fewer assignments. Future endorsements are predicted to have better financial performance than those in the existing portfolio.

[20] Short-term trend means the growth rate over CY 2014Q3-CY 2015Q3. Long-term trend means the annualized growth rate from CY 2014 to CY 2034.

## 2. Interest Rates

According to Federal Reserve Board statistics, the one-year U. S. Treasury rate has stayed at record low level over the past several years. In response to the Federal Reserve's second round of quantitative easing (QE2) in November 2010, and "Operation Twist" started in September 2011, the 10-year Treasury rate continued to drop since 2010 and reached its lowest point since the 1950s in the third quarter of 2012, as shown in Exhibit I-4a. Since then, it started to slowly crawl upward, and reached 2.71% in 2013Q3. The one-year London Interbank Offered Rate (LIBOR) is forecasted to stay at an historical low level in the near future, similar to the 0.67 percent observed at the third quarter of CY 2013.

**Exhibit I-4a. Selected Historical Interest Rates**

| Rate type | Interest Rate | | |
|---|---|---|---|
| | 2012 Q3 | 2013 Q3 | 2014 Q3 (Forecast) |
| 1yr CMT | 0.18% | 0.12% | 0.16% |
| 10yr CMT | 1.64% | 2.71% | 2.97% |
| 1yr LIBOR | 1.04% | 0.67% | 0.65% |

The expected HECM mortgage interest rate, which is calculated as the sum of the ten-year rate and the lender's margin for a variable rate HECM, affects the percentage of equity available to borrowers. The PLF increases as the expected rate declines for a given borrower age. Moody's has forecasted the ten-year Treasury rate to rise steadily to 4.0 percent by 2016 and then stabilize around 4.6 percent after 2018.[21] The ten-year Treasury rate forecast implies a continued low interest rate environment, which enables borrowers to access a large percentage of their home equity. However, even though ten-year Treasury rates remain at a low level, average lender margins have increased from an average of 1.5 percent for 2008 and prior years to 2.5 percentage points from 2009 to 2011. In 2012, lender margins further increased to 3.0 percentage points. In FY 2014 originations, the margin has been lower, to 2.46 percent for adjustable-rate loans.

Exhibit I-4b shows the comparison of the 10-year Treasury rate forecasts in the 2013 and 2014 Reviews. The predicted 10-year Treasury rate rise in 2013 did not materialize. The forecasted long-term level of the 10-year Treasury rate is also lowered in July 2014, compared to last year's forecast.

Approximately 83 percent of loans in the FY 2014 book of business are monthly adjustable rate loans (see Section IV for a detailed breakdown). The mortgage interest rate for adjustable-rate HECMs is equal to the sum of the base rate and the lender's margin. Moody's has forecasted the one-year Treasury rate to rise steadily to 3.5 percent by FY 2016 and stabilize to a long-run rate of around 4.0.

Exhibit I-4c shows the comparison of the 1-year Treasury rate forecasts in the 2013 and 2014 Reviews. The realized 1-year Treasury rates in 2014 turned out to be lower than what was

[21] At the time of the review, Moody's did not forecast the LIBOR ten-year SWAP rate. For modeling purposes, we leveraged the FHA-estimated relationship between the U. S. Treasury and the LIBOR ten-year rates, and accordingly estimated the future LIBOR ten-year rate using the Moody's ten-year Treasury rate forecast.

forecasted by Moody's in July 2013. Also the forecast of long-term level of the 1-year Treasury rate is adjusted downward this year, compared to Moody's July 2013 forecast.

**Exhibit I-4b. 10-Year Treasury Rate Forecasts**

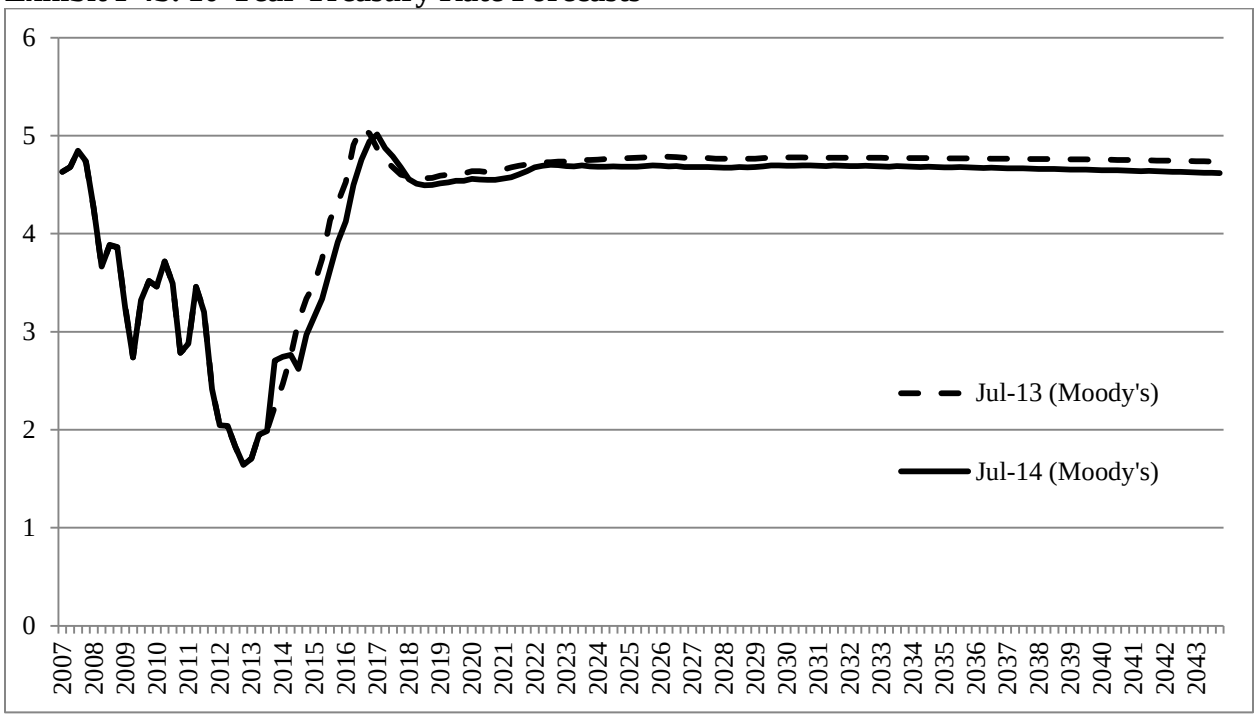
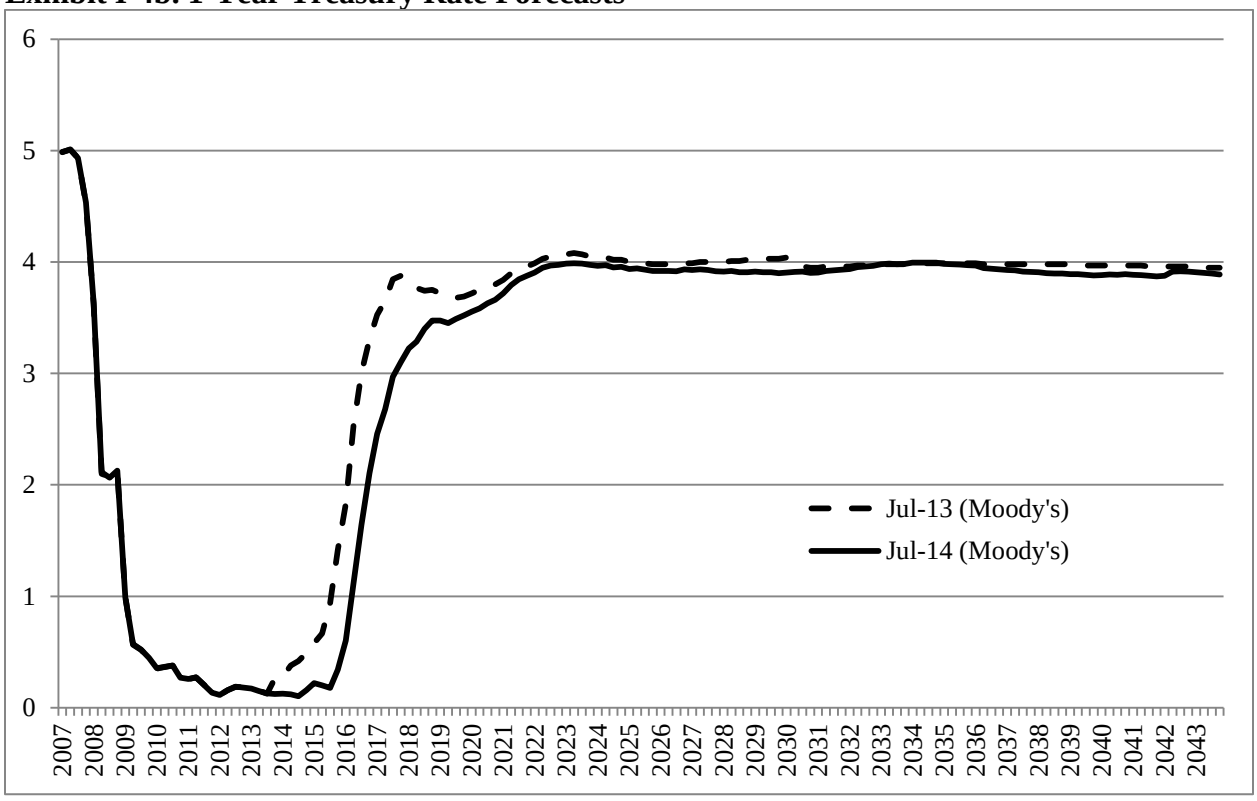



**Exhibit I-4b. 1-Year Treasury Rate Forecasts**



### 3. HECM Demand

HECMs started as a pilot program in 1989 and became a permanent program in 1998. Between 2003 and 2008, the number of HECM loans grew steadily because of increased product awareness on the part of potential applicants, lower interest rates, higher home values and higher loan limits. Demand remained steady during the financial crisis with about 114,412 endorsements in FY 2009, similar to the level in FY 2008. The PLF reductions listed in Exhibit I-2 and house price depreciation have contributed to a decline in HECM demand since FY 2009. The initial disbursement limitation and reduction of PLFs in FY 2014 significantly decreased HECM demand compared with 2013 actual endorsements. Exhibit I-5 shows the actual numbers and dollars of endorsements in FY 2009 through FY 2013 as well as the annualized values for FY 2014 (based on data as of June 30, 2014). The exhibit also presents the volume projections for FY 2015 through FY 2021 based on our updated HECM demand model described in Appendix E. The projection has included possible younger borrowers brought in by Mortgagee Letter 2014-12.

**Exhibit I-5. Actual and Forecasted FY 2009 to FY 2021 Endorsements**

| Fiscal Year | Number of Endorsements | Average MCA per Endorsement | Total Endorsements ($millions) |
|---|---|---|---|
| 2009 | 114,412 | $262,840 | $30,072 |
| 2010 | 79,055 | $266,565 | $21,073 |
| 2011 | 73,108 | $249,133 | $18,214 |
| 2012 | 54,820 | $240,141 | $13,165 |
| 2013 | 59,898 | $244,983 | $14,674 |
| 2014 | 52,757 | $262,748 | $13,862 |
| 2015 | 54,052 | $272,689 | $14,739 |
| 2016 | 59,206 | $276,675 | $16,381 |
| 2017 | 62,625 | $278,934 | $17,468 |
| 2018 | 65,580 | $283,336 | $18,581 |
| 2019 | 68,338 | $288,653 | $19,726 |
| 2020 | 70,734 | $295,027 | $20,869 |
| 2021 | 73,056 | $302,615 | $22,108 |

HECM borrowers represent about 0.9 percent of all households with at least one member aged 62 years or older (according to AARP). If this ratio is maintained, the number of reverse mortgages will continue to increase with the expected growth in the senior population. In FY 2010, 16 percent of the population (approximately 50 million) was 62 or older. According to the U.S. Census Bureau's projection, 20 percent of the population (approximately 67 million) will be 62 or older in 2020 and this will grow to 22 percent of the population (approximately 84 million) by 2030. Furthermore, as longevity is expected to increase, more seniors may have insufficient savings to sustain their financial needs in retirement, potentially increasing the demand for HECMs.

### 4. HECM Secondary Market

The HECM secondary market increases liquidity by providing capital market funding to primary market HECM lenders, broadening distribution channels for HECM loans and expanding the investor base for the HECM product. Fannie Mae has been the largest portfolio investor of HECM loans. As of 2013Q1, Fannie Mae held for investment $50.2 billion in HECM loans representing about 57 percent of the HECM insurance in force.

Ginnie Mae implemented a HECM Mortgage Backed Security (HMBS) product in 2007. Under this program, Ginnie Mae approved issuers can pool and securitize newly originated HECMs. During FY 2010, Ginnie Mae had issued nearly $12 billion in HMBS compared to $5.1 billion in FY 2009. The FY 2011 issuance level dropped to $10.8 billion, the FY 2012 level was $9.0 billion and around $ 9.4 billion in FY 2013.

The secondary market activities do not directly affect our actuarial projections, but a change in secondary market liquidity could potentially impact the volume of future endorsements.

## E. Data Sources and Future Projections

This Review focuses on the economic value of HECM loans in the MMI Fund, which consists of the loans from FY 2009 through FY 2014 endorsement cohorts that were active at the end of FY 2014. All historical HECM data were used to analyze and better understand the performance of the loans within the program and to develop the termination model estimates. These data include loans that were endorsed under the General Insurance (GI) Fund over FY 1990 to FY 2008, as well as the loans endorsed under the MMI Fund beginning in FY 2009. Since the MMI fund was charged with covering the losses accruing in loans endorsed after FY 2008, the "MMI HECM portfolio" is defined to include only these more recent endorsements.

Borrower characteristics and loan features are based on loan-level data as of June 30, 2014. The actual endorsement volume is annualized for the remaining three months of the fiscal year. Historical data and forecasts of economic data were collected from Moody's economy.com website. These data include the one-year and ten-year Treasury rates, one-year LIBOR rates, the house median price, the unemployment rate and the purchase-only house price appreciation rates for the Federal Housing Finance Agency (FHFA) conventional and conforming loans. FHA

provided estimates of borrower characteristics for future endorsements. The cash flow model used to estimate the present value of future cash flows on outstanding insurance tracks the cash flows on a fiscal year basis.

## F. Structure of this Report

The remainder of this report consists of the following sections:

- Section II. Summary of Findings – presents the estimated economic value and insurance-in-force for the FY 2014 through FY 2021 MMI HECM portfolios. It also provides a step-by-step analysis of changes from last year's Review.
- Section III. Current Status of the HECM Program – analyzes the estimated economic values in further detail.
- Section IV. Characteristics of MMI HECMs – presents various characteristics of HECM endorsements for fiscal years 2009 through 2014.
- Section V. HECM Performance under Alternative Scenarios – presents the HECM portfolio economic values using alternative economic scenarios.
- Section VI. Summary of Methodology – presents the loan performance and cash flow models used to estimate the economic values in this report.
- Section VII. Qualifications and Limitations – describes the main assumptions and the limitations of the data and models relevant to the results presented in this Review.
- Appendix A. HECM Base Termination Model – provides a technical description of the loan performance model for the causes of loan termination excluding Tax and Insurance defaults (which is described separately in Appendix D).
- Appendix B. HECM Loan Performance Projections – provides a technical description of the loan termination projection methodology and the characteristics of the future endorsement cohorts modeled in this Review. It also gives an overview of Moody's economic forecasts for interest rates and home prices that produced the baseline Monte Carlo simulation as well as six selected alternative scenarios.
- Appendix C. HECM Cash Flow Analysis – provides a technical description of the cash flow model covering the various sources of cash inflows and cash outflows that HECM loans generate.
- Appendix D. Tax and Insurance Default Analysis – presents a technical description of the tax and insurance default model developed for this Review. It also explains how the tax and insurance default model is implemented in the cash flow projections.
- Appendix E. HECM Demand Model – presents a technical description of the HECM demand forecasting model and its implementation.
- Appendix F. Stochastic Forecast of Economic Variables – presents the time series econometric model estimates of the stochastic economic variables that drive future cash flows.

## Section II. Summary of Findings

This section presents the projected economic values and insurance in force of the FY 2014 through the FY 2021 HECM MMI portfolios. An MMI-designated fiscal year's portfolio is defined as the set of loans that survive to the end of the fiscal year and were endorsed in FY 2009 or later, when the MMI fund was responsible for HECM losses. In addition to initial capital resources and net earnings through the year, the economic value of the HECM MMI portfolio depends on the discounted net present value of the future cash flows from the surviving portfolio of loans existing at the start of the valuation forecast (the end of the fiscal year under review). A fiscal year's economic value calculation does not include the effect of endorsements from future fiscal years.

### A. The FY 2014 Actuarial Review

The FY 2014 Actuarial Review assessed the actuarial soundness of the HECM portfolio in the MMI Fund as of the end of FY 2014 and projected the status of the portfolio through FY 2021. In this Review, we:

- Analyzed all HECM historical termination experience and the associated recoveries using loan-level HECM data maintained by FHA through June 2014.
- Developed loan termination models to estimate the relationship between loan termination cash flows and various economic, borrower and loan-specific factors.
- Constructed a stochastic simulation model for 100 possible economic scenarios of interest rates and house price indices. These economic paths were calibrated to center around the baseline macroeconomic forecasts published by Moody's Analytics in July 2014.
- Estimated future cash flows associated with the projected FY 2014 to FY 2021 HECM MMI portfolios using various assumptions. These assumptions included simulated economic conditions from our Monte Carlo model, borrower characteristics of future endorsements and home-maintenance-risk adjustment factors.
- Estimated the economic value of the HECM MMI portfolio from FY 2014 through FY 2021, using expected cash flows from the Monte Carlo simulation and discount rates prescribed by the OMB.
- Conducted scenario analysis using five scenarios from our Monte Carlo simulation paths and Moody's Protracted Slump scenario.

The following is a summary of the major findings in this Review, as shown in Exhibit II-1. These findings come from the stochastic simulations of 100 economic paths around Moody's baseline economic trend forecast. Our baseline estimate is the average of the economic values over these 100 paths.

- The economic value at the end of FY 2014 was estimated to be *negative* $1,166 million.

- The economic value of the HECM MMI portfolio was projected to improve steadily over the next seven years and become $1,036 million by FY 2021.
- The insurance-in-force (IIF) is expressed as the sum of the maximum claim amounts (MCAs) of all HECM loans remaining in the insurance portfolio (even though losses are not limited to the MCA). The estimated IIF reflects the combined, cumulative impacts of loan terminations and new endorsements. The IIF was estimated to be $96,816 million at the end of FY 2014 and was estimated to increase to $169,995 million by the end of FY 2021.

**Exhibit II-1. Economic Value, Insurance-In-Force, and Endorsements for FY 2014 through FY 2021 ($ Millions)**

| Fiscal Year* | Economic Value | Insurance in Force** | Volume of New Endorsements*** | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | -$1,166 | $96,816 | $13,729 | -$513 | |
| 2015 | -1,071 | 107,021 | 14,739 | 98 | -3 |
| 2016 | -794 | 112,942 | 16,381 | 290 | -13 |
| 2017 | -424 | 123,995 | 17,468 | 388 | -18 |
| 2018 | -121 | 135,241 | 18,581 | 317 | -13 |
| 2019 | 191 | 146,700 | 19,726 | 316 | -5 |
| 2020 | 591 | 158,253 | 20,869 | 393 | 8 |
| 2021 | 1,036 | 169,995 | 22,108 | 420 | 25 |

* All values, except the volume of new endorsements, are as of the end of the fiscal year.
** Insurance in Force is estimated as the total of the MCAs of the remaining loans in the insurance portfolio.
*** Projections based on the HECM demand model in Appendix E multiplied by the average MCA. This volume number in FY 2014 reflects the outstanding loans at the end of the fiscal year, and excludes loans endorsed and terminated in the same fiscal year.

## B. Changes in the Economic Value

The FY 2013 HECM Review estimated that the HECM portfolio had an economic value of $6,541 million at the end of FY 2013 compared to the estimate of this year's Review of *negative* $1,136 million at the end of FY 2014. Exhibit II-2 shows the accounting line items that underlie the year-over-year change in value. Total HECM capital resources were reported to be $9,119 million at the end of FY 2013. Based on actual results through September 31, 2014, the sum of the net insurance income, the net gains from investments, the net change in value of properties in inventory and a transfer to the MMI forward mortgage Capital account increased the HECM capital resources to $8,816 million. We estimated the net present value of future cash flows for surviving loans at the end of FY 2014 at *negative* $9,982 million. The economic value at the end of FY 2013 was therefore estimated as *negative* $1,166 million.

**Exhibit II-2. Projected Economic Value of the HECM Portfolio in the MMI Fund at the End of FY 2014 ($ Millions)**

| Item | End of FY2013[(1)] | End of FY2014 |
|---|---|---|
| Cash | $8,725 | |
| Investments | 0 | |
| Properties and Mortgages | 458 | |
| Other Assets and Receivables | 3 | |
| Total Assets | $9,186 | |
| Liabilities (Account Payables) | (67) | |
| Total Capital Resources | $9,119 | |
| Net Gain from Investment[(2)] | | $327 |
| Net Insurance Income in FY 2014[(3)] | | (178) |
| Net Change in Value of Property Inventory | | 316 |
| Net Change in Accounts Payable | | 1 |
| Transfer to SF Financing Account | | (770) |
| **Total Capital Resources as of EOY** | | **$8,816** |
| NPV of Future Cash Flows on Outstanding Business | | (9,982) |
| **Economic Value** | | **($1,166)** |
| **Insurance- In- Force** | | $96,816 |

(1) Source: Audited Financial Statements for FY 2013
(2) Based on audited investment income provided by FHA.
(3) Based on audited net cash flow through the end of FY2014 provided by FHA.

## C. Decomposition of the Differences in the FY 2014 Economic Value as Reported in the FY 2013 Review and the FY 2014 Review

The economic value of the HECM portfolio in the MMI Fund changed from $6,541 million in FY 2013 as estimated in the FY 2013 Review to *negative* $1,166 million in FY 2014 as reported in this year's Review, as taken from the first and last lines of Exhibit II-3, representing a *decrease* in value of $7,707 million. This change resulted from data changes, economic forecast changes and modeling changes.

In Exhibit II-3, we present the step-by-step changes in the economic value from the FY 2013 Review to the FY 2014 Review. A similar analysis for FY 2020 is also included. Note that FY 2020 is the last projected fiscal year common to both Reviews. Also note that the order of the decomposition affects the magnitude of the individual attributions of the changes in value.

The FY 2014 HECM portfolio economic value projected in the FY 2013 Review was $7,523 million. After updating the net gain from investment, net insurance income in FY 2014, the net change in value of properties in inventory, net change in Accounts Payable and a transfer of $770 million to the forward mortgage MMI Capital Account, as shown in the table, we describe the decomposition in more detail starting with the FY 2014 HECM Fund valued at $7,523 million.

**Exhibit II-3. Sources of the Change in Economic Value for the HECM Portfolio in the MMI Fund between FY 2013 and FY 2014 ($ Millions)**

| Decomposition Steps | Change in FY 2014 Economic Value | FY 2014 Economic Value | Change in FY 2020 Economic Value | FY 2020 Economic Value |
|---|---|---|---|---|
| FY 2013 Economic Value Presented in FY 2013 Review | | 6,541 | | |
| FY 2014 Economic Value Presented in the FY 2014 Review Excluding the FY 2014 Book-of-Business | 13 | 6,554 | | |
| Plus: Forecasted Value of FY 2014 Book-of-Business Presented in the FY 2013 Review | 969 | | | |
| Equals: FY 2014 Economic Value Presented in the FY 2013 Review | | 7,523 | | 15,378 |
| plus: a. Transfer to MMI Single Family Financing Account | -770 | 6,753 | -891 | 14,487 |
| plus: b. Origination Volume Update for FY 2013 and Later Book | -34 | 6,719 | -1,076 | 13,411 |
| plus: c. FY 2014 Composition Update and Policy Change | -886 | 5,833 | -1,237 | 12,174 |
| plus: d. Economic Scenario Update | -961 | 4,872 | -3,842 | 8,332 |
| plus: e. 2014 Model Update | -856 | 4,016 | 6,022 | 14,354 |
| plus: f. Discount Factor Update | -5,182 | -1,166 | -13,763 | 591 |
| **Equals: Estimate of Economic Value** | **-8,689** | **-1,166** | **-14,787** | **591** |

### a. Transfer to MMI Single Family Financing Account

There is a $770 million transfer to the MMI Single Family Financing Account. As a result, the economic value of FY 2014 is lowered by $770 million, and the FY 2020 economic value is lowered by $891 million.

### b. Origination Volume Update for FY 2013 and Later Book

In the 2014 Review, the volume of endorsements occurring in FY 2013 and FY 2014 was lower than the endorsement projections used in the 2013 Review. The lower volume reduces the economic value of the FY 2014 portfolio by $34 million. Also, lower volumes of projected future books further reduce the economic value of the FY 2020 portfolio by $1,076 million.

### c. FY 2014 Composition Update and Policy Change

When we use FY 2014 actual data to replace estimated 2014 data used in the 2013 Review, we also used updated future books 2015-2021. The new future book introduces non-borrowing spouses younger than 62 as instituted in the August 4, 2014 policy change and more conservative PLFs. It changed PLFs for borrowers both younger and older than 62. Therefore, the change of 2014 portfolio value in this step mainly consists of three parts: (i) data update for FY 2014 endorsements; (ii) FY 2009-2013 books are updated with actual survival data in the past year; and (iii) the effect from the new PLFs. The combined effect is an $886 million drop in the economic value for FY 2014. For future books, the effect for allowing younger non-borrowing spouse introduced on August 4, 2014 is incorporated into the projections in this year's Review. That caused the future economic value at FY 2020 to drop by 1,237 million.

### d. Economic Scenario Update

From the 2013 to the 2014 Review, the macroeconomic forecast changes have an adverse impact on the forecasted FY 2014 economic value. First, the lower long-term HPI forecast will reduce the sales revenue for conveyed properties. Second, the lower long-term 1-year Treasury rate will reduce the speed the mortgage insurance premiums accrue. After using FY 2014 data and updating market condition, the economic value drops by $961 million for FY 2014 and by $3,842 for FY 2020.

### e. 2014 Model Update

In this 2014 Review, the major improvement in the termination models is the mortality calculation. As described in Appendix A, we made a substantial enhancement to project HECM borrower mortality to reflect the trend of increasing longevity of HECM borrowers observed over the years. Combining with other model updates, the FY 2014 model update reduces the FY 2014 economic value by $856 million. The FY 2020 economic value improves by $6,022 million.

### f. Discount Factor Update

This decomposition step shows the effect of the FY 2015 budget discount factors. The latest OMB published discount factors are higher than the values of the FY 2014 factors used in last year's Review, as shown in Appendix C. The higher discount factors decrease the present values of both future positive and negative cash flows. The net impact of discount factors is a balance among these opposing cash flow items. As HECM recoveries occur at longer durations in the future than claims, the higher interest rate assumption in the long run has a larger negative impact on the cash inflows than outflows. As the result, the FY 2014 HECM economic value decreased by $5,182 million and the FY 2020 HECM economic value decreased by $13,763 million. This is the largest factor leading to the much lower economic value this year than last year.

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## Section III. Current Status of HECMs in the MMI Fund

This section presents the components of the economic value for FY 2014 and also the projections through FY 2021. The HECM portion of the MMI Fund has an estimated economic value of *negative* $1,166 million at the end of FY 2014. The economic value and the insurance-in-force of the HECM program are both projected to increase over time.

### A. Estimating the Current Economic Value and Insurance-in-Force of HECM in the MMI Fund

This section discusses the economic value and the insurance-in-force of the MMI Fund HECM portfolio.

#### 1. Economic Value

According to NAHA, the economic value of the Fund is defined as the "cash available to the Fund, plus the net present value of all future cash inflows and outflows expected to result from the outstanding mortgages in the Fund." We estimated the current economic value for the HECM portfolio as the sum of the amount of capital resources and the net present value of all expected future cash flows from the estimated insurance-in-force as of the end of FY 2014. Exhibit III-1 presents the components of the economic value for FY 2014.[22] Data through June 2014 was annualized to estimate the total capital resources and the loan performance to the end of FY 2014. The total economic value consists of the following components:

- *Total Capital Resources* equals assets less liabilities in FY 2013 plus additional cash available from investments, fund transfers and operational activities during FY 2014. We estimated the total capital resources to be $8,816 million at the end of FY 2014, which consists of the following components:
    - *Total Assets* include cash and other assets, Treasury investments, and properties and notes held by FHA. The total assets were $9,186 million as of the end of FY 2014.
    - *Total Liabilities* include accounts payable. This is $67 million as of the end of FY 2013.
    - *Net Gain from Investments* includes the estimated revenue from the investment of capital resources and the interest from the HECM Financing Account during FY 2014. The total investment gain is $327 million.
    - *Net Insurance Income in FY 2014* includes the estimated premiums, claims and recoveries, derived by annualizing the year-to-date data for FY 2014. The net insurance income for FY 2014 from the still-active FY 2009 through FY 2014 endorsements is *negative* $178 million.

[22] Note that Exhibit III-1 is the same as Exhibit II-2, reproduced in this section for easy reading.

- *Net Change in the Value of Property Inventory* refers to the change in the value of the inventory of HECM-funded properties that are held by FHA. The value of properties in inventory is projected to increase by $316 million by the end of FY 2014, largely due to the increase in the number of such properties.

- *Net Change in Accounts Payable* is the change in the balance in Accounts Payable from the beginning to the end of FY 2014. It is $1 million.

- *Transfer to the MMI Forward Fund Financing Account*, which is the transfer of funds to the MMI Capital Reserve account from the HECM Financing Account, is $770 million in FY 2014.

- *Present Value of Future Cash Flows on Outstanding Business* consists of cash inflows and outflows. HECM cash inflows consist of premiums and recoveries. Cash outflows consist of claims and note-holding expenses. The cash flow model projects cash inflows and outflows using economic forecasts and loan performance projections. The present value of net future cash flows is *negative* $9,982 million as of the end of FY 2014.

**Exhibit III-1. Projected Economic Value of the HECM Portfolio in the MMI Fund at the End of FY 2014 ($ Millions)**

| Item | End of FY2013[(1)] | End of FY2014 |
|---|---|---|
| Cash | $8,725 | |
| Investments | 0 | |
| Properties and Mortgages | 458 | |
| Other Assets and Receivables | 3 | |
| Total Assets | $9,186 | |
| Liabilities (Account Payables) | (67) | |
| Total Capital Resources | $9,119 | |
| Net Gain from Investment[(2)] | | $327 |
| Net Insurance Income in FY 2014[(3)] | | (178) |
| Net Change in Value of Property Inventory | | 316 |
| Net Change in Accounts Payable | | 1 |
| Transfer to SF Financing Account | | (770) |
| **Total Capital Resources as of EOY** | | **$8,816** |
| NPV of Future Cash Flows on Outstanding Business | | (9,982) |
| **Economic Value** | | **($1,166)** |
| **Insurance- In- Force** | | $96,816 |

(1) Source: Audited Financial Statements for FY 2013
(2) Based on audited investment income provided by FHA.
(3) Based on audited net cash flow through the end of FY2014 provided by FHA.

### 2. Insurance-in-Force

According to NAHA, the insurance-in-force (IIF) is defined as the "obligation on outstanding mortgages." We estimate the IIF as the total maximum claim amount (MCA) of all HECM loans remaining in the insurance portfolio as of the end of FY 2014. Another possible IIF measure is the outstanding loan balances, which tend to increase over time from interest accruals, premiums, service fees and borrower cash draws. As the main purpose of this review is to assess the long-term financial performance of the HECM portfolio, using the current loan balances to estimate the IIF could over- or under-represent FHA's long-term insurance exposure depending on the distribution of loan ages in the HECM portfolio. In contrast, the aggregate MCAs for the portfolio will only depend on insurance termination and will be more stable over time. The MCA is the highest claim amount FHA can pay out at insurance termination, although it does not cap the possible exposure.

Exhibit III-2 illustrates the estimated survival loan count and insurance-in-force for FY 2009 to FY 2014 endorsements at the end of FY 2014.

**Exhibit III-2. Estimated Survival Loan Count and Insurance-in-Force($ Millions)**

| Endorsement Fiscal Year | Net Present Value | Survival Loan Count | Insurance-in-Force |
|---|---|---|---|
| 2009 | -$3,178 | 94,318 | $24,364 |
| 2010 | -2,373 | 67,167 | 17,495 |
| 2011 | -1,321 | 64,170 | 15,633 |
| 2012 | -960 | 49,671 | 11,726 |
| 2013 | -1,372 | 57,039 | 13,869 |
| 2014 | -778 | 52,319 | 13,729 |

## B. Projected Future Economic Values and Insurance-In-Force of HECMs in the MMI Fund

In this section, we present the forecasts of the future economic values and insurance-in-force projections for MMI HECMs. We estimated these future values by applying our termination, loss rate and cash-flow models to the endorsements, which were forecasted by the HECM demand model described in Appendix E. FHA's forecast of borrower characteristics determined the loan-level composition of future endorsements.

Exhibit III-3 shows the estimated economic values of future MMI HECM books of business and the corresponding insurance-in-force.[23] All values in the exhibit are discounted to the end of each corresponding fiscal year.

[23] Note that Exhibit III-2 is the same as Exhibit II-1, reproduced in this section for convenience.

Under the stochastic simulation approach, we estimated the economic value by taking the average over 100 simulated paths. On this basis, we project the economic value of the MMI HECM portfolio to gradually increase from *negative* $1,166 million in FY 2014 to $1,036 million in FY 2021, as shown in the first column of Exhibit III-3. This increase is primarily due to the projected positive economic value brought to the Fund by new endorsements. The initial disbursement limitations and the strong housing market recovery make these newer books profitable.

With the addition of new endorsements, the total insurance-in-force is estimated to increase from $96,816 million at the end of FY 2014 to $169,995 million in FY 2021. This represents an average increase of $10,454 million per year.

**Exhibit III-3. Projected Economic Value of the HECM Portfolio in the MMI Fund in Future Years ($ Millions)**

| Fiscal Year* | Economic Value | Insurance in Force** | Volume of New Endorsements*** | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | -$1,166 | $96,816 | $13,729 | -$513 | |
| 2015 | -1,071 | 107,021 | 14,739 | 98 | -3 |
| 2016 | -794 | 112,942 | 16,381 | 290 | -13 |
| 2017 | -424 | 123,995 | 17,468 | 388 | -18 |
| 2018 | -121 | 135,241 | 18,581 | 317 | -13 |
| 2019 | 191 | 146,700 | 19,726 | 316 | -5 |
| 2020 | 591 | 158,253 | 20,869 | 393 | 8 |
| 2021 | 1,036 | 169,995 | 22,108 | 420 | 25 |

* All values, except the volume of new endorsements, are expressed as of the end of the fiscal year.

** Insurance in force is estimated as the sum of the maximum claim amounts of the remaining insured loans.

*** Projections based on the HECM demand model in Appendix E multiplied by the average MCA. This volume number in FY 2014 reflects the outstanding loans at the end of the fiscal year, and excludes loans endorsed and terminated in the same fiscal year.

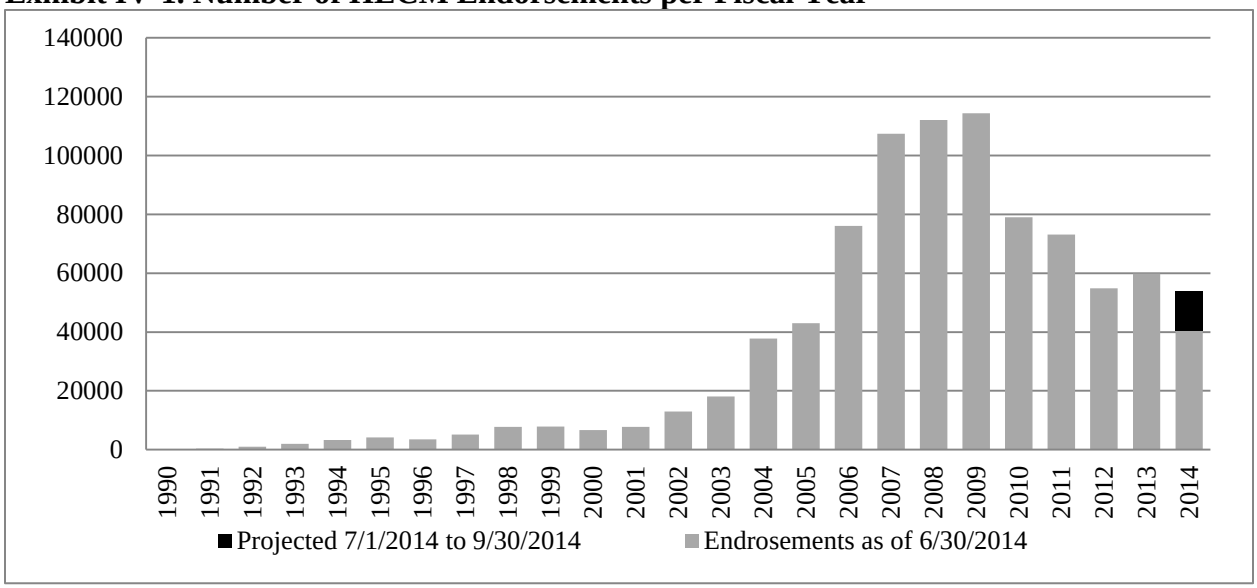
## Section IV. Characteristics of the MMI HECM Books of Business

This section presents the characteristics of the HECM portfolio for the HECM loans endorsed from FY 2009 through FY 2014. HECM loans were first included in the MMI Fund in FY 2009. The loans from these books of business that have not terminated constitute the MMI HECM portfolio as of the end of FY 2014. A review of the characteristics of these books helps define the current risk profile of MMI HECMs, which includes these books and, going forward, all future HECM books. Some of the characteristics of previous books are shown as well, to indicate trends. All data used for this analysis were provided by FHA as of June 30, 2014.

### A. Volume and Share of Mortgage Originations

FHA endorsed 40,494 HECM loans from October 1, 2013 to June 30, 2014, with a total dollar value, defined as the MCA, of $10.63 billion. FHA estimates that the total annual endorsements in FY 2014 will be 52,757 and the corresponding dollar value will be $13.86 billion. The total endorsement number of FYs 2009-2013 was 381,293. The corresponding dollar value was $97.20 billion. Since the inception of the HECM program, this program has been the largest reverse mortgage product in the U.S. market, representing the vast majority of total reverse mortgages. Exhibit IV-1 presents the count of HECM endorsements by fiscal years.

**Exhibit IV-1. Number of HECM Endorsements per Fiscal Year**



## B. Payment Types

HECM borrowers receive loan proceeds by selecting from various payment plans, *viz*., term, line of credit, tenure and combinations. Exhibit IV-2 presents the distributions of HECM endorsement over FYs 2009 and 2014 by payment plan. The line of credit and lump-sum options shown separately in the 2013 Review are combined as one category (line of credit) in this year's calculation. As of June 30, 2014, the majority of HECM borrowers selected the line of credit option. This option accounted for 93 percent of the FY 2014 endorsements.

**Exhibit IV-2. Distribution of FY 2009 to FY 2014 HECM Loans by Payment Type**

| FY | Loan Type | Term Only | Line of Credit Only | Tenure | Term + Line of Credit | Tenure + Line of Credit | Total |
|---|---|---|---|---|---|---|---|
| 2009 | Number of Loans | 1,018 | 104,539 | 1,997 | 4,315 | 2,543 | 114,412 |
| | Percentage | 0.89% | 91.37% | 1.75% | 3.77% | 2.22% | 100.00% |
| 2010 | Number of Loans | 421 | 74,277 | 815 | 2,197 | 1,345 | 79,055 |
| | Percentage | 0.53% | 93.96% | 1.03% | 2.78% | 1.70% | 100.00% |
| 2011 | Number of Loans | 331 | 68,854 | 748 | 2,014 | 1,161 | 73,108 |
| | Percentage | 0.45% | 94.18% | 1.02% | 2.75% | 1.59% | 100.00% |
| 2012 | Number of Loans | 212 | 51,756 | 580 | 1,431 | 841 | 54,820 |
| | Percentage | 0.39% | 94.41% | 1.06% | 2.61% | 1.53% | 100.00% |
| 2013 | Number of Loans | 358 | 56,639 | 733 | 1,312 | 856 | 59,898 |
| | Percentage | 0.60% | 94.56% | 1.22% | 2.19% | 1.43% | 100.00% |
| 2014 | Number of Loans | 416 | 37,575 | 824 | 971 | 708 | 40,494 |
| | Percentage | 1.03% | 92.79% | 2.03% | 2.40% | 1.75% | 100.00% |

## C. Interest Rate Type

HECM borrowers can select fixed or adjustable rate mortgages. Exhibit IV-3 shows the distribution of HECM endorsements over FYs 2009 through 2014 by interest rate type. The majority of HECM borrowers selected monthly or annually adjustable rate mortgages in FY 2009. However, the percentage of fixed-rate endorsements increased sharply from 12 percent in FY 2009 to 69 percent in FY 2010 and stabilized at 69 percent of endorsements in FYs 2011 and 2012 and climbed to 72 percent of endorsements in the first three quarters of FY 2013 (see the 2013 Actuarial Review). After that, fixed-rate HECM loans dropped sharply. In FY 2013 it dropped to 61 percent, and in FY 2014, it dropped dramatically to 17 percent.

The LIBOR-indexed loans were in the 30 to 40 percent range over FYs 2009-2013, and in FY 2014, it increased to 83 percent, as the fixed-rate option correspondingly declined in popularity.

**Exhibit IV-3. Distribution of FY 2009 to FY 2014 HECM Loans by Interest Rate Type**

| FY | Index Type Rate Type | Libor Indexed | | Treasury Indexed | | Fixed | Total |
|---|---|---|---|---|---|---|---|
| | | Annually Adjustable | Monthly Adjustable | Annually Adjustable | Monthly Adjustable | | |
| 2009 | Number of Loans | 23 | 39,574 | 697 | 60,809 | 13,309 | 114,412 |
| | Percentage | 0.02% | 34.59% | 0.61% | 53.15% | 11.63% | 100.00% |
| 2010 | Number of Loans | 7 | 24,172 | 9 | 398 | 54,469 | 79,055 |
| | Percentage | 0.01% | 30.58% | 0.01% | 0.50% | 68.90% | 100.00% |
| 2011 | Number of Loans | 8 | 23,317 | 2 | 44 | 49,737 | 73,108 |
| | Percentage | 0.01% | 31.89% | 0.00% | 0.06% | 68.03% | 100.00% |
| 2012 | Number of Loans | 3 | 16,686 | 4 | 79 | 38,048 | 54,820 |
| | Percentage | 0.01% | 30.44% | 0.01% | 0.14% | 69.41% | 100.00% |
| 2013 | Number of Loans | 2 | 23,562 | 0 | 19 | 36,315 | 59,898 |
| | Percentage | 0.00% | 39.34% | 0.00% | 0.03% | 60.63% | 100.00% |
| 2014 | Number of Loans | 111 | 33,367 | 11 | 5 | 7,000 | 40,494 |
| | Percentage | 0.27% | 82.40% | 0.03% | 0.01% | 17.29% | 100.00% |

## D. Product Type

Almost all of the loans endorsed in FY 2009 through FY 2014 are "traditional" HECMs, where the borrowers had purchased their homes prior to taking out the reverse mortgage. A HECM-for-Purchase program was introduced in January 2009. This program allows seniors to purchase a new principal residence and obtain a reverse mortgage with a single transaction. However, these HECM-for-Purchase loans represent a small portion of the total FYs 2009 through 2014 HECM endorsements, as seen in Exhibit IV-4.

**Exhibit IV-4. Distribution of FY 2009-FY 2014 HECM Loans by Product Type**

| FY | Product Type | Traditional HECMs | HECM for Purchase | | Total |
|---|---|---|---|---|---|
| | | | First Month Cash Draw >= 90% of Initial Principal Limit | First Month Cash Draw < 90% of Initial Principal Limit | |
| 2009 | Number of Loans | 113,854 | 84 | 474 | 114,412 |
| | Percentage | 99.51% | 0.07% | 0.41% | 100.00% |
| 2010 | Number of Loans | 77,666 | 199 | 1,190 | 79,055 |
| | Percentage | 98.24% | 0.25% | 1.51% | 100.00% |
| 2011 | Number of Loans | 71,570 | 326 | 1,212 | 73,108 |
| | Percentage | 97.90% | 0.45% | 1.66% | 100.00% |
| 2012 | Number of Loans | 53,193 | 390 | 1,237 | 54,820 |
| | Percentage | 97.03% | 0.71% | 2.26% | 100.00% |
| 2013 | Number of Loans | 57,810 | 102 | 1,986 | 59,898 |
| | Percentage | 96.51% | 0.17% | 3.32% | 100.00% |
| 2014 | Number of Loans | 39,177 | 305 | 1,012 | 40,494 |
| | Percentage | 96.75% | 0.75% | 2.50% | 100.00% |

## E. Endorsement Loan Counts by State

Among all endorsements over FY 2009 and FY 2014, approximately 37 percent were originated in California, Florida, Texas, and New York as measured by loan counts. California had the highest endorsement volume every year over FYs 2009 through 2014 at 13.7 percent, 14 percent, 13.5 percent, 12.7 percent, 14.1 percent, and 17.4 percent, respectively. While Florida had the second highest endorsement volume in both FY 2009 and 2010, the percentage in FY 2010 decreased by more than one-third, from 13.2 percent of the previous year to 9.0 percent. Its volume continued to drop to 6.8 percent in FY 2011. Since then, it stabilized in the range of 6-7 percent. The endorsement volume in Texas increased steadily from FY 2009 to 2011 and has been the second highest state of endorsement volume since FY 2011. The endorsement breakdown of these top four states is shown in Exhibit IV-5.

**Exhibit IV-5. Percentage of Endorsements by State for FY 2009-FY 2014 HECM Loans**

| FY | State | California | Florida | New York | Texas | Total |
|---|---|---|---|---|---|---|
| 2009 | Number of Loans | 15,658 | 15,090 | 6,084 | 7,590 | 114,412 |
| | Percentage | 13.69% | 13.19% | 5.32% | 6.63% | |
| 2010 | Number of Loans | 11,059 | 7,109 | 4,624 | 6,307 | 79,055 |
| | Percentage | 13.99% | 8.99% | 5.85% | 7.98% | |
| 2011 | Number of Loans | 9,851 | 4,971 | 4,342 | 6,671 | 73,108 |
| | Percentage | 13.47% | 6.80% | 5.94% | 9.12% | |
| 2012 | Number of Loans | 6,962 | 3,369 | 3,943 | 4,900 | 54,820 |
| | Percentage | 12.70% | 6.15% | 7.19% | 8.94% | |
| 2013 | Number of Loans | 8,424 | 3,908 | 3,807 | 5,126 | 59,898 |
| | Percentage | 14.06% | 6.52% | 6.36% | 8.56% | |
| 2014 | Number of Loans | 7,064 | 2,780 | 2,425 | 3,038 | 40,494 |
| | Percentage | 17.44% | 6.87% | 5.99% | 7.50% | |

## F. Maximum Claim Amount Distribution

The MCA is the minimum of the FHA HECM loan limit and the appraised value (or if a HECM-for-purchase, the minimum of the purchase price or appraisal). It is used as the basis of the initial principal limit determination and as the cap on the potential insurance claim amount. Exhibit IV-6 shows the distribution of HECM endorsements over FYs 2009 through 2014 by the MCA level. Approximately 64 percent of loans endorsed in FY 2009 had an MCA less than $300,000 and this percentage was approximately 66 percent for FY 2010. The number of loans with MCA less than $300,000 increased to 70 percent in FY 2011, 72 percent in FY 2012, and 71 percent in FY 2013. In FY 2014, this number dropped to 67 percent.

The percentage of endorsements with an MCA between $300,000 and $417,000 dropped from 18 percent in 2009 and was around 13 percent since then. The percentage of endorsements with an MCA greater than $417,000 is quite volatile.

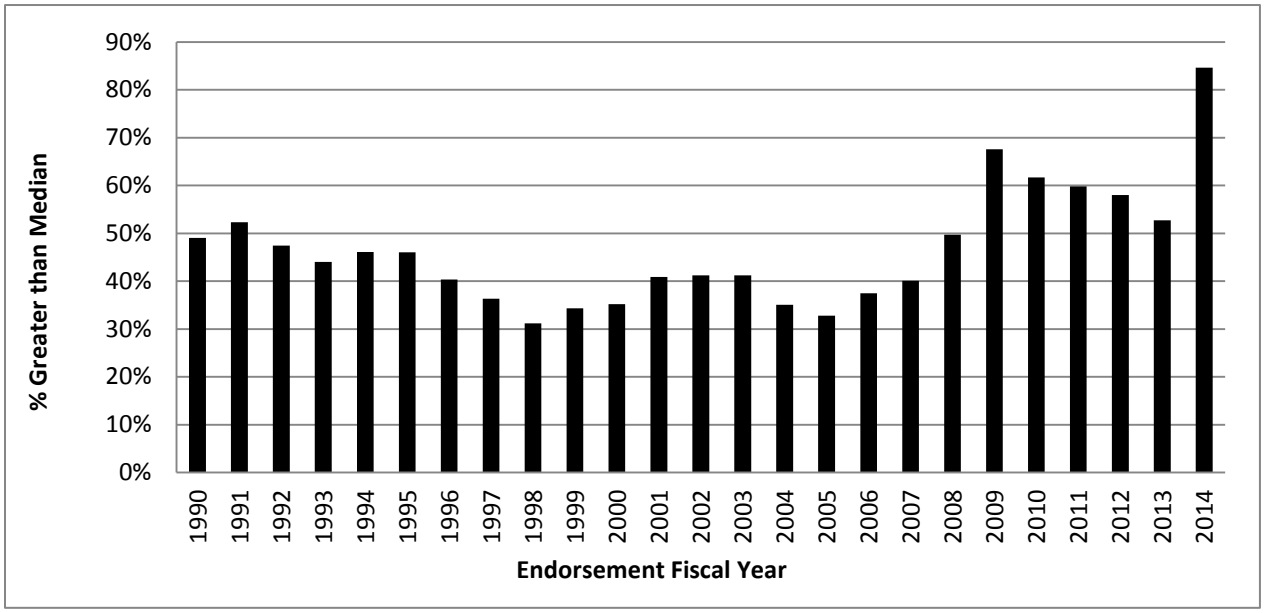
**Exhibit IV-6. Distribution of FY 2009-FY 2014 HECM Loans by MCA Level**

| FY | Less Than $100k | $100k to $200k | $200k to $300k | $300k to $417k | Greater Than $417k | Total |
|---|---|---|---|---|---|---|
| 2009 | 9.51% | 31.91% | 22.85% | 17.60% | 18.14% | 100% |
| 2010 | 12.14% | 33.95% | 19.97% | 13.82% | 20.13% | 100% |
| 2011 | 14.89% | 35.69% | 19.43% | 12.91% | 17.08% | 100% |
| 2012 | 16.11% | 36.97% | 18.75% | 12.62% | 15.55% | 100% |
| 2013 | 15.63% | 36.30% | 18.78% | 13.07% | 16.22% | 100% |
| 2014 | 12.94% | 34.15% | 19.63% | 14.01% | 19.27% | 100% |

## G. Appraised House Value

FHA research has found that loans associated with properties with an appraised value at origination greater than their area median tend to have lower home maintenance risk than those below the area median. Exhibit IV-7 shows the percentage of HECM borrowers with an appraised house value greater than the area median value. Starting with the FY 2005 book of business, there has been an upward trend in the ratio of appraised values to the area medians. The passage of the American Recovery & Reinvestment Act and HERA increased the HECM loan limit and further accelerated the upward trend as seen in FY 2009. In the FY 2009 endorsement book of business, 68 percent of the HECM properties were appraised at higher than the area median. After a small drop from FYs 2011 to 2013, this ratio suddenly increased to 85 percent.

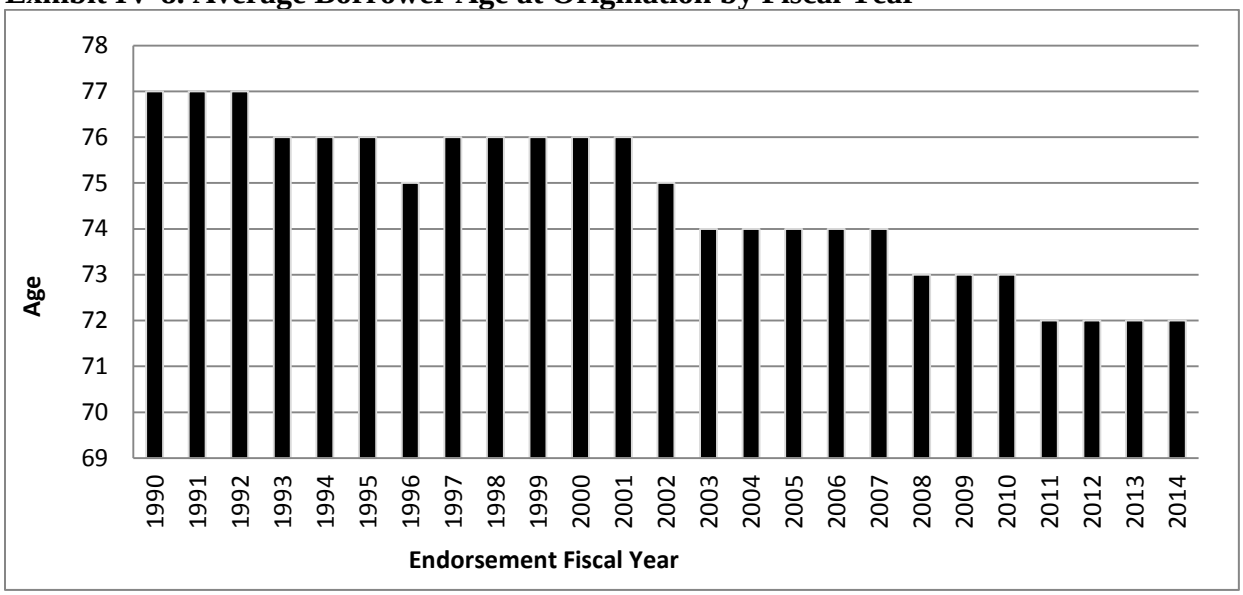
**Exhibit IV-7. Percentage of Borrowers with Appraised House Value Greater than Area Median Value**




## H. Borrower Age Distribution

The borrower age profile of an endorsement year affects loan termination rates and the percentage of initial equity available to the borrower. Exhibit IV-8 presents the average borrower age at origination from FY 1990 to 2013 endorsements (recall that only endorsements in FY 2009 and later are part of the MMI Fund). The average borrower age has declined over time. Younger borrowers are associated with a higher financial risk exposure for FHA as they have a longer life expectancy. To manage this risk, the PLFs, which limit the percentage of initial equity available to the borrower (See Section I), are lower for younger borrowers, limiting them to a smaller portion of their equity. The average borrower age was about 73 years for FYs 2009-2010 endorsements, and 72 years for FYs 2011-2014 endorsements. As HUD allows non-borrowing spouse to be younger than 62 years, it is expected the age profile will change.

**Exhibit IV-8. Average Borrower Age at Origination by Fiscal Year**




## I. Borrower Gender Distribution

Gender also affects termination behavior due to differences in mortality and possibly other factors. The gender distribution of the HECM portfolio has remained steady over time. HECM loan behavior indicates that males tend to terminate their loans the fastest, females terminate the second fastest, and couples terminate the slowest. Exhibit IV-9 presents the gender distribution of HECM endorsements from FY 2009 through 2014. Females comprise the largest gender cohort of the FY 2009 endorsements at 41 percent, followed by couples at 37 percent, and males at 22 percent. A similar distribution pattern is observed for FYs 2010, 2011 and 2012 endorsements. In FY 2013 and 2014 endorsements, couples comprise 39 percent, surpassing females to become the largest gender cohort. The female share reduced to around 38 percent while males remain the lowest at 21 percent, about the same as in prior years.

**Exhibit IV-9. Distribution of FY 2009-FY 2014 HECM Endorsements by Gender**

| Endorsement Fiscal Year | Male | Female | Couple | Missing |
|---|---|---|---|---|
| **2009** | 21.70% | 40.93% | 36.77% | 0.61% |
| **2010** | 21.48% | 41.89% | 35.26% | 1.38% |
| **2011** | 20.90% | 40.32% | 37.15% | 1.63% |
| **2012** | 21.23% | 39.17% | 37.36% | 2.25% |
| **2013** | 21.15% | 37.58% | 38.96% | 2.32% |
| **2014** | 20.50% | 38.41% | 38.94% | 2.15% |

## J. Cash Draw Distribution

Data show that loans which have drawn a higher percentage of the initial amount of equity available have a higher likelihood of refinancing. Exhibit IV-10 shows the distribution of the first-month cash draw as a percentage of the initial principal limit among different borrower age groups for HECM endorsements from FY 2009 through FY 2014.

Younger borrowers tend to draw a higher percentage of the initial amount of equity available than older borrowers. In FY 2009, 63 percent of the 62-65 age group drew over 80 percent of their initial principal limit, compared with 44 percent of the greater-than-85 years-old age group. The incidence of initial draws of above 80 percent of the principal limit rose sharply to above 70 percent over all age groups during the FYs 2010-2012 endorsements. This was mainly driven by the disproportionally high initial draws required by most fixed-rate HECMs during that period. This trend reversed dramatically in FY 2013, where only 39 percent of the 62-65 age group drew over 80 percent of the initial principal limit compared to 30 percent for greater-than-85 years-old age group. Note that the differential in the rate at which the younger group had larger first-month withdrawals diminished as well. This differential increased in the FY 2014 book. Note that the overall first-month draw over 80 percent fell from 73 percent in FY 2013 to 47 percent in FY 2014, although this trend for the most recent vintage is likely due to reporting lags, as the same phenomenon was observed last year, where the FY 2013 early withdrawal of over 80 percent was reported as 36 percent and is reported here one year later as 73 percent.

Although younger borrowers typically draw a higher percentage of the initial principal limit in the first month, the amount of cash drawn represents a smaller percentage of the MCA, because the PLF is lower for younger borrowers to account for the risk implied by their longer life expectancy.

**Exhibit IV-10. First-Month Borrower Cash Draw of FY 2009-FY 2013 HECM Endorsements as a Percentage of the Initial Principal Limit**

| Endorsement Fiscal Year | Age Group | Number of Loans | Variable Rate Loans | | | Fixed Rate Loans | |
|---|---|---|---|---|---|---|---|
| | | | 0-40% | 40-80% | 80-100% | 0-80% | 80-100% |
| 2009 | 62-65 | 20,722 | 11.84% | 24.15% | 50.40% | 0.49% | 13.13% |
| | 66-70 | 28,474 | 14.30% | 24.72% | 47.87% | 0.35% | 12.75% |
| | 71-75 | 25,386 | 18.38% | 24.99% | 44.97% | 0.28% | 11.38% |
| | 76-85 | 30,186 | 24.29% | 24.45% | 41.24% | 0.28% | 9.74% |
| | 85+ | 9,644 | 34.71% | 20.67% | 36.62% | 0.29% | 7.72% |
| | Total | 114,412 | 19.12% | 24.27% | 44.99% | 0.34% | 11.30% |
| 2010 | 62-65 | 15761 | 7.38% | 7.99% | 4.21% | 1.40% | 79.02% |
| | 66-70 | 18,813 | 8.93% | 9.62% | 4.99% | 1.15% | 75.31% |
| | 71-75 | 16,997 | 12.86% | 11.28% | 5.74% | 0.94% | 69.20% |
| | 76-85 | 20,323 | 19.44% | 13.98% | 6.58% | 0.78% | 59.21% |
| | 85+ | 7,161 | 30.96% | 14.64% | 8.38% | 0.84% | 45.19% |
| | Total | 79,055 | 14.16% | 11.23% | 5.71% | 1.03% | 67.87% |
| 2011 | 62-65 | 17,003 | 8.29% | 9.98% | 5.02% | 1.06% | 75.66% |
| | 66-70 | 18,139 | 10.58% | 10.32% | 4.75% | 1.08% | 73.27% |
| | 71-75 | 15,171 | 14.63% | 11.63% | 4.88% | 0.86% | 68.00% |
| | 76-85 | 16,788 | 21.84% | 13.59% | 5.15% | 0.91% | 58.51% |
| | 85+ | 6,007 | 35.11% | 13.15% | 5.36% | 0.60% | 45.78% |
| | Total | 73,108 | 15.49% | 11.50% | 4.98% | 0.95% | 67.08% |
| 2012 | 62-65 | 13,712 | 8.74% | 10.21% | 5.47% | 2.30% | 73.29% |
| | 66-70 | 13,782 | 10.75% | 10.25% | 4.44% | 2.29% | 72.28% |
| | 71-75 | 10,897 | 14.06% | 11.27% | 4.32% | 2.17% | 68.18% |
| | 76-85 | 11,923 | 20.36% | 12.04% | 4.78% | 2.37% | 60.44% |
| | 85+ | 4,506 | 32.49% | 12.58% | 4.93% | 1.86% | 48.14% |
| | Total | 54,820 | 14.78% | 11.03% | 4.79% | 2.25% | 67.15% |
| 2013 | 62-65 | 14,918 | 8.11% | 11.15% | 15.23% | 1.62% | 63.89% |
| | 66-70 | 15,875 | 9.92% | 11.01% | 14.95% | 1.49% | 62.63% |
| | 71-75 | 12,098 | 13.44% | 11.24% | 14.02% | 1.84% | 59.46% |
| | 76-85 | 12,648 | 19.24% | 12.88% | 13.17% | 1.61% | 53.10% |
| | 85+ | 4,359 | 30.21% | 12.30% | 10.99% | 1.74% | 44.76% |
| | Total | 59,898 | 13.63% | 11.58% | 14.17% | 1.64% | 58.99% |
| 2014 | 62-65 | 9,402 | 12.50% | 31.52% | 34.41% | 3.23% | 18.35% |
| | 66-70 | 10,925 | 15.11% | 30.90% | 34.76% | 3.10% | 16.13% |
| | 71-75 | 8,346 | 19.47% | 30.65% | 32.75% | 2.96% | 14.17% |
| | 76-85 | 8,738 | 24.70% | 32.06% | 30.09% | 3.14% | 10.03% |
| | 85+ | 3,083 | 36.52% | 29.45% | 24.62% | 3.28% | 6.13% |
| | Total | 40,494 | 19.10% | 31.13% | 32.48% | 3.12% | 14.16% |

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## Section V. HECM Performance under Alternative Scenarios

The realized economic value of HECMs will vary from the Review's estimate if the drivers of loan performance deviate from the baseline projection. In this section, we present the baseline economic value from the Monte Carlo simulation and seven alternative scenarios. The baseline case in the Review is the mean of the economic values of the MMI HECM portfolio over the 100 equally likely simulated paths. Each alternative scenario estimates the performance of the Fund under the future interest rate, unemployment rate and house price appreciation rates specific to that scenario.

The first five alternative economic scenarios were based on our 100 simulated paths, corresponding to the paths that yielded the 10th best, 25th best, 25th worst, 10th worst and the worst projected economic values. The sixth alternative path is the most stressful scenario among Moody's Analytics alternative forecasts published in July 2014, and is called the Prolonged Slump. The seventh alternative path is Moody's July 2014 baseline forecast. Here are the seven alternative scenarios: [24]

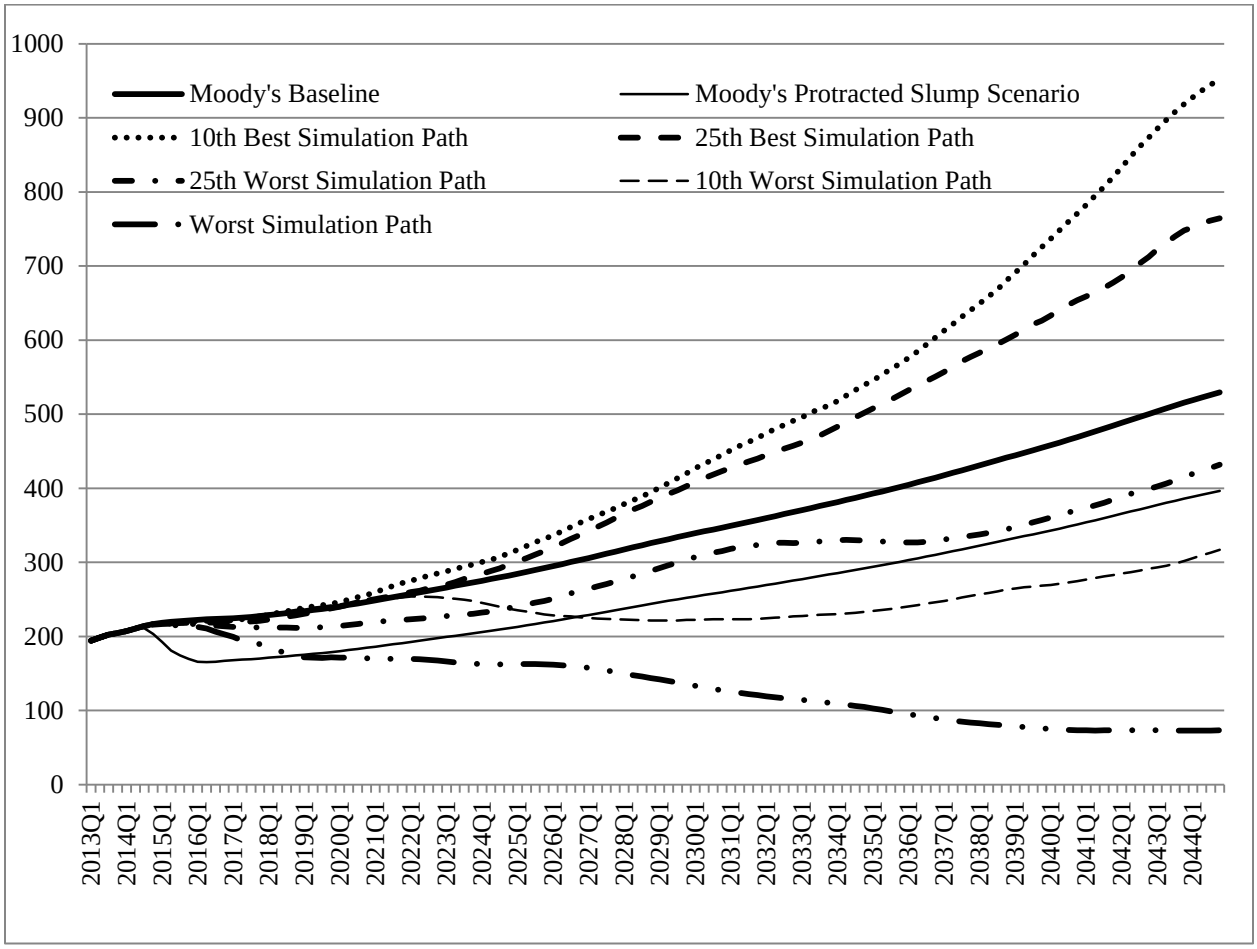
- 10th Best Path in Simulation, the path that resulted in the 10th highest economic value in the Monte Carlo simulation.
- 25th Best Path in Simulation, the path that resulted in the 25th highest economic value in the Monte Carlo simulation.
- 25th Worst Path in Simulation, the path that resulted in the 25th lowest economic value in the Monte Carlo simulation.
- 10th Worst Path in Simulation, the path that resulted in the 10th lowest economic value in the Monte Carlo simulation.
- The Worst Path in Simulation, the path that resulted in the lowest economic value in the Monte Carlo simulation.
- Moody's Protracted Slump Scenario, the most stressful alternative scenario forecasted by Moody's Analytics in July 2014.
- Moody's Baseline Scenario, as of July 2014.

Under Moody's protracted slump scenario, the levels of the house price indices converge to a long-term index level similar to its baseline forecast. As a result, this scenario shows low house price growth rates in the short-term, followed by higher growth after it passes the lowest point. We applied a similar adjustment to this methodology as we did last year, where the growth rates converge to long-run growth rates, instead of the Moody's methodology where the indices converge to their long-term levels. This adjustment avoids having the stress scenario show unusual growth after the initial stress period. As a result, the protracted slump scenario analyzed in this Review is more stressful than the original Moody's scenario. Appendix B provides more details about this adjustment.

[24] Detailed description of these alternative scenarios is presented in Appendix B.

Exhibit V-1 shows the future movements of the national-level House Price Index under Moody's baseline and the six alternative economic scenarios used in our analysis. As noted in Section I, as of last year we have changed to the Purchase-Only HPI instead of the all-transaction HPI which was used in previous Reviews.

**Exhibit V-1. Future National Purchase-Only House Price Indexes for Different Economic Scenarios**




The macroeconomic factors that serve as inputs to the HECM model include the FHFA national, state, and MSA house price indices, the unemployment rate, the one-year and ten-year Treasury rates and the one-year and ten-year LIBOR rate. Moody's house price forecasts are part of its macroeconomic model which considers local area economic environments including unemployment rates. The mortality rates were based on the 1999-2001 U.S. Decennial Life Tables published by the Center for Disease Control and Prevention published in 2004. Borrower cash-draw assumptions were based on past program experience, with adjustments to account for different borrower composition provided by FHA.

Exhibit V-2 reproduces the projected expected economic values from FY 2014 through FY 2021 from our Monte Carlo simulation. This is our baseline stochastic case. Recall that this involves taking the average of 100 randomly simulated paths.[25] The estimated economic value of the HECM portfolio in the MMI Fund at the end of FY 2014 is *negative* $1,166 million, and its economic value is projected to grow steadily to $1,036 million by the end of FY 2021.

**Exhibit V-2. Fund Performance: Baseline Monte Carlo Simulation ($ Millions)**

| Fiscal Year* | Economic Value | Insurance in Force** | Volume of New Endorsements*** | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | -$1,166 | $96,816 | $13,729 | -$513 | |
| 2015 | -1,071 | 107,021 | 14,739 | 98 | -3 |
| 2016 | -794 | 112,942 | 16,381 | 290 | -13 |
| 2017 | -424 | 123,995 | 17,468 | 388 | -18 |
| 2018 | -121 | 135,241 | 18,581 | 317 | -13 |
| 2019 | 191 | 146,700 | 19,726 | 316 | -5 |
| 2020 | 591 | 158,253 | 20,869 | 393 | 8 |
| 2021 | 1,036 | 169,995 | 22,108 | 420 | 25 |

* All values, except the volume of new endorsements, are expressed as of the end of the fiscal year.
** Insurance-in-force is estimated as the MCAs of the remaining insured loans.
*** Projections are based on the HECM demand model in Appendix E times the average MCA. This volume number in FY 2014 reflects the outstanding loans at the end of the fiscal year, and excludes loans endorsed and terminated in the same fiscal year.

The impact of each of the alternative scenarios on the performance of the HECM portion of the MMI Fund is now presented.

## A. Selected Scenarios from Monte Carlo Simulation

The Monte Carlo simulation approach provided additional information about the probability distribution of the economic value of HECM with respect to different possible future economic conditions and the corresponding prepayments and claims. In addition to the estimation of the "expected" economic value of the HECM portfolio, the simulation also provided the economic value associated with each one of the 100 possible future economic paths. In other words, the simulation is composed of 100 different scenario analyses. The distribution of economic values based on these scenarios allowed us to gain insights into the sensitivity of the Fund's economic value to different economic conditions.

Exhibit V-3 presents the projected economic values for FY 2014 through FY 2021 under six different simulated future economic paths, and two additional Moody's scenarios. The 10$^{th}$ best economic value at the end of FY 2014 is estimated to be $11,998 million. Compared with the baseline result (the mean across the 100 paths), the estimated economic value is $13,164 million higher in this scenario. There is approximately a 10 percent chance the economic conditions can be even more favorable and yield a higher economic value than $11,998 million.

[25] Note that Exhibit V-2 is the same as Exhibit II-1, reproduced in this section for convenience.

The projected economic value for FY 2014 under the 10th worst simulated path is *negative* $15,343 million. There is approximately a 10 percent probability that the actual realized economic value would be even more stressful than this path, resulting in an economic value worse than *negative* $15,343 million.

These two alternative scenarios suggest that there is an 80 percent chance that the economic value of the HECM portfolio would be between *negative* $15,343 and positive $11,998 million in FY 2014. From these two scenarios, we observe that the downside risk of HECM economic value is bit smaller than the upside potential.

Under the 25th best scenario, the HECM economic value is projected to be positive $7,736 million in FY 2014, whereas the economic value under the 25th worst scenario is projected to be *negative* $8,908 million. These two alternative scenarios suggest that there is a 50 percent chance that the economic value of the HECM portfolio would be between *negative* $8,908 million and positive $7,736 million in FY 2014. Under the worst scenario, the economic value is *negative* $33,671 million in FY 2014.

**Exhibit V-3. HECM Economic Value under Different Scenarios ($ Millions)**

| Fiscal Year | Mean Stochastic Simulation | 10th Best Path in Simulation | 25th Best Path in Simulation | 25th Worst Path in Simulation | 10th Worst Path in Simulation | The Worst Path in Simulation | Moody's Baseline Path | Moody's Protracted Slump Path |
|---|---|---|---|---|---|---|---|---|
| 2014 | -$1,166 | $11,998 | $7,736 | -$8,908 | -$15,343 | -$33,671 | -$189 | -$11,706 |
| 2015 | -1,071 | 12,995 | 8,653 | -8,861 | -17,551 | -35,701 | 271 | -11,556 |
| 2016 | -794 | 13,982 | 9,535 | -8,500 | -19,565 | -38,264 | 1,013 | -11,742 |
| 2017 | -424 | 15,080 | 10,841 | -7,960 | -20,817 | -41,354 | 1,847 | -11,670 |
| 2018 | -121 | 16,942 | 12,804 | -7,421 | -22,394 | -44,927 | 2,730 | -11,409 |
| 2019 | 191 | 19,214 | 15,050 | -6,843 | -24,276 | -49,072 | 3,706 | -11,042 |
| 2020 | 591 | 21,406 | 17,291 | -6,559 | -26,266 | -53,829 | 4,775 | -10,609 |
| 2021 | 1,036 | 24,435 | 19,240 | -5,902 | -28,222 | -59,277 | 5,943 | -10,109 |

The impact of each of the simulated scenarios on the performance of the HECM portion of the MMI Fund is presented in Exhibit V-4 to V-8.

Exhibit V-4 presents the projected economic values for FY 2014 through FY 2021 under the 10th best simulated path. This scenario results in the highest economic value among all alternative paths presented in this section. The economic values at the end of FY 2014 and FY 2021 are estimated to be positive $11,998 million and positive $24,435 million, respectively. The high economic value in this alternative path is generated by a stable and faster house price appreciation rate than Moody's baseline after FY 2016. This creates low claim losses and high recoveries. As a result, it led to the highest economic value among the six presented scenarios through FY 2020.

**Exhibit V-4. HECM Economic Value: 10th Best Simulation Path ($ Millions)**

| Fiscal Year | Economic Value | Insurance in Force | Volume of New Endorsements | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | $11,998 | $96,608 | $12,932 | $1,290 | |
| 2015 | 12,995 | 111,089 | 14,526 | 963 | 34 |
| 2016 | 13,982 | 127,075 | 16,099 | 836 | 152 |
| 2017 | 15,080 | 144,198 | 17,196 | 782 | 316 |
| 2018 | 16,942 | 162,556 | 18,438 | 1,385 | 477 |
| 2019 | 19,214 | 182,237 | 19,777 | 1,617 | 656 |
| 2020 | 21,406 | 203,098 | 20,975 | 1,403 | 789 |
| 2021 | 24,435 | 225,350 | 22,364 | 2,130 | 899 |

Exhibit V-5 presents the projected economic values for FY 2014 through FY 2021 under the 25th best simulated path. The economic values at the end of FY 2014 and at the end of FY 2021 are estimated to be positive $7,736 million and positive $19,240 million, respectively. The FY 2014 economic value under this scenario is $4,262 million less than the FY2014 economic value under the 10th best scenario. This path has higher than baseline house price appreciation before 2021, which results in higher than average FY 2014 economic value.

**Exhibit V-5. HECM Economic Value: 25th Best Simulation Path ($ Millions)**

| Fiscal Year | Economic Value | Insurance in Force | Volume of New Endorsements | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | $7,736 | $94,925 | $13,467 | $866 | |
| 2015 | 8,653 | 109,920 | 15,042 | 896 | 22 |
| 2016 | 9,535 | 126,432 | 16,620 | 780 | 101 |
| 2017 | 10,841 | 144,046 | 17,687 | 1,091 | 215 |
| 2018 | 12,804 | 162,839 | 18,880 | 1,620 | 343 |
| 2019 | 15,050 | 182,995 | 20,234 | 1,750 | 496 |
| 2020 | 17,291 | 204,519 | 21,612 | 1,623 | 618 |
| 2021 | 19,240 | 227,359 | 22,947 | 1,223 | 726 |

Exhibit V-6 presents the projected economic values for FY 2014 through FY 2021 under the 25th worst simulated path. Under this path, house prices in general appreciate at a slower rate than the baseline. Consequently, this path projects a relatively low economic value through FY 2021. The economic values at the end of FY 2014 and at the end of FY 2021 are estimated to be *negative* $8,908 million and *negative* $5,902 million, respectively.

**Exhibit V-6. HECM Economic Value: 25th Worst Simulation Path ($ Millions)**

| Fiscal Year | Economic Value | Insurance in Force | Volume of New Endorsements | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | -$8,908 | $97,197 | $14,371 | -$1,480 | |
| 2015 | -8,861 | 112,744 | 15,591 | 72 | -25 |
| 2016 | -8,500 | 129,784 | 17,140 | 465 | -104 |
| 2017 | -7,960 | 147,821 | 18,097 | 732 | -192 |
| 2018 | -7,421 | 166,869 | 19,119 | 791 | -252 |
| 2019 | -6,843 | 186,974 | 20,189 | 865 | -287 |
| 2020 | -6,559 | 208,285 | 21,390 | 565 | -281 |
| 2021 | -5,902 | 230,978 | 22,790 | 933 | -275 |

Exhibit V-7 presents the projected economic values for FY 2014 through FY 2021 under the 10th worst simulated path. Under this path, house price depreciates significantly between FY 2022 and 2027, before it rebounds moderately till 2037. As a result, the economic value under the 10th worst path projects a low economic value through FY 2021. The economic values at the end of FY 2014 and FY 2021 are estimated to be *negative* $15,343 million and *negative* $28,222 million, respectively.

**Exhibit V-7. HECM Economic Value: 10th Worst Simulation Path ($ Millions)**

| Fiscal Year | Economic Value | Insurance in Force | Volume of New Endorsements | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | -$15,343 | $96,037 | $13,261 | -$2,685 | |
| 2015 | -17,551 | 110,362 | 14,364 | -2,164 | -43 |
| 2016 | -19,565 | 126,210 | 15,948 | -1,809 | -205 |
| 2017 | -20,817 | 143,302 | 17,154 | -810 | -442 |
| 2018 | -22,394 | 161,526 | 18,300 | -919 | -659 |
| 2019 | -24,276 | 180,882 | 19,436 | -1,015 | -867 |
| 2020 | -26,266 | 201,332 | 20,525 | -994 | -997 |
| 2021 | -28,222 | 222,878 | 21,631 | -853 | -1,103 |

Exhibit V-8 presents the projected economic values as for FY 2014 through FY 2021 under the worst simulated path. This stress path has a long protracted house price decrease until FY 2040, and stays stagnant until FY 2044. This creates a severe claim loss and very low recoveries. As a result, it led to the lowest economic value by far among the 100 simulated scenarios for the whole HECM portfolio. The economic values at the end of FY 2014 and FY 2021 are estimated to be *negative* $33,671 million and *negative* $59,277 million, respectively.

**Exhibit V-8. HECM Economic Value: Worst Simulation Path ($ Millions)**

| Fiscal Year | Economic Value | Insurance in Force | Volume of New Endorsements | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | -$33,671 | $96,381 | $13,155 | -$4,793 | |
| 2015 | -35,701 | 110,345 | 14,004 | -1,936 | -94 |
| 2016 | -38,264 | 125,498 | 15,248 | -2,146 | -417 |
| 2017 | -41,354 | 141,157 | 15,714 | -2,226 | -864 |
| 2018 | -44,927 | 157,172 | 16,072 | -2,264 | -1,309 |
| 2019 | -49,072 | 173,642 | 16,544 | -2,406 | -1,739 |
| 2020 | -53,829 | 191,341 | 17,774 | -2,741 | -2,015 |
| 2021 | -59,277 | 210,367 | 19,121 | -3,188 | -2,260 |

## B. Moody's Alternative Scenarios

Exhibit V-9 presents the estimated economic value of HECM based on Moody's protracted slump economic scenario. This scenario provides a reasonableness check of the range of results obtained from the Monte Carlo simulation. The economic value at the end of FY 2014 decreases from the base case *negative* $1,166 million to *negative* $11,706 million under this alternative scenario. This is primarily due to high near-term house price depreciation which reduces the amount of recovery at termination. The FY 2021 value is about $11,144 million lower than in the baseline Monte Carlo scenario. The protracted slump scenario projects an economic value that corresponds approximately to the 5$^{th}$ worst economic value in our simulation; the projected economic values lie between those of the 10$^{th}$ and 25$^{th}$ worst path from our 100 simulated paths.

**Exhibit V-9. HECM Economic Value: Protracted Slump Scenario ($ Millions)**

| Fiscal Year | Economic Value | Insurance in Force | Volume of New Endorsements | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | -$11,706 | $96,816 | $13,729 | -$1,500 | |
| 2015 | -11,556 | 107,343 | 13,893 | 183 | -33 |
| 2016 | -11,742 | 112,404 | 14,034 | -52 | -135 |
| 2017 | -11,670 | 122,319 | 15,465 | 337 | -265 |
| 2018 | -11,409 | 133,108 | 17,233 | 630 | -370 |
| 2019 | -11,042 | 144,413 | 18,799 | 809 | -442 |
| 2020 | -10,609 | 156,255 | 20,253 | 886 | -454 |
| 2021 | -10,109 | 168,477 | 21,706 | 946 | -445 |

Exhibit V-10 presents the estimated economic value of HECM based on Moody's baseline scenario. The result is very close to the median of the Monte Carlo simulation results, as the stochastic paths are constructed by centering on the Moody's baseline scenario.

**Exhibit V-10. HECM Economic Value: Moody's Baseline Scenario ($ Millions)**

| Fiscal Year | Economic Value | Insurance in Force | Volume of New Endorsements | Economic Value of Each New Book of Business | Investment Earnings on Fund Balance |
|---|---|---|---|---|---|
| 2014 | -$189 | $96,816 | $13,729 | -$294 | |
| 2015 | 271 | 107,043 | 14,739 | 461 | -1 |
| 2016 | 1,013 | 112,865 | 16,381 | 739 | 3 |
| 2017 | 1,847 | 123,877 | 17,490 | 811 | 23 |
| 2018 | 2,730 | 135,030 | 18,608 | 824 | 58 |
| 2019 | 3,706 | 146,380 | 19,752 | 870 | 106 |
| 2020 | 4,775 | 157,948 | 20,902 | 916 | 152 |
| 2021 | 5,943 | 169,751 | 22,140 | 968 | 200 |

## Section VI. Summary of Methodology

This section summarizes the analytical approach implemented in this Review. Detailed descriptions of the component models for HECMs are provided in Appendices A-F. The following sections summarize each of these appendices.

### A. HECM Base Termination Model (Appendix A)

No repayment of principal is required on a HECM loan when the loan is active. Termination of a HECM loan typically occurs due to death, moving out, or voluntary termination via refinance or payoff. The termination model estimates the probabilities of the three mutually exclusive HECM termination events denoted as mortality, mobility and refinance. A multinomial logistic regression modeling approach is adopted to capture the competing-risk structure of the different termination events.

The termination model incorporates four main categories of explanatory variables:

- Fixed initial borrower characteristics: borrower age at origination and gender.
- Fixed initial loan characteristics: loan interest rate, origination year and quarter the first month cash draw percentage, the estimated ratio of property value to the local area's median home values at time of origination, and the estimated ratio of the local area's median home value to national loan limit at the time of origination.
- Dynamic variables based entirely on loan/borrower characteristics: loan age, updated borrower's age.
- Dynamic variables derived by combining loan characteristics with external macroeconomic data: interest rates, house price indices (which determine the cumulative house price growth), the amount of additional equity available to the borrower through refinancing and the updated loan-to-value ratio.

For each termination event type, a separate binomial logistic model is estimated based on loan-level historical HECM performance data and economic factors. The three logistic models are then aggregated to estimate the overall termination probabilities for the HECM program, following the approach developed in Begg and Gray (1984). The logistic model for each termination event is unique, including only the variables that impact the occurrence of that particular event. For example, the mobility model includes an estimate of the updated loan-to-value ratio over time to model the impact of potential gains from resale upon contemplation of moving out. The refinance model includes a refinance incentive variable. The mortality model includes the attained age of the borrower over the life of the loan and the borrower's gender for the impact of age and gender on the probability of death.

### B. Loan Performance Projections (Appendix B)

The estimated HECM future termination rates are based on the characteristics of the surviving portfolio. To estimate the economic value of the current book of business, we project termination rates for the outstanding endorsement portfolio beyond the end of FY 2014. For future books'

economic values, we also project the composition and volume of future endorsements. Each loan creates annual observations from its origin to the policy year when the loan reaches 74 years' duration, the maximum assumed duration of a HECM loan. Thus the projection period for future books last till FY 2095. The assumed characteristics of the future HECM endorsements for FY 2015 through FY 2021 are based on FHA's projections.

At the time of HECM loan termination, the borrower or the heir also has the option to convey the property to HUD, or payoff the outstanding loan balance. The decision is highly dependent on the house price at the time of loan termination, and the accrued balance. Thus both the house price appreciation and current loan to value ratio will affect the final outcome. The conveyance model is also presented in Appendix B.

### C. HECM Cash Flow Analysis (Appendix C)

The cash flow model estimates the HECM economic values for the FY 2009 through FY 2021 books of business. For the books through the FY 2014 book, the economic values are computed on the projected cash flows from the end of FY 2014. The economic values are the net present value of future cash flows for these books of business. The HECM cash flow model consists of four components: upfront and annual HECM mortgage insurance premiums, lender insurance claims before and upon assignment, note holding expenses (post-assignment) and recoveries on assigned notes in inventory. The cash flows are discounted according to the most updated Federal credit subsidy present value conversion factors.

### D. HECM Tax and Insurance Default Model (Appendix D)

HECM tax and insurance defaults are imposed by HUD when tax or insurance payments are in arrears. A binomial logistic model estimates the probability of borrower defaults on tax and insurance obligations as a function of various borrower, loan and economic characteristics. The model's implementation allows these defaults to happen before or after loan assignment. The HECM portfolio of active loans as of the end of FY 2014 has a base-case projected cumulative tax and insurance default rate of 12.04% percent.

### E. HECM Demand Model (Appendix E)

We updated the HECM demand volume model for this year's Review. This is a quarterly time series econometric model built on data of HECM loan counts, house price growth rates at the national level and the national senior population. The model predicts the number of HECM loans to be endorsed in FY 2015 through FY 2021. Without younger borrower data, the 2014 model made some reasonable assumption and included that effect. Different economic scenarios for house prices and interest rates generate different predictions of the future HECM loan counts.

### F. Economic Scenario Simulations (Appendix F)

To forecast the economic values of the MMI HECM portfolio, simulated economic scenarios were generated by a Monte Carlo stochastic model. The simulated economic scenarios were

calibrated to center around Moody's economic forecasts released in July 2014. Deterministic sensitivity analyses were also conducted to provide insights into the sensitivity of the portfolio with respect to changes in future economic conditions. The assumption of these future interest and house price growth rates are the fundamental economic factors that drive future termination rates, HECM tax and insurance default rates and the HECM demand volume in each of the stochastic simulation paths and the specified deterministic alternative scenarios.

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## Section VII. Qualifications and Limitations

The economic value estimates provided in this Review are based on the component models that were discussed in Section VI. The models make predictions about HECM-related variables and relevant market conditions that change over time in response to economic, institutional and policy changes.

### A. Basic Data Limitations

The quality of any model built on historical data is constrained by the scope, availability and accuracy of the data. Key variables determining market behavior may not be observed or they may be observed with error. Moreover, the theoretical specification of a model may not adequately capture the economic phenomena it tries to represent.

As an example of data limitations, HECM has a relatively short program history. The pilot program began in FY 1989 and became permanent in FY 1998 after endorsing 20,000 loans. The endorsements exceeded 10,000 loans per year in FY 2002 and reached 100,000 per year in FY 2007. Unlike the MMI Single Family forward mortgage program, HECM has a limited number of loans that have remained in FHA's portfolio for more than seven years. The lack of long-run performance data potentially limits the robustness of the models' predictive capacity for later policy years.

### B. Model Sensitivity to Economic Projections

The main purpose of this Review is to assess the long-term financial performance of the HECM Fund. Two of the critical economic variables used in making these projections are future house prices and interest rates. We use stochastic models to project the future distribution of house prices and interest rates and apply a Monte Carlo simulation technique. Our stochastic models are calibrated so that they are centered on Moody's July 2014 base-case economic forecast. Hence the estimated results captured the impact of future deviations from Moody's base-case projections.

The results of the alternative scenario analyses in Section V represent various selected outcomes in the projected distribution of house prices and interest rates. The estimated probabilities of economic values depend on the Monte Carlo simulation which in turn depends on our stochastic models.

### C. Changing Reverse Mortgage Market Landscape

Changes in financial markets and retirement needs will affect both the reasons why borrowers participate in the HECM program and the specifics of new product offerings. This will affect the loan characteristics and performance of future endorsements including cash draw patterns and repayment behavior. Borrower characteristics will vary with the changing demographics as the large baby boomer population transitions to retirement. Hence, the accuracy of the estimates on

the performance of future books is sensitive to the borrower composition and behavioral assumptions.

At the start of FY 2014, the current Standard and Saver products were eliminated and replaced by a single new program. The new program has a principal limit factor of 85 percent of the level of the Standard program. It reduced the allowable initial disbursement, where mortgagors are subject to an initial 12-month disbursement limitation of the greater of 60 percent of the initial principal limit or the sum of mandatory obligations that must be satisfied at closing plus an additional 10 percent of the initial principal limit, not to exceed the maximum principal limit. The existing annual MIP rate of 1.25 percent continued to be in effect. The initial MIP was changed, to be determined based on the amount of the mortgagor's initial draw at loan closing. A borrower would be charged an initial MIP of 0.50 percent of the maximum claim amount if the initial cash draw is equal to or less than 60 percent of the available principal limit. A borrower would be charged 2.50 percent of the maximum claim amount when the initial cash draw is greater than 60 percent of the available principal limit. The new origination requirements tended to defer cash outflows and increase cash inflows.

On August 4$^{th}$, 2014, HUD adjusted the HECM program by allowing non-borrowing spouse younger than 62 years old. This adjustment further reduces the PLFs, while extending the eligibility of HECM program to a larger clientele population. The effect on borrower reception and how they change their withdrawal behavior is still uncertain at this early stage.

In this Review, we have explicitly modeled the longevity improvement of HECM borrowers with endorsements between FY 1989 to 2013. However, future HECM borrowers may experience mortality uncertainty unobserved at the current time. This remains another area that could be investigated in the future.

# Appendix A

# HECM Base Termination Model

## Appendix A: HECM Base Termination Model

This appendix describes the methodology used to estimate the termination behavior of HECM loans. In this 2014 Actuarial Review we updated the methodology and the model specification from the FY 2013 HECM Review. We also updated the data and re-estimated model parameters using the updated data.

HECM loans terminate due to borrower mortality (death), loan refinancing or borrower move-outs (mobility). A multinomial logistic model is specified and estimated to capture the loan termination behavior. Pursuant to Mortgagee Letter 2011-01, HECM loans can be also terminated under foreclosure when borrowers fail to pay their real estate taxes or property insurance premiums as required by the HECM contract. Building upon the econometric model of tax and insurance (T&I) defaults constructed last year, we refined the specification of T&I defaults (discussed in Appendix D). When necessary, we distinguish the "base" termination model discussed in this appendix from the T&I default termination model described in Appendix D. To clarify another possible confusion, the HECM insurance terminates at mortgage note assignment (because then HUD owns the loan) but the HECM loan itself does not terminate at this time as the borrower continues to live in the home. Hence, note assignments were not modeled as HECM loan terminations. Also note that the HECM model is an annual model, whereas the models we use for FHA forward mortgages are quarterly.

The available FHA historical HECM termination data were used to estimate the base termination model. These data include loans that were endorsed under the General Insurance (GI) Fund between FY 1990 and FY 2008, and loans endorsed under the Mutual Mortgage Insurance (MMI) Fund in FY 2009 through the end of March of 2014. Only the loans endorsed under the MMI Fund, however, are included to determine the economic value of the MMI Fund in this Review.

### A1. The Multinomial Logistic Model

Similar to Szymanoski, DiVenti, and Chow (2000), Yuen-Reed and Szymanoski (2007) and last year's Actuarial Review of HECM loans (IFE Group 2013), a competing-risk multinomial logistic model is used to estimate the probabilities of HECM loan termination events excluding T&I default terminations.

Given survival to the beginning of time period *t*, the conditional probabilities that a loan will terminate due to mortality ( $P_D(t)$ ), refinance ( $P_R(t)$ ) or mobility ( $P_M(t)$ ) are given by:

$$P_D(t) = \frac{e^{\alpha_D + X_D(t)\beta_D}}{1 + e^{\alpha_M + X_M(t)\beta_M} + e^{\alpha_R + X_R(t)\beta_R} + e^{\alpha_D + X_D(t)\beta_D}} \quad (1)$$

$$P_R(t) = \frac{e^{\alpha_R + X_R(t)\beta_R}}{1 + e^{\alpha_M + X_M(t)\beta_M} + e^{\alpha_R + X_R(t)\beta_R} + e^{\alpha_D + X_D(t)\beta_D}} \quad (2)$$

$$P_M(t) = \frac{e^{\alpha_M + X_M(t)\beta_M}}{1 + e^{\alpha_M + X_M(t)\beta_M} + e^{\alpha_R + X_R(t)\beta_R} + e^{\alpha_D + X_D(t)\beta_D}} \quad (3)$$

The probability of remaining active during the period is simply one minus the sum of these three probabilities. The constant terms $\alpha_D$, $\alpha_R$ and $\alpha_M$ and the coefficient vectors $\beta_D$, $\beta_R$ and $\beta_M$ are parameters estimated by the multinomial logistic model. The subscripts D, R and M denote mortality, refinance and mobility, respectively. The vectors of dependent variables for predicting the conditional probability of termination due to mortality, refinance and mobility are represented by $X_D(t)$, $X_R(t)$ and $X_M(t)$, respectively. Loan and borrower characteristics as well as economic variables are included in each vector to predict HECM terminations. Some of these variables are held constant over the life of the loan while others vary over time.

To classify observed terminations among the three possible outcomes, terminations that resulted from refinancing were based on FHA's endorsement records. That is, these refinancing terminations would lead to FHA endorsement of new HECM loans. The remaining terminations were cross-referenced with the Social Security Administration's mortality data provided by FHA. If a loan terminated within one year prior to and two years after the borrower's recorded death date,[26] the loan was considered to have terminated due to death. The remaining terminations are classified as mobility terminations.

The estimation technique for the multinomial logistic equation system follows Begg and Gray (1984), who showed that it is statistically equivalent to model a multinomial logistic regression model as a special aggregation of individually estimated binomial logistic regression models. For more details, see the FY 2014 Actuarial Review (IFE Group 2014) for forward mortgages. The next subsections describe the three binomial logistic sub-models.

### A1.1. Mortality Model

The mortality model estimates the probability that a HECM loan terminates due to the death of the borrower. Social Security Administration mortality data obtained by FHA indicates the date of death of HECM borrowers. IFE Group received updated mortality data in March of 2014. Death dates were aligned with a two-year shift after and one-year shift before termination dates to determine which loans terminated due to death, in order to account for the time lag between the dates of the recorded termination and the actual death.

We used four variables to forecast death terminations: rates from actuarial mortality tables, gender, policy year and percent of the available cash draw taken in the first month.

The *Mortality* variable is used as the baseline of the mortality model. It corresponds to the gender-specific mortality rates $m_g(t)$ from the U.S. Life Table from the Center for Disease Control and Prevention (CDC). For loans with co-borrowers (couples), we created a joint mortality table, and calculated the likelihood of both borrowers not surviving up to the period. *Equation 4* below depicts the *Mortality* [*M(t)*] calculation.

26 For loans with multiple borrowers, the most recent date of death among all borrowers is used.

$$M(t)\begin{cases} m_g(t) & if\ single \\ m_b(t)|\ D_{co}(t-1)S_b(t-1) + m_{co}(t)|\ D_b(t-1)S_{co}(t-1) + m_b(t) * m_{co}(t)\ |S(t-1) & if\ couple \end{cases} \quad (4)$$

where *M(t)* represents the mortality rate at *t* ;
$m_g(t)$ represents the conditional mortality rate (gender and age specific) for borrower dying at time t based on the U.S. Census Decennial Life Table;
$m_i(t)|\ D_j(t-1)S_i(t-1)$ represents the mortality rate of borrower *i* at time *t* conditional on that borrower *j* died before time *t-1* and borrower *i* survived up to time *t-1*. The notation here is as follows. If *i= b, j=co,* and if *i=co, j=b.*; and
$m_b(t) * m_{co}(t)\ |S(t-1)$ represents the probability that both borrower and co-borrower die at time t conditional that both survived to *t-1*.

Next, we use equation 5 to transform *M(t)* into *xbetaM(t)* as the input explanatory variable for the regression:

$$xbetaM(t) = -log(\frac{1}{M(t)} - 1) \quad (5)$$

A piece-wise linear spline function was used to capture the increasing rate of mortality as the age of the borrower increases.

The HECM program now has more than 20 years of history since its inception in 1989. Mortality rates across gender and age groups have decreased during this time period. In order to capture this trend, we used various life tables from the Census to calculate the corresponding mortality rate. The life tables we used include CDC 1989-1991[27], 1999-2001, and 2009[28] mortality rates. We used the exact mortality rate for these years, and performed interpolations for the years in between. We extrapolated the mortality rate from 2009 to 2013 which covers our estimation data. For forecasts after 2014, we keep mortality assumption constant at the 2013 level for each given age.

Even though the second part of equation 4 accounts for when the last survivor dies, historical evidence shows that mortality-related HECM termination rates for couples tend to be lower than the joint mortality rate estimated in Equation 4. The dummy variable *Gender(Couple)*, which equals 1 if a couple and 0 otherwise, is designed to account for this experience.

Prior HECM experience also indicates that the likelihood of death terminations increases with policy year, controlling for borrower age induced mortality increase. A piece-wise linear spline function of time-dependent variable *PolicyYear* was used to capture variations in the trend (see the details in the next section). HECM loans have been endorsed in the past twenty-four years,

[27] U.S. Decennial Life Tables for 1989-91, From the Centers For Disease Control And Prevention/National Center for Health Statistics.
[28] Revised United States Life Tables, 2001-2009, the Centers For Disease Control And Prevention, http://www.cdc.gov/nchs/nvss/mortality/lewk3.htm

but most of the loans came from the last 11 years. Due to the limited number of loan terminations in late policy years, we restricted our sample to observations that are shorter than policy year 12.

Historical HECM experience also suggests that borrowers who experience heavier mortality than the baseline actuarial table seem to have a propensity to have a higher draw-down of their eligible draw in the first month. Therefore, the variable *CashDraw* captures this self-selection of borrowers into the HECM program. In the 2014 model, we also introduced two new dummy variables: one for Term product and the other for Term product with Line of Credit feature, in order to catch additional self-selection feature.

### A1.2. Refinance Model

Termination occurs if the loan is refinanced. The refinance model consists of three types of explanatory variables: loan age, borrower-related characteristics, and economic variables. We use loan observations with less than or equal to 18 policy years due to the limited number of observations beyond 18 years.

#### A1.2.1. Loan Age Variables for the Refinance Model

Prior HECM experience shows that the majority of refinances occur after the first few years of the loan. To capture this experience, the same *PolicyYear* as defined in the mortality model is included. The series of piece-wise linear functions for loan age are defined as follows[29]:

$$Pol\_yr1 = \begin{cases} loan\ age & if\ loan\ age \le k_1 \\ k_1 & if\ loan\ age > k_1 \end{cases}$$

$$Pol\_yr2 = \begin{cases} 0 & if\ loan\ age \le\ k_1 \\ loan\ age - k_1 & if\ k_1 < loan\ age \le k_2 \\ k_2 - k_1 & if\ loan\ age > k_2 \end{cases}$$

$$Pol\_yr3 = \begin{cases} 0 & if\ loan\ age \le k_2 \\ loan\ age - k_2 & if\ loan\ age > k_2 \end{cases}$$

where $k_1 = 3$, $k_2 = 6$ and $k_3 = 11$.

Coefficient estimates for each variable are the slopes of the line segments between each knot point. The overall generic *PolicyYear* function for the three *Pol_yr* segment is given by:

$$PolicyYear \text{ function} = Pol\_yr1 * \beta_1 + Pol\_yr2 * \beta_2 + Pol\_yr3 * \beta_3$$

29 All piece-wise linear functions for other variables are defined in a similar way. The boundary values are specified in the exhibits for each estimated model.

### A1.2.2. Borrower-Related Variables for the Refinance Model

The variables *borrower's age at origination*, *Mortality Rate*, and *Gender* are borrower characteristics in the refinance model. Historical experience suggests that older borrowers are less likely to refinance, but this propensity decreases at a decreasing rate. Similarly, borrowers of different genders also refinance at differing rates. *Gender* refers to categorical variables representing female, male, couple and missing; with female as the baseline in this model (and it is not included in the equation). Historical experience suggests that couples and males are more likely to refinance than females, holding everything else constant.

The likelihood of refinancing is also affected by the cash draw utilization of the borrower. An analysis of the data suggests that the first-month cash draw (*CashDraw1-CashDraw2*) was a positive predictor of the likelihood of future refinances. We used a piece-wise linear functions of the variable percentage cash draw.

The ratio of local area median house price to national loan limit at HECM origination is used to capture how expensive a house is compared to the national average. A high ratio indicates more dollar amount saving if borrowers chose to refinance, thus implies higher probability of refinance.

This 2014 model introduced two HPI related variables: the 2-year HPI change that captures the short term change and the current LTV that captures both HPI and UPB changes since origination.

### A1.2.3. Economic Variables for the Refinance Model

The refinance incentive measure was designed to model HECM borrowers' potential benefit of refinancing a loan. The refinance incentive measure represents the net increase in the principal limit for a borrower relative to the costs associated with refinancing. Equation 6 is the refinance incentive measure we used:

$$rfi_t\_new = \frac{\min\left(MCA_0 \times \Delta H, LoanLimit_t\right) \times PLF_t - C - PL_t}{C} \qquad (6)$$

where $MCA_0$ = Original maximum claim amount for loan at time 0

$\Delta H = \frac{HPI_t}{HPI_0}$, HPI is the FHFA house price index per MSA (or state if loans are located outside of an MSA)

$LoanLimit_t$ = FHA loan limit for time $t$

$PLF_t$ = New principal limit factor for the borrower's age and the current interest rate at time $t$

$C$ = Transaction cost to originate the refinanced loan

$PL_t$ = Gross principal limit on the original HECM loan at time $t$

We also used a piece-wise linear function of the period-by-period interest rate change (*int_change1-int_change2*) to measure the periodic refinance incentive.

At loan origination, the relative value of the property affects the future house price appreciation. Properties with higher values tend to have a larger appreciation amount in the HECM program and therefore lead to a higher probability of refinance. We used Home Value above Area Median as an indicator to measure relative house price compared with local area median house price. The local median house price data was obtained from Census at the MSA and state levels, with the most granular level available being used for each property.

### A1.3. Mobility Model

The mobility model estimates the probability that a HECM loan terminates due to the borrower moving out of the HECM property. Factors representing borrower characteristics, economic conditions, and loan-specific variables were used to define this sub-model specification. For the same reason as the refinance model, we limit our sample to loans aged less than or equal to 18 years.

#### A1.3.1. Loan Age Variables for the Mobility Model

As before, the *PolicyYear* is a series of piece-wise linear functions for loan age, but with different knot points in model of termination due to mobility.

#### A1.3.2. Borrower-related Variables for the Mobility Model

Borrower-specific characteristics are also key drivers of the likelihood of moving out. Historical experience suggests that compared with younger borrowers, older borrowers are more likely to move out, such as moving to a nursing home. We include *orig_age* to capture the borrowers' age at origination.

The *Gender_Couple*, *gender_male* and *gender_missing* refer to couple borrowers, single male borrowers and borrowers without gender information, respectively. Results show that couples are more likely to move out compared with single borrowers.

The Mortality *xbetaM(t)* of Equation 5 is used as a piece-wise gender-specific transformed mortality function that captures the borrower's mobility based on age-related issues, including health reasons, moving to a nursing home or to an assisted-living facility, or to live with their children.

Because loans with line of credit (LOC) are almost 90 percent in the HECM population, we removed this variable in the 2014 model. Instead, we added other two loan type dummy variables to capture the difference: Term HECM and loans with Term and Line of Credit. The pure Term loans seem to have mobility rates above the average and the Term loans with LOC have mobility rates below the average, which indicates self-selection effect for borrowers with different mobility preference.

### A1.3.3. Economic Variables for the Mobility Model

In order to capture HECM programs changes, we added *pre2004* to indicate whether the HECM loan was originated before CY 2004. Results show that HECM borrowers are less likely to move out if a loan is originated after year 2004.

The *Home Value vs. Area Median* variable estimates the ratio of appraised property value at origination to median value in the local (MSA or state) area. This variable reflects the higher propensity to move for borrowers whose houses have higher values.

We used updated loan-to-value ratio and house price volatility. Historical experience indicated that HECM borrowers with higher updated loan-to-value ratios tend to move out of their homes earlier than borrowers with lower loan-to-value ratios. The house price dispersion parameter estimated by FHFA was used to capture the variability among locational house price appreciation rates. The 2014 model also added the 2-year HPI change to capture the short-term effect caused by house price change.

### A1.4. Combining the Three Risks

The joint termination hazard rate can be defined as

$$P(t) = \sum_{j=1}^{3} P_j(t) \qquad (7)$$

where $P_j$ is defined in Equations 1, 2, and 3; which are estimated from the binomial logistic models and transferred to the competing risk probabilities using the Begg and Gray (1984) methodology. *P(t)* is an augmented joint conditional probability that a HECM loan will terminate due to any one of the three competing risks. These *P(t)* probabilities are calculated at the loan level and used to estimate future cash flows.

The majority of HECM loans have been endorsed in the past seven years, which limits the number of loans that have remained in FHA's portfolio for a significant amount of time. As a result of this limited seasoning experience, the accuracy of the model to predict terminations for later policy years is limited. Experience with HECMs has shown that as the borrower ages, the mortality rate increases at increasing rate and becomes the single dominant termination reason among the three possible causes.

## A2. Model Estimation Results

Exhibits A-1, A-2, and A-3 present the coefficient estimates for the parameters of the binomial logistic regression models and the goodness-of-fit statistics for the mortality, refinance, and mobility termination probabilities.

**Exhibit A-1. Mortality Termination Model Estimation Results**

| Analysis of Maximum Likelihood Estimates | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Boundary Values** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | | -3.3741 | 0.0430 | 6145.1540 | <.0001 |
| **pol_yr_d1** | **[1,2]** | 1.5058 | 0.0202 | 5570.7991 | <.0001 |
| **pol_yr_d2** | **(2,7)** | -0.0404 | 0.00279 | 209.4596 | <.0001 |
| **pol_yr_d3** | **(7, 74)** | 0.0792 | 0.00674 | 138.0927 | <.0001 |
| **Gender_Couple** | | -0.3540 | 0.0137 | 667.2878 | <.0001 |
| **mortality_d1** | **(-∞,-2]** | 0.8760 | 0.00615 | 20257.8016 | <.0001 |
| **mortality_d2** | **(-2, ∞)** | 1.1609 | 0.0190 | 3750.7859 | <.0001 |
| **pct_cashdd** | | -0.9451 | 0.0135 | 4896.8454 | <.0001 |
| **TERM** | | 0.2252 | 0.0279 | 64.9237 | <.0001 |
| **TMLC** | | 0.1471 | 0.0144 | 104.5074 | <.0001 |

| Association of Predicted Probabilities and Observed Responses | | | |
|---|---|---|---|
| **Percent Concordant** | 79.8 | **Somers' D** | 0.619 |
| **Percent Discordant** | 17.9 | **Gamma** | 0.634 |
| **Percent Tied** | 2.3 | **Tau-a** | 0.020 |
| **Pairs** | 217656933296 | **c** | 0.810 |

* Death date used in mortality calculation may be later than the actual up to two years.

**Exhibit A-2. Refinance Termination Model Estimation Results**

| Analysis of Maximum Likelihood Estimates | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Boundary Values** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | | -7.1352 | 0.1660 | 1848.3646 | <.0001 |
| **pol_yr_r1** | **[1,3]** | 0.7502 | 0.00963 | 6071.8239 | <.0001 |
| **pol_yr_r2** | **(3,6]** | -0.1417 | 0.00616 | 529.7196 | <.0001 |
| **pol_yr_r3** | **(6,11]** | -0.00903 | 0.00761 | 1.4093 | 0.2352 |
| **pol_yr_r4** | **(11,74]** | -0.2510 | 0.0271 | 85.7768 | <.0001 |
| **Orig_Age** | | -0.00476 | 0.00157 | 9.1333 | 0.0025 |
| **hp_above_med** | | 0.0447 | 0.0107 | 17.3133 | <.0001 |
| **mortality_r1** | **(-∞,-0.5]** | 0.1292 | 0.0112 | 132.8059 | <.0001 |
| **mortality_r2** | **(-0.5,+∞)** | 0.4302 | 1.1615 | 0.1372 | 0.7111 |
| **RFI_new1** | **(-∞,0]** | -0.0377 | 0.00189 | 396.1602 | <.0001 |
| **RFI_new2** | **(0,+∞)** | 0.1384 | 0.00339 | 1664.2742 | <.0001 |
| **pct_cashdd_r1** | **(0,0.7]** | 2.7798 | 0.0406 | 4691.0754 | <.0001 |
| **pct_cashdd_r2** | **(0.7,1]** | 2.0562 | 0.0649 | 1004.7354 | <.0001 |
| **int_change1** | **(-∞,0]** | 0.0881 | 0.0135 | 42.6730 | <.0001 |
| **int_change2** | **(0,+∞)** | -0.3822 | 0.0178 | 463.5182 | <.0001 |
| **limit1** | **[0,1]** | 1.9617 | 0.0226 | 7508.3378 | <.0001 |
| **limit2** | **(1,+∞)** | 0 | . | . | . |
| **Gender_Couple** | | 0.0760 | 0.0191 | 15.9309 | <.0001 |
| **Gender_Male** | | 0.0657 | 0.0151 | 18.8362 | <.0001 |
| **Gender_Missing** | | -0.2711 | 0.1039 | 6.8049 | 0.0091 |
| **LOC** | | -0.0564 | 0.0163 | 11.9061 | 0.0006 |
| **HPA_2Y_r** | | -0.1733 | 0.0525 | 10.9186 | 0.0010 |
| **CLTV1** | **[0,0.5]** | -0.5367 | 0.0645 | 69.2001 | <.0001 |
| **CLTV2** | **(0.5,0.8]** | -6.1597 | 0.0674 | 8353.4657 | <.0001 |
| **CLTV3** | **(0.8, +∞)** | -3.7387 | 0.0902 | 1716.6082 | <.0001 |

| Association of Predicted Probabilities and Observed Responses | | | |
|---|---|---|---|
| **Percent Concordant** | 77.7 | **Somers' D** | 0.598 |
| **Percent Discordant** | 17.9 | **Gamma** | 0.625 |
| **Percent Tied** | 4.4 | **Tau-a** | 0.013 |
| **Pairs** | 152184358290 | **c** | 0.799 |

**Exhibit A-3. Mobility Termination Model Estimation Results**

| Analysis of Maximum Likelihood Estimates | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Boundary Values** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | | -7.9466 | 0.1564 | 2581.6732 | <.0001 |
| **OneYrCmt_bucket1** | | 0.0227 | 0.0118 | 3.7415 | 0.0531 |
| **OneYrCmt_bucket3** | | -0.0854 | 0.0137 | 39.0534 | <.0001 |
| **pol_yr_n1** | **[1,2]** | 1.3860 | 0.0201 | 4744.6519 | <.0001 |
| **pol_yr_n2** | **(2,3]** | 0.3266 | 0.0129 | 640.3717 | <.0001 |
| **pol_yr_n3** | **(3,74]** | 0.0398 | 0.00368 | 117.0276 | <.0001 |
| **Gender_Couple** | | 0.3940 | 0.0138 | 817.0652 | <.0001 |
| **Gender_Male** | | -0.0746 | 0.0127 | 34.6342 | <.0001 |
| **Gender_Missing** | | 0.1749 | 0.0661 | 7.0129 | 0.0081 |
| **mortality_n1** | **(-∞,-6]** | -0.1155 | 0.0193 | 35.8751 | <.0001 |
| **mortality_n2** | **(-6, -0.5)** | 0.4049 | 0.0117 | 1201.9672 | <.0001 |
| **mortality_n3** | **(-0.5,+∞)** | -0.5683 | 0.5288 | 1.1548 | 0.2825 |
| **Orig_Age** | | 0.00436 | 0.00146 | 8.9419 | 0.0028 |
| **pre2004** | | 0.4283 | 0.0101 | 1790.8208 | <.0001 |
| **rel_hp** | | 0.0795 | 0.00763 | 108.5704 | <.0001 |
| **CLTV1** | **[0,0.4]** | -1.1204 | 0.0526 | 453.7347 | <.0001 |
| **CLTV2** | **(-0.4,1.0]** | -2.4670 | 0.0261 | 8942.7476 | <.0001 |
| **CLTV3** | **(-1.0,+∞)** | 0 | . | . | . |
| **sigma** | | -1.7202 | 0.1948 | 77.9407 | <.0001 |
| **hpa_2y_n1** | **(-∞,-0]** | 2.6866 | 0.0863 | 970.2003 | <.0001 |
| **hpa_2y_n2** | **(0,+∞)** | 1.5627 | 0.0513 | 927.8942 | <.0001 |

| Analysis of Maximum Likelihood Estimates | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Boundary Values** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **TERM** | | 0.1167 | 0.0252 | 21.3856 | <.0001 |
| **TMLC** | | -0.1145 | 0.0150 | 58.5925 | <.0001 |

| Association of Predicted Probabilities and Observed Responses | | | |
|---|---|---|---|
| **Percent Concordant** | 75.8 | **Somers' D** | 0.544 |
| **Percent Discordant** | 21.4 | **Gamma** | 0.559 |
| **Percent Tied** | 2.8 | **Tau-a** | 0.020 |
| **Pairs** | 249704152416 | **c** | 0.772 |

## A3. Base Termination Model Implementation

Representing the combined hazard rate, Exhibit A-4 below shows the average conditional HECM termination rates projected by our simulation models by policy year (loan age) and the endorsement fiscal year. In Exhibit A-4, shaded numbers and above are historical observed termination rates, except for FY 2014 termination year (shaded), which was estimated based on partial year observation. The Mortgage Letter 2014-12 allowed the borrowers to be as young as 18. The composition of future books projected by FHA contains borrowers as young as age 38. Correspondingly, the future book part in A-4 now extends to policy year 71.

## Exhibit A-4. HECM Termination Rates Conditional on Surviving to the Beginning of the Policy Year

| Policy Year | Endorsement Fiscal Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| 1 | 1.7% | 0.9% | 0.9% | 1.0% | 1.2% | 0.7% | 2.2% | 2.7% | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% |
| 2 | 2.9% | 3.4% | 3.1% | 4.4% | 3.0% | 5.8% | 6.9% | 7.1% | 7.4% | 7.3% | 7.3% | 7.3% | 7.4% |
| 3 | 2.9% | 3.4% | 5.0% | 4.2% | 4.5% | 10.2% | 11.2% | 11.8% | 12.0% | 11.8% | 11.9% | 12.1% | 12.0% |
| 4 | 3.2% | 4.6% | 3.8% | 4.5% | 4.6% | 9.2% | 10.3% | 11.0% | 11.1% | 11.0% | 11.2% | 11.2% | 11.2% |
| 5 | 4.6% | 3.5% | 4.4% | 4.5% | 4.2% | 8.4% | 9.5% | 10.2% | 10.4% | 10.5% | 10.5% | 10.5% | 10.5% |
| 6 | 3.7% | 4.2% | 4.4% | 4.3% | 4.1% | 7.6% | 8.6% | 9.7% | 10.0% | 9.8% | 9.9% | 9.9% | 9.9% |
| 7 | 4.7% | 4.4% | 4.4% | 4.4% | 4.1% | 7.3% | 8.5% | 9.8% | 10.1% | 9.9% | 9.9% | 9.9% | 9.9% |
| 8 | 5.1% | 4.6% | 4.6% | 4.5% | 4.2% | 7.1% | 8.5% | 9.9% | 10.2% | 10.0% | 10.0% | 10.0% | 9.9% |
| 9 | 5.3% | 4.9% | 4.8% | 4.7% | 4.4% | 7.1% | 8.5% | 10.0% | 10.4% | 10.1% | 10.1% | 10.1% | 10.0% |
| 10 | 5.7% | 5.2% | 5.1% | 4.9% | 4.6% | 7.1% | 8.5% | 10.2% | 10.6% | 10.2% | 10.2% | 10.2% | 10.1% |
| 11 | 6.1% | 5.5% | 5.4% | 5.2% | 4.9% | 7.2% | 8.6% | 10.3% | 10.7% | 10.2% | 10.2% | 10.2% | 10.1% |
| 12 | 6.4% | 5.8% | 5.6% | 5.5% | 5.1% | 7.0% | 8.1% | 9.6% | 10.1% | 9.6% | 9.6% | 9.5% | 9.4% |
| 13 | 6.8% | 6.2% | 5.9% | 5.8% | 5.5% | 7.1% | 8.0% | 9.3% | 9.7% | 9.2% | 9.2% | 9.1% | 9.1% |
| 14 | 7.3% | 6.7% | 6.4% | 6.3% | 5.9% | 7.3% | 8.0% | 9.2% | 9.5% | 9.0% | 9.0% | 9.0% | 9.0% |
| 15 | 7.9% | 7.3% | 6.9% | 6.8% | 6.5% | 7.7% | 8.2% | 9.2% | 9.5% | 9.1% | 9.1% | 9.1% | 9.0% |
| 16 | 8.6% | 8.0% | 7.5% | 7.4% | 7.1% | 8.2% | 8.5% | 9.3% | 9.7% | 9.3% | 9.3% | 9.3% | 9.2% |
| 17 | 9.4% | 8.8% | 8.2% | 8.1% | 7.8% | 8.8% | 8.9% | 9.7% | 10.0% | 9.6% | 9.6% | 9.6% | 9.5% |
| 18 | 10.3% | 9.6% | 9.0% | 8.9% | 8.6% | 9.6% | 9.4% | 10.1% | 10.4% | 10.0% | 10.1% | 10.0% | 10.0% |
| 19 | 11.3% | 10.6% | 9.9% | 9.8% | 9.5% | 10.5% | 10.1% | 10.7% | 10.9% | 10.6% | 10.6% | 10.6% | 10.6% |
| 20 | 12.4% | 11.6% | 10.9% | 10.8% | 10.6% | 11.5% | 10.9% | 11.3% | 11.6% | 11.2% | 11.3% | 11.2% | 11.2% |
| 21 | 13.6% | 12.7% | 12.0% | 11.9% | 11.7% | 12.7% | 11.8% | 12.1% | 12.3% | 12.0% | 12.0% | 12.0% | 12.0% |
| 22 | 14.9% | 14.0% | 13.3% | 13.1% | 13.0% | 14.0% | 12.8% | 13.0% | 13.1% | 12.8% | 12.9% | 12.9% | 12.8% |
| 23 | 16.4% | 15.4% | 14.7% | 14.5% | 14.4% | 15.5% | 13.9% | 13.9% | 14.1% | 13.8% | 13.8% | 13.8% | 13.8% |
| 24 | 18.0% | 17.0% | 16.2% | 16.1% | 16.0% | 17.1% | 15.2% | 15.0% | 15.1% | 14.8% | 14.9% | 14.9% | 14.9% |
| 25 | 19.8% | 18.7% | 17.9% | 17.8% | 17.7% | 18.9% | 16.5% | 16.2% | 16.3% | 16.0% | 16.1% | 16.1% | 16.1% |
| 26 | 21.8% | 20.6% | 19.8% | 19.7% | 19.6% | 20.9% | 18.0% | 17.6% | 17.6% | 17.3% | 17.4% | 17.4% | 17.4% |
| 27 | 24.0% | 22.6% | 21.9% | 21.8% | 21.8% | 23.1% | 19.6% | 19.0% | 18.9% | 18.7% | 18.8% | 18.8% | 18.8% |
| 28 | 26.4% | 25.0% | 24.2% | 24.1% | 24.1% | 25.5% | 21.3% | 20.5% | 20.4% | 20.2% | 20.3% | 20.3% | 20.3% |
| 29 | 29.0% | 27.5% | 26.8% | 26.7% | 26.7% | 28.1% | 23.0% | 22.1% | 21.9% | 21.7% | 21.8% | 21.8% | 21.8% |
| 30 | 31.8% | 30.3% | 29.6% | 29.5% | 29.6% | 31.0% | 24.7% | 23.6% | 23.4% | 23.2% | 23.3% | 23.3% | 23.3% |
| 31 | 34.9% | 33.3% | 32.6% | 32.6% | 32.7% | 34.0% | 26.4% | 25.1% | 24.9% | 24.7% | 24.7% | 24.8% | 24.8% |
| 32 | 38.2% | 36.5% | 35.9% | 35.9% | 36.0% | 37.3% | 28.0% | 26.4% | 26.1% | 25.9% | 26.0% | 26.0% | 26.1% |
| 33 | 41.6% | 40.0% | 39.3% | 39.4% | 39.5% | 40.7% | 29.4% | 27.4% | 27.1% | 27.0% | 27.0% | 27.1% | 27.1% |
| 34 | 45.2% | 43.6% | 43.0% | 43.1% | 43.1% | 44.3% | 30.5% | 28.1% | 27.8% | 27.7% | 27.7% | 27.8% | 27.8% |
| 35 | 49.0% | 47.4% | 46.8% | 46.9% | 46.9% | 48.0% | 31.2% | 28.5% | 28.2% | 28.0% | 28.1% | 28.1% | 28.1% |
| 36 | . | . | . | . | . | . | 31.6% | 28.6% | 28.3% | 28.1% | 28.2% | 28.2% | 28.2% |
| 37 | . | . | . | . | . | . | 31.6% | 28.4% | 28.2% | 28.1% | 28.1% | 28.1% | 28.1% |
| 38 | . | . | . | . | . | . | 31.6% | 28.2% | 28.0% | 27.9% | 28.0% | 28.0% | 27.9% |
| 39 | . | . | . | . | . | . | 31.4% | 28.0% | 27.8% | 27.8% | 27.8% | 27.8% | 27.7% |
| 40 | . | . | . | . | . | . | 31.3% | 27.8% | 27.7% | 27.8% | 27.7% | 27.7% | 27.6% |
| 41 | . | . | . | . | . | . | 31.3% | 27.7% | 27.7% | 27.8% | 27.6% | 27.6% | 27.5% |
| 42 | . | . | . | . | . | . | 31.4% | 27.8% | 27.7% | 27.8% | 27.7% | 27.6% | 27.6% |
| 43 | . | . | . | . | . | . | 31.5% | 28.0% | 27.9% | 28.0% | 27.8% | 27.7% | 27.8% |
| 44 | . | . | . | . | . | . | 31.8% | 28.5% | 28.4% | 28.5% | 28.3% | 28.2% | 28.2% |
| 45 | . | . | . | . | . | . | 32.5% | 29.6% | 29.4% | 29.5% | 29.3% | 29.1% | 29.2% |

| Policy Year | Endorsement Fiscal Year | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| 46 | . | . | . | . | . | . | 33.7% | 31.4% | 31.0% | 31.1% | 30.9% | 30.7% | 30.8% |
| 47 | . | . | . | . | . | . | 35.5% | 33.6% | 33.1% | 33.2% | 33.0% | 32.7% | 32.9% |
| 48 | . | . | . | . | . | . | 38.0% | 36.5% | 35.9% | 36.0% | 35.8% | 35.5% | 35.6% |
| 49 | . | . | . | . | . | . | 41.1% | 39.9% | 39.2% | 39.3% | 39.0% | 38.7% | 38.8% |
| 50 | . | . | . | . | . | . | 44.6% | 43.6% | 42.8% | 42.9% | 42.6% | 42.3% | 42.3% |
| 51 | . | . | . | . | . | . | 48.5% | 47.5% | 46.7% | 46.8% | 46.5% | 46.2% | 46.2% |
| 52 | . | . | . | . | . | . | 52.5% | 51.5% | 50.7% | 50.8% | 50.5% | 50.2% | 50.1% |
| 53 | . | . | . | . | . | . | 56.6% | 55.6% | 54.9% | 55.0% | 54.6% | 54.3% | 54.2% |
| 54 | . | . | . | . | . | . | 61.1% | 60.0% | 59.4% | 59.5% | 59.1% | 58.8% | 58.8% |
| 55 | . | . | . | . | . | . | 65.5% | 64.5% | 63.9% | 64.0% | 63.6% | 63.4% | 63.3% |
| 56 | . | . | . | . | . | . | 69.7% | 68.8% | 68.2% | 68.4% | 67.9% | 67.7% | 67.7% |
| 57 | . | . | . | . | . | . | 73.6% | 72.8% | 72.3% | 72.4% | 72.0% | 71.8% | 71.8% |
| 58 | . | . | . | . | . | . | 77.2% | 76.4% | 76.0% | 76.2% | 75.7% | 75.6% | 75.5% |
| 59 | . | . | . | . | . | . | 80.5% | 79.7% | 79.4% | 79.5% | 79.1% | 79.0% | 79.0% |
| 60 | . | . | . | . | . | . | 83.4% | 82.7% | 82.4% | 82.6% | 82.2% | 82.1% | 82.0% |
| 61 | . | . | . | . | . | . | 85.9% | 85.3% | 85.1% | 85.2% | 84.8% | 84.8% | 84.7% |
| 62 | . | . | . | . | . | . | 88.1% | 87.6% | 87.4% | 87.5% | 87.2% | 87.2% | 87.1% |
| 63 | . | . | . | . | . | . | 90.0% | 89.6% | 89.4% | 89.5% | 89.2% | 89.2% | 89.2% |
| 64 | . | . | . | . | . | . | 91.6% | 91.3% | 91.1% | 91.2% | 91.0% | 91.0% | 90.9% |
| 65 | . | . | . | . | . | . | 93.0% | 92.7% | 92.6% | 92.7% | 92.5% | 92.5% | 92.4% |
| 66 | . | . | . | . | . | . | 94.2% | 94.0% | 93.8% | 93.9% | 93.7% | 93.7% | 93.7% |
| 67 | . | . | . | . | . | . | 95.2% | 95.0% | 94.9% | 94.9% | 94.8% | 94.8% | 94.8% |
| 68 | . | . | . | . | . | . | 96.0% | 95.8% | 95.8% | 95.8% | 95.7% | 95.7% | 95.7% |
| 69 | . | . | . | . | . | . | 96.7% | 96.6% | 96.5% | 96.5% | 96.4% | 96.4% | 96.4% |
| 70 | . | . | . | . | . | . | 97.3% | 97.2% | 97.1% | 97.1% | 97.0% | 97.0% | 97.0% |
| 71 | . | . | . | . | . | . | 97.7% | 97.7% | 97.6% | 97.6% | 97.6% | 97.6% | 97.6% |

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# Appendix B

# HECM Loan Performance Projections

## Appendix B: HECM Loan Performance Projections

This appendix explains how the HECM termination model, described in Appendix A, was used to forecast future loan terminations. We briefly summarize the economic scenarios for interest rates and home prices that were used in our projections. The adjustments to home price to account for deferred maintenance are also presented below. Finally, this appendix describes how assumptions about the future cohort characteristics along with the HECM loan volume forecasts generate new loan-level endorsements for the future fiscal years 2014-2021.

### B1. General Approach to Loan Termination Projections

HECM loan termination rates are estimated for all future policy years for each surviving (active) loan. The policy year is the annual loan age and by assumption that the maximum possible policy year can be realized by any HECM loan is 74 years. To illustrate the initial conditions of the forecast, a loan endorsed in FY 2009, that is still active in FY 2014, has its first full year termination rate estimated in policy year seven since the first six policy years have already elapsed by the end of FY 2014 (the starting date of the forecast). Active loans are distinguished by the fiscal year of endorsement from FY 2009 through FY 2014. Future endorsements are generated for FY 2014 Q4 to FY 2021 as described in Section B4 below.

The variables used in the analysis are derived from loan characteristics and economic forecasts. Moody's July 2014 forecasts of interest rates and house price indices are combined with the loan-level data to simulate the stochastic economic paths and create the necessary variables. MSA-level forecasts of house price indices apply to loans in metropolitan areas; otherwise loans inherit their state-level house price index forecasts. Moody's house price forecasts are generated simultaneously with various macroeconomic variables including the local unemployment rate.

For each loan during future policy years, the derived loan variables serve as inputs to the logistic termination models described in Appendix A. The termination projections by type of termination are combined to generate conditional termination rates per policy year, representing the probability of loan termination in a policy year by different modes of termination given that it survives to the end of the prior policy year. The HECM cash flow model uses these forecasted termination rates to project the cash flows associated with different termination events.

### B2. Economic Scenarios

We used 100 simulated stochastic economic paths that are calibrated to center around Moody's baseline scenario as of July 2014 to generate our benchmark results. We also applied seven alternative economic scenarios for sensitivity analysis, including five economic paths from our stochastic simulation, the Moody's baseline as a deterministic scenario and the "Protracted Slump Scenario" suggested by Moody's economy.com as of July 2014. The economic factors include the FHFA national, state and MSA purchase-only house price indices, the national, state,

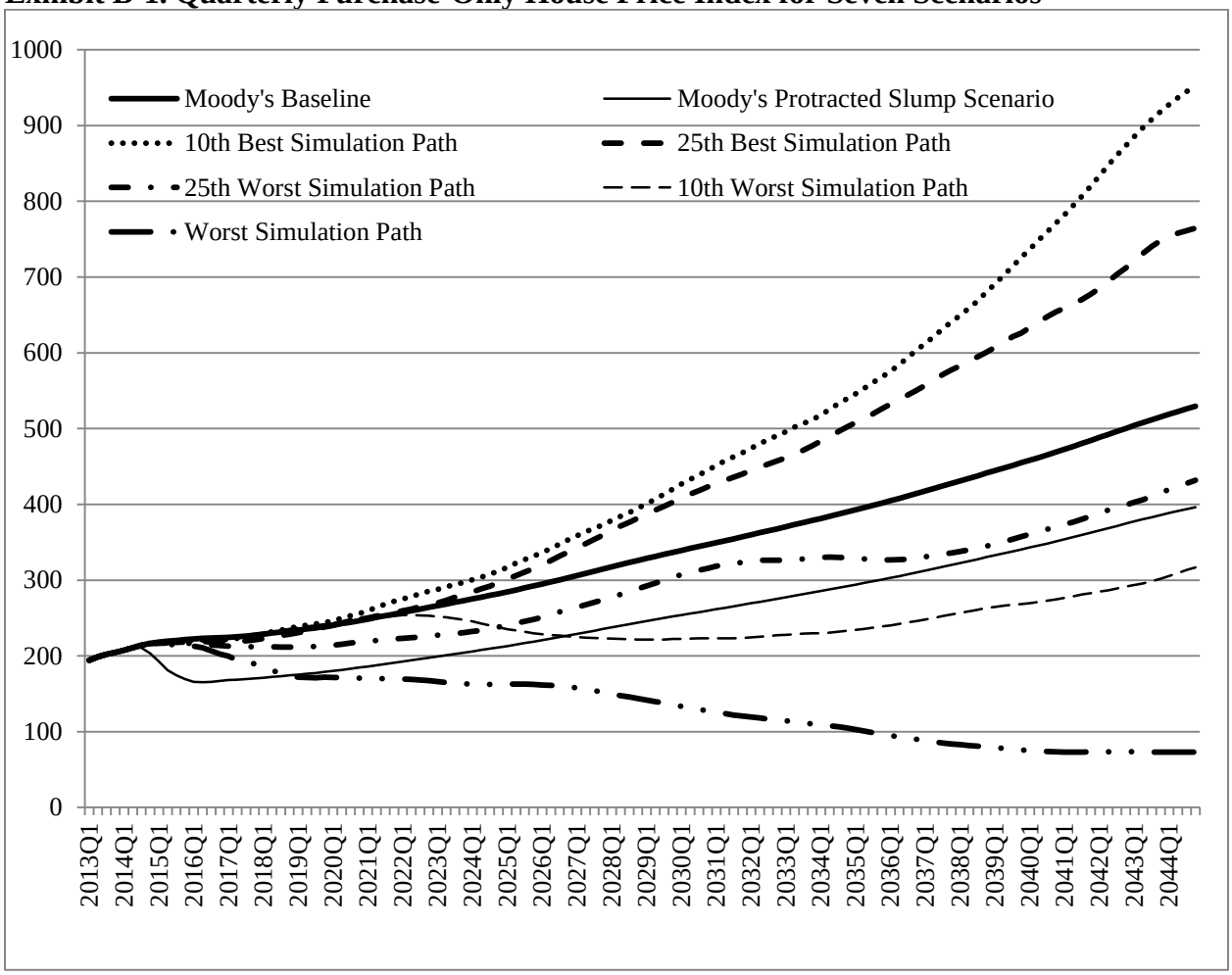
and MSA unemployment rate, the 10-year Treasury rate, the 1-year Treasury rate and the 1-year LIBOR rate.

The seven alternative scenarios are:

- Moody's July 2014 baseline as a deterministic scenario;
- 10th Best Path in the simulation, the path that resulted in the 10th highest economic value in the Monte Carlo simulation;
- 25th Best Path in the simulation;
- 25th Worst Path in the simulation, the path that resulted in the 25th lowest economic value in the Monte Carlo simulation;
- 10th Worst Path in the simulation;
- The Worst Path in the simulation, the path that resulted in the lowest economic value in the Monte Carlo simulation and
- Moody's Protracted Slump Scenario.

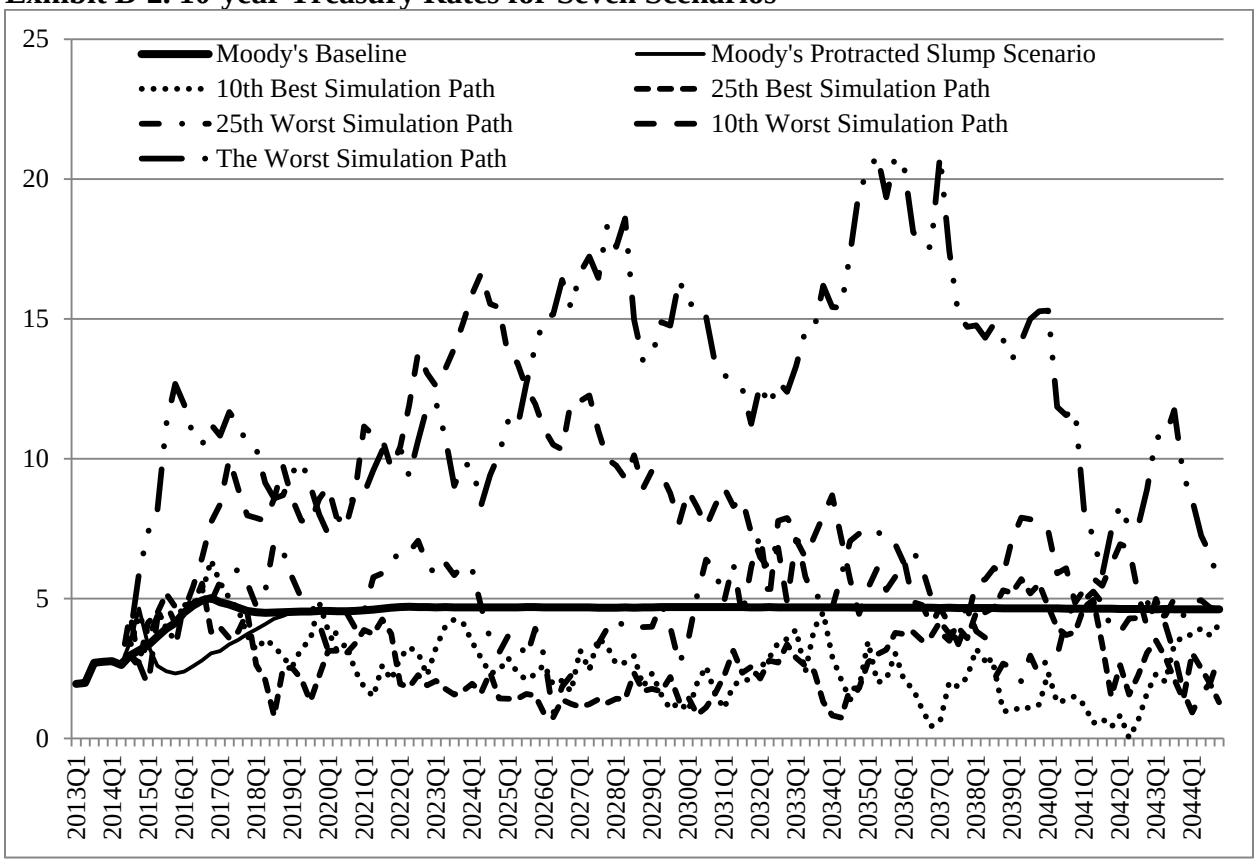
Under Moody's forecast methodology, the levels of the home price indices for any scenario converge to the base-case long-term index values. As a result, the stress scenarios show faster house price growth after the index bottoms out. As in the corresponding Actuarial Review for forward mortgages, we made an adjustment to this methodology whereby the growth rates converge to the long-run growth rates instead of converging to the base-case levels of the indices. This adjustment eliminates the stress scenarios showing a faster growth after the index bottoms out. Based on quarterly data, the graph in Exhibit B-1 illustrates the historical quarterly national house price changes and those for each of the selected scenarios above.

**Exhibit B-1. Quarterly Purchase-Only House Price Index for Seven Scenarios**




A similar chart for the 10-year constant maturity Treasury (CMT) rates appears in Exhibit B-2 below. The Federal Reserve Board has kept interest rates low for the past few years. However, due to the concern of the effectiveness of the Quantitative Easement III reduction, the long-term interest rate has increased sharply since July 2013. In Moody's alternative economic scenarios, the future paths of interest rates all rise rapidly in the near term. The one-year and ten-year LIBOR rates tend to reflect a small, positive and time-varying credit spread over Treasury rates of the same duration. The LIBOR series is not shown for brevity.

**Exhibit B-2. 10-year Treasury Rates for Seven Scenarios**




## B3. Maintenance-Risk Adjustments

Recent research on the HECM portfolio indicates the need to account for the home maintenance risk posed by HECM borrowers. Maintenance risk refers to the moral hazard that HECM borrowers may underinvest in the maintenance on their homes, especially when their anticipated equity upon termination is low or negative. First we derive the cumulative house price discount factor by using the HECM property sales price data collected from CoreLogic. The formula for the discount is

$$House\ Price\ Discount\ Factor = 1 - \frac{HP_t}{HP_0 * \frac{HPI_t}{HPI_0}} \qquad (1)$$

where $HP_t$ is the sale price of house underlying a HECM loan obtained from the CoreLogic;

$HP_0$ is the appraisal value of the same house at time of HECM loan origination;

$HPI_t$ is the local FHFA purchase-only housing price index at time *t*. We calculated the average housing price discount factor for HECM termination loans regardless of termination type. Then, we used an exponential decay function of the policy year to fit the historical average, as shown in

the formula below. Based on the work of Capone, et al. (2010), HECM loans with prices lower than the local median price tend to be less carefully maintained than those with prices above the local median. We included an indicator *hp_above_med* (i.e., the appraisal value is above the local median house price) to capture this effect.

$$House\ price\ discount\ factor\ at\ loan\ age\ t$$

$$= \begin{cases} 0.2 - 0.3 * e^{-0.2*\min(age,6)} & if\ age < 10 \\ 0.25 - 0.9 * e^{-0.2*age} & if\ age \geq 10 \end{cases} \quad if\ hp\_above\_med = 0 \qquad (2)$$

$$House\ price\ discount\ factor\ at\ loan\ age$$

$$= \begin{cases} 0.13 - 0.25 * e^{-0.35*\min(age,4)} & if\ age < 10 \\ 0.2 - 0.8 * e^{-0.2*age} & if\ age \geq 10 \end{cases} \quad if\ hp\_above\_med = 1 \qquad (3)$$

We used the above equations to project the maintenance-risk adjustment factors. The projected recovery from property disposition is computed as:

$$Estimated\ Property\ Sale\ Price = HP_0 \times \frac{HPI_t}{HPI_0} \times (1 - House\ Price\ Adjustment\ Discount\ Factor) \qquad (4)$$

And the net sale price of the property is:

*Net Property Sale Price = Estimated Property Sale Price × (1 – % sales expenses)* (5)

The maintenance-risk adjustment factors apply only to property revenue recovery at the projected HECM loan termination date.

## B4. Conveyance and Payoff Selection Model

In this year's Review, we used HECM loans terminated with payoff and conveyance type from 2005 through 2014 to analyze HECM's conveyance and payoff selection choice. There were 7,576 observations for the logistic model.

Most variables in the equation have the same specification in the termination model shown in Appendix A, with one additional variable included: the national relative unemployment rate *rel_ue_usa* which reflects macro-economic conditions that imply a higher probability of conveyance in a bad economy. The results also indicate that HECM borrowers in areas with higher house prices than the national average are more likely to pay off. For example, borrowers in California may have more incentive to keep their houses than borrowers in Texas. Also, HECM borrowers with higher appreciation in home value, with higher relative home price relative to local median price, or with lower loan-to-value ratio are less likely to convey because

of the higher possibility of retaining some equity in the house after paying off the loan balance. Older borrowers or those with higher upfront cash draws are less likely to keep the house and thus are more likely to convey. Exhibit B-3 shows the estimation results.

**Exhibit B-3. Conveyance and Payoff Selection Model Coefficients**

| Analysis of Maximum Likelihood Estimates | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Description** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | | -14.6948 | 0.9248 | 252.4847 | <.0001 |
| **pol_yr1** | loan age <=7 | 0.9240 | 0.0765 | 146.0347 | <.0001 |
| **pol_yr2** | loan age >7 | 0.3843 | 0.0183 | 441.4804 | <.0001 |
| **Orig_Age** | borrower's age at origination | 0.0940 | 0.00705 | 177.4782 | <.0001 |
| **limit1** | ratio of median local house price to national loan limit at origination <= 1 | -3.4892 | 0.1757 | 394.2873 | <.0001 |
| **rel_ue_usa** | ratio of unemployment rate to past 10y average at termination, at national level | 0.3372 | 0.1258 | 7.1885 | 0.0073 |
| **pct_cashdd** | first month cash draw | 0.8017 | 0.1146 | 48.9812 | <.0001 |
| **rel_hp** | relative house price | -1.3894 | 0.1019 | 185.7920 | <.0001 |
| **Cumulative HPI_Change** | Cumulative HPA between termination and origination | -0.0286 | 0.00149 | 368.5643 | <.0001 |
| **Cltv** | updated loan to value ratio | 2.7555 | 0.1945 | 200.6260 | <.0001 |

| Association of Predicted Probabilities and Observed Responses | | | |
|---|---|---|---|
| **Percent Concordant** | 91.7 | **Somers' D** | 0.834 |
| **Percent Discordant** | 8.3 | **Gamma** | 0.835 |
| **Percent Tied** | 0.1 | **Tau-a** | 0.413 |
| **Pairs** | 13702976 | **c** | 0.917 |

## B5. Forecasted Endorsement Volume and Portfolio Composition

Based on HECM loan data observed through June 2014, the Moody's July 2014 baseline economic forecast, and the HECM total demand count model in Appendix E, Exhibit B-4 shows forecasted HECM endorsement volumes and MCAs for FY 2015 through FY 2021. Starting in FY 2014, FHA canceled the Standard and Saver programs and introduced a new program which has an initial disbursement cap of 60 percent, and has principal limit as 85 percent of the original

Standard product. We assume that the maximum claim amount (MCA) of individual loans will grow by Moody's July 2014 forecast of national HPI from FY 2014 through FY 2021.

**Exhibit B-4. HECM Volume and MCA Projections for the FY 2014 Program and Current Program (allowing younger borrower)**

| FY | Total Average MCA | Total Count Volume | Total Dollar Volume ($m) |
|---|---|---|---|
| **2015** | $272,697 | 54,048 | $14,739 |
| **2016** | $276,684 | 59,205 | $16,381 |
| **2017** | $278,942 | 62,699 | $17,490 |
| **2018** | $283,345 | 65,672 | $18,608 |
| **2019** | $288,661 | 68,426 | $19,752 |
| **2020** | $295,036 | 70,846 | $20,902 |
| **2021** | $302,624 | 73,159 | $22,140 |

The assumptions on the age and gender distribution for FY 2015-2021 new programs were based on the distribution of the FY2014 endorsements and are shown in Exhibit B-5.

**Exhibit B-5. Future Endorsement Age and Gender Distribution**

| Current Program FYs 2015-2021 (Adjusted for Non-Borrowing Spouse) | | | | |
|---|---|---|---|---|
| Age Group | Male | Female | Couple | Row Totals |
| < 62 | 0.0% | 0.0% | 100.0% | 100.0% |
| 62 to 65 | 13.9% | 18.9% | 67.2% | 100.0% |
| 66 to 70 | 13.0% | 22.9% | 64.1% | 100.0% |
| 71 to 75 | 14.6% | 31.6% | 53.8% | 100.0% |
| 76 to 85 | 15.9% | 37.5% | 46.6% | 100.0% |
| 85+ | 22.0% | 60.8% | 17.2% | 100.0% |
| **All Ages** | **13.8%** | **27.0%** | **59.1%** | **100.0%** |

Based on recent data and expected market changes, assumptions about the future market shares of loan amortization types were projected by FHA as shown in Exhibit B-6.

**Exhibit B-6. Future Distribution of Loan Amortization Types**

| FY | Fixed Rate Loan | Variable Rate Loan |
|---|---|---|
| **2015-2021** | 20% | 80% |

Based on the distribution of FY 2014 actual cash draws, assumptions for each future cohort were projected by FHA in Exhibit B-7. These buckets represent the cash draw preferences of future

borrowers from the 3rd to the 35th policy years, without policy restrictions on upfront draw amounts. However, since predicted behavior is expected to change due to new policy mandates, borrowers are not allowed to draw more "single disbursement at origination equal to the greater of 60% of the Principal Limit, or the mandatory obligations plus 10% of the Principal Limit"[30]. in the first policy year. The mandatory draw distribution was provided by FHA. Also, we assume that the first-month cash draw equals the first-year cash draw for future cohorts for their termination and T&I projections.

**Exhibit B-7. Future Distribution of Projected Cash Draws for FYs 2015- 2021**

| Percentages | Cash draw to initial principal limit (Cash Draw Down Bucket) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Age Group** | **0%-10%** | **10%-20%** | **20%-30%** | **30%-40%** | **40%-50%** | **50%-60%** | **60%-70%** | **70%-80%** | **80%-90%** | **90%-100%** | **100%** |
| **62 to 65** | 3.3% | 1.9% | 1.9% | 2.1% | 2.3% | 2.4% | 1.9% | 1.9% | 1.7% | 3.0% | 77.7% |
| **66 to 70** | 4.2% | 2.3% | 2.4% | 2.5% | 2.4% | 2.0% | 2.0% | 1.6% | 1.5% | 2.5% | 76.5% |
| **71 to 75** | 5.4% | 3.4% | 3.1% | 2.7% | 2.6% | 2.7% | 2.2% | 1.7% | 1.3% | 2.7% | 72.2% |
| **76 to 85** | 7.9% | 5.1% | 4.3% | 3.5% | 3.1% | 2.7% | 2.5% | 1.9% | 1.3% | 2.9% | 64.7% |
| **85+** | 12.4% | 9.4% | 6.4% | 4.0% | 3.3% | 2.8% | 2.0% | 1.5% | 1.6% | 3.1% | 53.5% |
| **Weighted Column Totals** | **5.4%** | **3.4%** | **3.0%** | **2.7%** | **2.6%** | **2.4%** | **2.1%** | **1.8%** | **1.5%** | **2.8%** | **72.2%** |

The above assumptions form the basis for generating projected future HECM endorsements for FYs 2015 to 2021. We cloned recent endorsement records and updated the loan variables according to the various assumptions described above regarding the future HECM market.

[30] Mortgagee-Letter 2013-27, Department of Housing and Urban Development, September 3, 2013.

# Appendix C

# HECM Cash Flow Analysis

## Appendix C. HECM Cash Flow Analysis

This Appendix describes the calculation of the present value of future cash flows. Future cash flow calculations are based on forecasted variables, such as house price appreciation and interest rates, in addition to individual loan characteristics and borrower behavior assumptions. There are four major components of HECM cash flows: insurance premiums, claims, note holding expenses and recoveries on notes in inventory (after assignment). HECM cash flows are discounted according to the latest discount factors published by the Office of Management and Budget (OMB). These elements of cash flow and the present value calculations are described in this appendix.

### C1. Definitions

The following definitions will facilitate the discussion of HECM cash flows:

- **Maximum Claim Amount (MCA):** Maximum claim amounts are calculated as the minimum of three amounts: the HECM property's appraised value at the time of loan application, the sales price, and the national HECM FHA loan limit ($625,500 for FY 2014).

- **Insurance-In-Force (IIF):** Refers to the active loans in the FHA insurance portfolio (prior to loan assignment) and calculated as the total of their maximum claim amounts.

- **Conditional Claim Type 1 Rate (CC1R):** Among loans that terminated before note assignment, the percentage of such loans that had a shortfall. The shortfalls are labeled as claim type 1. The other terminations before assignment have zero claim amounts, corresponding to when the property value exceeds the outstanding loan balance by more than the sales transactions cost.

- **Claim Type 2 (Assignment):** When the cumulative UPB of an HECM reaches 98 percent of the MCA, the lender can assign the promissory note to FHA. FHA pays the UPB at the time of assignment to take the ownership of the note. The assignment events are labeled as claim type 2.

- **Note Holding Period:** The length of time from note assignment to loan termination. During this period, FHA takes possession of the loan, now called an assigned note, and services it until loan termination.

- **Recoveries**: The property recovery amount received by FHA at the time of note termination after assignment, expressed as the minimum of the loan balance and the predicted net sales proceeds at termination. The recovery amount for refinance termination is the loan balance.

## C2. Cash Flow Components

HECM cash flows are comprised of premiums, claims, assignment costs and recoveries. Premiums consist of upfront and annual mortgage insurance premiums, which are inflows to the HECM program. Recoveries after assignment, a cash inflow, represent cash recovered from the sale of the property once the loan terminates. Claim type 1 payments are cash outflows paid to the lender when the sale of a property is insufficient to cover the balance of the loan. Assignment claims and note holding payments are additional outflows. Exhibit C-1 summarizes the HECM inflows and outflows.

**Exhibit C-1. HECM Cash Flows**

| Cash Flow Component | Inflow | Outflow |
|---|---|---|
| Upfront Premiums | X | |
| Annual Premiums | X | |
| Claim Type 1 Payments | | X |
| Claim Type 2 (Assignment) Payments | | X |
| Note Holding Expenses | | X |
| Recoveries | X | |

We next discuss the major components and calculations associated with these HECM cash flows.

### C2.1. Loan Balance

The unpaid principal balance (UPB) is a key input to the cash flow calculations. The UPB at a given time *t* is calculated as follows:

$$UPB_t = UPB_{t-1} + Cash\ Draw_t + Accruals_t$$

The UPB for each period *t* consists of the previous loan balance plus any new borrower cash draws and accruals. The accruals include interest, mortgage insurance premiums, and servicing fees. Future borrower draws are estimated by assigning draw patterns to loans based upon the cash draws during the first two years. As noted in Appendix D, we assume that tax and insurance default terminations will accrue additional UPB at an annual rate of 2.5 percent of the estimated property value for the assumed two years between the default date and the property disposition date.

### C2.2. Premiums

Upfront and annual mortgage insurance premiums are the primary sources of FHA revenue from the HECM program. Borrowers typically finance the upfront premium when taking out a HECM loan. Similarly, the recurring annual premiums are added to the balance of the loan.

#### C2.2.1. Upfront Premiums

The upfront premium is paid to FHA at the time of loan closing. It is equal to a stated percentage of the MCA. Since FY 2009, the upfront premium rate for the Standard HECM contract has been 2 percent of the MCA. This rate remained the same for the Standard program through FY 2013. For FY 2011 to 2013, the upfront premium rate for the Saver program was 0.01 percent (1 basis point) of the MCA. For the new program to be introduced in FY 2014, the upfront premium rate will be 0.5 percent of the MCA if the first-year cash draw is less than or equal to 60 percent of the initial principal limit, and 2.5 percent of MCA if the first-year cash draw is more than 60 percent of the initial principal limit. Typically, the upfront premium is financed by the HECM lender and hence added to the loan balance. In this Review, we assume the upfront premium is paid in full to FHA at the loan closing, so it is treated as a positive cash flow.

### C2.2.2. Annual Premiums

The annual premium is calculated as a percentage of the current loan balance. For FY 2009 and FY 2010 books of business, the annual premium was 0.5 percent of the UPB. From FY 2011 and onward, the annual premium was set to 1.25 percent of the UPB for all Standard, Saver, and the new program to be introduced in FY2014. Before a loan is assigned, the annual premium is assumed to be paid to FHA and added to the accruing loan balance.

## C2.3. Claims

HECM claims consist of two types: claim type 1 and claim type 2.

### C2.3.1. Claim Type 1 (Pre-assignment)

Claim type 1 enters the HECM cash flows as payments to the lender when a property is sold and the net proceeds from the sale are insufficient to cover the balance of the loan at termination. Since the inception of the HECM program in 1989, the occurrence of claim type 1 has been rare. The losses from claim type 1 can be expressed as:

Minimum of zero and the predicted net sales proceeds at termination deducted from the unpaid loan balance, where a loan terminates before the UPB reaches 98 percent of the MCA.

### C2.3.2. Claim Type 2 (Assignment)

Lenders can assign a loan to FHA when the UPB reaches 98 percent of the MCA. FHA acquires the note resulting in a cash outflow, the acquisition cost, equal to the loan balance (up to the MCA). The majority of HECM lenders assign loans to FHA as soon as the UPB reaches 98 percent of the MCA. Thus, the HECM forecasting model assumes that the assignment occurs when the projected UPB reaches 98 percent of the MCA threshold. Based on the historical average, the cash outflow at assignment averaged at approximately 99 percent of the MCA. The net losses from claim type 2 depend on two components, the note holding expenses after assignment and recoveries from assigned notes, now discussed.

### C2.4. Note Holding Expenses after Assignment

The note holding expenses after assignments are the additional cash draws by the borrower that occur under the contract after FHA takes ownership of the note. This happens only if the total cash drawn by the borrower has not reached the maximum principal limit upon the assignment date.

### C2.5. Recoveries from Assigned Loans

At note termination for an assigned loan, the HECM loan is due and payable to FHA. The timing of loan terminations after assignment (when UPB reaches 98 percent of MCA) are projected with the termination model in Appendix A and the T&I default model in Appendix D. The amount of recovery equals the minimum of the loan balance and the predicted net sales proceeds at termination, where net sales proceeds equals the projected property value less selling expenses. For tax and insurance (T&I) defaults that occur after assignment, the dollar amount of T&I default accruals are subtracted from the recovery. In effect, FHA books the T&I arrearage through UPB accrual and then pays out the T&I arrearage at loan termination using recovered revenue. According to this convention, T&I arrearage can be viewed as additional property selling expenses.

## C3. Net Future Cash Flows

The portfolio cash flow for a HECM book of business can be computed by summing the individual components as they variously occur over time:

$$\begin{aligned} \textit{Net Cash Flow}_t = \quad & \textit{Upfront Premiums}_t + \textit{Annual Premiums}_t + \textit{Recoveries}_t \\ & - \textit{Claim Type 1s}_t - \textit{Claim Type 2s}_t - \textit{Note Holding Expenses}_t \end{aligned}$$

The discount factors applied in computing the present value of cash flows are the annual Federal credit subsidy present value conversion factors published by the Office of Management and Budget (OMB). The credit subsidy discount factors for the 2015 President's Budget reflect the most recent Treasury yield curve, which captures the Federal government's cost of capital in raising funds. These factors reflect the capital market's expectation of the consolidated interest and credit risks of the US Treasury securities. The discount factors vary depending on how far into the future a cash flow will occur. The discount factors are shown in Exhibit C-2. As an example, a cash flow occurring at the end of FY 2015 is multiplied by 0.9985 to convert it into a present value for year-end FY 2014. The discount factors used in this Review are lower than the corresponding discount factors in last year's Review.

**Exhibit C-2. OMB Discount Factors**

| Fiscal Year | Discount Factor |
|---|---|
| 2015 | 0.9972 |
| 2016 | 0.9857 |
| 2017 | 0.9639 |
| 2018 | 0.9343 |
| 2019 | 0.8995 |
| 2020 | 0.8640 |
| 2021 | 0.8292 |
| 2022 | 0.7943 |
| 2023 | 0.7594 |
| 2024 | 0.7247 |
| 2025 | 0.6914 |
| 2026 | 0.6597 |
| 2027 | 0.6295 |
| 2028 | 0.6007 |
| 2029 | 0.5733 |
| 2030 | 0.5473 |
| 2031 | 0.5224 |
| 2032 | 0.4987 |
| 2033 | 0.4761 |

| Fiscal Year | Discount Factor |
|---|---|
| 2034 | 0.4545 |
| 2035 | 0.4340 |
| 2036 | 0.4144 |
| 2037 | 0.3957 |
| 2038 | 0.3779 |
| 2039 | 0.3609 |
| 2040 | 0.3447 |
| 2041 | 0.3292 |
| 2042 | 0.3145 |
| 2043 | 0.3004 |
| 2044 | 0.2870 |
| 2045 | 0.2741 |
| 2046 | 0.2619 |
| 2047 | 0.2501 |
| 2048 | 0.2389 |
| 2049 | 0.2283 |
| 2050 | 0.2180 |
| 2051 | 0.2083 |
| 2052 | 0.1990 |

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# Appendix D

# HECM Tax and Insurance Default Model

## Appendix D: HECM Tax and Insurance (T&I) Default Model

This Appendix presents the tax and insurance default model. In Section D1 we provide some background information. Section D2 describes the data and provides summary descriptive statistics. Section D3 introduces the model and provides parameter estimates and other statistics. Section D4 describes various aspects of model implementation. Section D5 reports the projected cumulative lifetime T&I default rates by endorsement year cohorts.

### D1. Background

In Mortgagee Letter (ML) 2011-01, FHA announced that HECM loans with tax or insurance (T&I) delinquencies are considered due and payable, and therefore subject to foreclosure if they do not comply with repayment plans. Through impacts on termination speeds and recovery rates, this ruling has the potential to impact the economic value of the HECM program. We developed a methodology for treating HECM T&I defaults in the 2011 Actuarial Review, and the 2014 T&I default model is based on the same methodology.

### D2. Data

FHA's data bases identify which HECM loans have had episodes of T&I delinquency. Some of these loans may terminate through foreclosure pursuant to ML 2011-01 or for other reasons, and some may cure. For purposes of this analysis, "default" is defined as a T&I delinquent loan not making any partial T&I repayments over a 12-month consecutive period. Correspondingly, a loan can stay in delinquency as long as a partial repayment is made in any 12-month window period. A T&I delinquent loan is cured only when the T&I debt is paid in full by the borrower. Under this definition of T&I default, a loan that owes $1,000 T&I in month 1 will not be considered in default if this borrower makes a $10 repayment within the next 12 months. However, if this borrower makes a $10 repayment in month 5, but does not make any additional repayments until month 20, this loan will be considered in default at month 17, after 12 months of no repayments. T&I default is defined as the terminal status. A binomial logistic regression estimates the probability of a T&I default as a function of various explanatory variables.

We processed the HECM loan data provided by FHA to create a unique record for each loan/activity-year combination. In order to build the predictive model, we obtained the following static loan attributes for the entire active HECM loan universe as of March 31, 2014: loan type (line of credit or other); borrower age at origination; borrower gender; origination date; initial month cash drawdown as a percentage of the maximum allowable draw, whether the property is located in the two states with highest HECM concentration (California and Texas), an indicator of whether the home value at origination was above or below the local area median value; and loan age. In the 2014 model, we added the current LTV which further improves the in-sample fit.

### D2.1. Variable Definitions

We used the following variable specifications in our regression analysis:

**timeDfltAny** = 1 when the loan reaches 12 months delinquency status during the year with no partial repayments; = 0 if not delinquent or fully cured, partially repaid delinquent, or delinquent less than 12 months during the year. (Dependent variable)

**pct_cashdd =** the percentage of cash drawdown to the maximum allowed amount in the first month of loan origination. The model uses a linear spline function, with a cutpoint of 90%. For the new program starting from FY 2014, we assumed the first-year cash draw percentage is the same as the first-month cash draw percentage.

**Orig_Age =** borrower age at origination.

**LOC =** 1 if product type is line of credit; 0 otherwise.

**Single_Female** = 1 if single female borrower; 0 otherwise

**Single_Male** = 1 if single male borrower; 0 otherwise

**Gender_Missing** = 1 if borrower's gender is missing; 0 otherwise

**stateCA/stateTX** = 1 if collateral property is in California/Texas; 0 otherwise.

**Relative house price to median** = home value to local area median home value at origination.

**PolicyYear =** current loan age in years. Spline function is applied on this variable.

**LTV_Current** = current UPB divided by the estimated current property value, capped at 1.

### D2.2. Descriptive Statistics

Exhibit D-1 shows selected statistics for the estimation sample dataset. Also, 14.6 percent of HECM loans have had a T&I delinquency history, among which 39 percent are currently in default.

**Exhibit D-1. Descriptive Statistics of Active Loans**

| Variable | Number of Observations | Mean | Standard Deviation |
|---|---|---|---|
| Ever in Default | 93,422 | 0.392 | 0.488 |
| Default Policy Year | 36,655 | 3.585 | 1.625 |
| Percent Cash Draw Down | 641,141 | 0.708 | 0.306 |
| Original Age | 641,141 | 71.744 | 7.024 |
| LOC | 641,141 | 0.909 | 0.288 |
| Gender_Male | 641,141 | 0.185 | 0.388 |
| Gender_Female | 641,141 | 0.404 | 0.491 |
| Gender Missing | 641,141 | 0.007 | 0.082 |
| State CA | 641,141 | 0.156 | 0.363 |
| State TX | 641,141 | 0.071 | 0.257 |
| Relative house price to median | 641,141 | 1.210 | 0.657 |

## D3. T&I Default Model

The T&I default model was estimated based on the data extract from the FHA database as of the end of March 2014. All active loans endorsed in FY 2001 and later still active in the portfolio were included in the estimation sample. Endorsements prior to FY 2000 are excluded because of data limitations. Regression results are presented below in Exhibits D-.

**Exhibit D-2. Maximum Likelihood Estimates of the T&I Default Model**

| Analysis of Maximum Likelihood Estimates | | | | | |
|---|---|---|---|---|---|
| **Parameter** | **Boundary Values** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** |
| **Intercept** | | -7.6119 | 0.0823 | 8554.2241 | <.0001 |
| **pct_cashdd1** | **(0, 0.9)** | 1.6597 | 0.0390 | 1813.8371 | <.0001 |
| **pct_cashdd2** | **(0.9,∞)** | -13.4749 | 0.2643 | 2599.2964 | <.0001 |
| **Orig_Age** | | -0.0126 | 0.000852 | 218.6111 | <.0001 |
| **LOC** | | 0.8307 | 0.0427 | 377.7318 | <.0001 |
| **Gender_Female** | | 0.7226 | 0.0135 | 2877.8697 | <.0001 |
| **Gender_Male** | | 0.7881 | 0.0153 | 2641.9491 | <.0001 |
| **gender_missing** | | 0.4048 | 0.0927 | 19.0903 | <.0001 |
| **stateCA** | | -0.6294 | 0.0189 | 1112.7755 | <.0001 |
| **stateTX** | | 0.6923 | 0.0178 | 1504.8567 | <.0001 |
| **rel_hp** | | -0.1311 | 0.0120 | 120.1776 | <.0001 |
| **pol_yr1** | **(1,2)** | -0.2301 | 0.0145 | 252.5490 | <.0001 |
| **pol_yr2** | **(2,3)** | -0.5738 | 0.0150 | 1467.6291 | <.0001 |
| **pol_yr3** | **(3,+∞)** | -0.3652 | 0.00645 | 3209.5901 | <.0001 |
| **CLTV** | | 4.0452 | 0.0449 | 8109.4191 | <.0001 |

| Association of Predicted Probabilities and Observed Responses | | | |
|---|---|---|---|
| **Percent Concordant** | 77.4 | **Somers' D** | 0.577 |
| **Percent Discordant** | 19.6 | **Gamma** | 0.595 |
| **Percent Tied** | 3.0 | **Tau-a** | 0.015 |
| **Pairs** | 99024215600 | **c** | 0.789 |

Based on the regression results in Exhibit D-2, borrowers with a larger initial cash draw exhibit a higher default propensity than those with a lower initial cash draw. However, the default propensity is reduced if the initial cash draw is greater than 90 percent of the allowed draw, which were mostly among fixed-rate borrowers. Default risk is higher in Texas, and lower in California, other things equal. Default is a decreasing function of elapsed time from origination. Default propensity is lower among those with home prices above the area median. Single borrowers of either gender are more likely to default compared to the omitted category representing mainly couples.

## D4. T&I Default Model Implementation

We forecast T&I default behavior using the T&I binomial logistic default model derived above. A T&I default can happen in a future year only if the loan survives to the end of that year. Thus, the base termination model described in Appendix A takes sequential precedence over the T&I default termination model. For the loss severity, we assume that T&I defaults will accrue delinquent UPB at an annual rate of 2.5 percent of the then-property value. We also assume a fixed two-year period will elapse between the T&I default event and the subsequent property disposition.

### D4.1. Treatment of HECM loans in T&I default at the start of the forecast

We assume that active HECM loans already meeting the default definition, i.e., at any point of time a loan with 12 or more months of delinquency history without any repayment, will be resolved through involuntary termination. There were 36,655 such loans as of March 31, 2014. In view of the two-year disposition time assumption, these defaulted loans were treated as if defaults occurred in FY 2014 and the dispositions are assumed to occur in FY 2016. Thus, during the simulation, the T&I default model was not further applied to these loans.

### D4.2. Forecast implementation of T&I default model for the at-risk population

Delinquent loans meeting the cure definition, uncured delinquencies with less than one year of delinquency history, loans with no delinquency history and future endorsements are all treated as part of the "at risk" population for future T&I default. We start by applying the default model to determine the likelihood of default of each loan in each future fiscal year. Each loan is randomly assigned to either default or not default according to the computed probability of default. Once a loan is flagged as a default, we set the effective date of property disposition 2 years into the future.

## D5. Summary Forecast Results

To quantify the implementation of the model, the annual T&I default probabilities were forecasted for all active loans at the end of June 30, 2014 for all remaining years of the 74-year limit assumed for every HECM loan. The resultant cumulative lifetime T&I default rates by historical fiscal years of endorsement for the active loans appear in the Exhibit D-3 below. The

results include loans meeting the default definition as of June 30, 2014). The projected T&I default rate indicates a lower default rate for recent cohorts, owing in part to their limited time since endorsement and the more favorable housing market (HPA) they have experienced.

**Exhibit D-3. Lifetime T&I Default Rates for the Current Portfolio by Endorsement Year**

| Fiscal Year of Endorsements | HECM Loan Count | Lifetime T&I Default Rate |
|---|---|---|
| 1990 | 3 | 0.00% |
| 1991 | 13 | 0.00% |
| 1992 | 48 | 0.01% |
| 1993 | 98 | 3.06% |
| 1994 | 237 | 0.14% |
| 1995 | 249 | 0.80% |
| 1996 | 264 | 0.82% |
| 1997 | 434 | 3.18% |
| 1998 | 767 | 8.78% |
| 1999 | 1066 | 11.78% |
| 2000 | 858 | 12.71% |
| 2001 | 1,351 | 15.69% |
| 2002 | 3,109 | 15.47% |
| 2003 | 6,233 | 12.95% |
| 2004 | 15,058 | 15.47% |
| 2005 | 23,360 | 15.23% |
| 2006 | 50,603 | 14.42% |
| 2007 | 80,883 | 16.03% |
| 2008 | 90,039 | 16.58% |
| 2009 | 94,342 | 15.51% |
| 2010 | 67,199 | 13.10% |
| 2011 | 64,191 | 9.02% |
| 2012 | 49,682 | 6.65% |
| 2013 | 57,424 | 2.96% |
| 2014 | 40,226 | 2.04% |
| **Total** | **647,737** | **12.04%** |

*2014 endorsements through 6/30/2014

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# Appendix E
# HECM Demand Model

# Appendix E. HECM Demand Model

## E1. Background

The Actuarial Review requires forecasting future borrower demand for HECM loans for the FYs 2015 - 2021 in order to project future economic values of the MMI HECM portfolio. The HECM demand forecasting model was designed to respond to different future economic scenarios for house prices, and has a quarterly frequency. Since the HECM analysis uses an annual frequency, the quarterly projections are aggregated to an annual basis.

## E2. Data

The HECM demand model predicts demand by loan counts, not dollar volumes. Quarterly forecast for the FHFA purchase-only repeat-sales home price indices were based on Moody's Analytics July 2014 forecasts.

HECM demand depends on the number of eligible senior homeowners who might choose to borrow from the program. To proxy this demographic demand driver, historical estimates and future forecasts of the U.S. population aged 62 years and older were obtained from the U.S. Census Bureau's website:

*http://www.census.gov/population/projections/data/national/2012.html.*

The most recent year for which this data is available is 2012. The census forecast of future senior population had an annual instead of quarterly frequency. We applied linear interpolation to fill in quarterly observations. Although HECM model is on an annual basis, we use quarterly data here in order to have enough observation points to support the estimation of a time series model.

The number of quarterly observations used in the regression was 45 (FY 2003 Q2 to FY 2014 Q2), reflecting data availability and taking into account the lags used in connection with the explanatory variables. The forecasted data cover FYs 2014 Q3 through FY 2021 Q4 to encompass the new endorsements during FYs 2015-2021. Forecasts for FYs 2014 Q3 and 2014 Q4 are needed to update the HECM insurance portfolio base to end of FY 2014. Exhibit E-1 summarizes the input data for the demand model.

In this FY 2014 Review, the newly eligible younger borrowers introduce extra complications. Because this policy starts effective from August 4, 2014, we do not have historical data to do the analysis. We assumed that single borrower numbers will not change under the new policy. From historical data, we estimate the share attributed to couple is about 37.2% by a zero-intercept linear regression. We assume that the number of couple borrowers would increase 10 percent or 3.72 percent due to this policy change.

## Exhibit E-1. Input Data for the Demand Model

| Period | HECM Loan Count | Couple | US. Pop>= 62 Years Old | HPI Index |
|---|---|---|---|---|
| 2003Q1 | 3663 | 1341 | 42,543,076 | 169 |
| 2003Q2 | 4,999 | 1,928 | 42,828,724 | 171 |
| 2003Q3 | 5,843 | 2,212 | 43,006,256 | 175 |
| 2003Q4 | 7116 | 2632 | 43,184,524 | 179 |
| 2004Q1 | 9882 | 3545 | 43,338,700 | 183 |
| 2004Q2 | 9,823 | 3,514 | 43,444,736 | 187 |
| 2004Q3 | 10,956 | 3,993 | 43,599,840 | 192 |
| 2004Q4 | 9,425 | 3,477 | 43,755,500 | 197 |
| 2005Q1 | 11,781 | 4,439 | 43,923,080 | 202 |
| 2005Q2 | 9,129 | 3,553 | 44,115,412 | 207 |
| 2005Q3 | 12,707 | 4,862 | 44,284,368 | 212 |
| 2005Q4 | 14,730 | 5,802 | 44,453,972 | 217 |
| 2006Q1 | 18,337 | 7,217 | 44,628,464 | 220 |
| 2006Q2 | 22,434 | 8,749 | 44,813,524 | 222 |
| 2006Q3 | 20,597 | 7,840 | 44,989,424 | 223 |
| 2006Q4 | 23,967 | 9,001 | 45,166,016 | 224 |
| 2007Q1 | 29,007 | 10,615 | 45,491,776 | 225 |
| 2007Q2 | 27,328 | 10,382 | 46,125,232 | 225 |
| 2007Q3 | 27,111 | 9,974 | 46,457,912 | 222 |
| 2007Q4 | 24,647 | 9,087 | 46,792,992 | 218 |
| 2008Q1 | 30,480 | 11,083 | 47,113,548 | 213 |
| 2008Q2 | 28,663 | 10,188 | 47,406,636 | 208 |
| 2008Q3 | 28,255 | 9,530 | 47,731,396 | 203 |
| 2008Q4 | 27,557 | 9,566 | 48,058,380 | 197 |
| 2009Q1 | 30,073 | 13,005 | 48,355,036 | 196 |
| 2009Q2 | 28,617 | 10,882 | 48,591,744 | 193 |
| 2009Q3 | 28,162 | 10,408 | 48,891,692 | 192 |
| 2009Q4 | 24,773 | 8,995 | 49,193,492 | 192 |
| 2010Q1 | 20,437 | 6,955 | 49,480,656 | 190 |
| 2010Q2 | 15,348 | 5,445 | 49,739,692 | 190 |
| 2010Q3 | 18,497 | 6,826 | 50,030,044 | 186 |
| 2010Q4 | 18,384 | 7,234 | 50,322,088 | 185 |
| 2011Q1 | 20,659 | 7,808 | 50,669,320 | 180 |
| 2011Q2 | 17,161 | 6,371 | 51,016,551 | 179 |
| 2011Q3 | 16,904 | 6,166 | 51,363,783 | 180 |
| 2011Q4 | 13,929 | 5,363 | 54,138,257 | 180 |
| 2012Q1 | 14,978 | 5,710 | 54,693,152 | 182 |
| 2012Q2 | 14,115 | 5,335 | 55,248,046 | 185 |
| 2012Q3 | 11,661 | 4,502 | 55,802,941 | 187 |
| 2012Q4 | 12,083 | 4,733 | 55,636,807 | 190 |
| 2013Q1 | 15,822 | 6,293 | 56,047,496 | 195 |
| 2013Q2 | 16,356 | 6,677 | 56,458,185 | 199 |
| 2013Q3 | 15,623 | 6,368 | 56,868,874 | 203 |
| 2013Q4 | 13,089 | 5,387 | 57,332,874 | 205 |
| 2014Q1 | 14,820 | 5,897 | 57,754,226 | 208 |

## E3. Quarterly Time Series Model of HECM Demand

The dependent variable is the natural log of the number of HECM loans endorsed in a quarter. The explanatory variables, also in log form, include the first and second lags of the dependent variable, the year-over-year change in home prices, and the senior population.

We used an Ordinary Least Squares (OLS) regression approach similar to previous years. The various explanatory variables, their coefficients and significance levels are shown in Exhibit E-2.

**Exhibit E-2. OLS Regression of Log of HECM Loan Count**

| | Parameter Estimate | Standard Error | t-stat value | Pr > \|t\| |
|---|---|---|---|---|
| 1-quarter lag of log of loan count | 0.828 | 0.154 | 5.370 | <.0001 |
| 2-quarter lag of log of loan count | 0.065 | 0.150 | 0.430 | 0.667 |
| log (HPI at t / HPI at t - 4) | 0.214 | 0.538 | 0.400 | 0.693 |
| log(Pop >= 62 yr at t) | 0.060 | 0.034 | 1.750 | 0.088 |
| Adj R-Sq = 0.9998<br>Durbin-Watson = 2.005<br>Number of Observations = 45 | | | | |

## E4. Forecasts of HECM Loan Counts based on HECM Demand Model

The HECM demand model takes as input scenarios for the following variables: forecasts of home prices and the senior population, as well as the lagged values of the dependent variable. The steady growth in the future senior population and general autoregressive momentum produced forecasts that somewhat exceeded FHA's projected HECM volume. A calibration factor is derived by dividing FHA's projected FY 2015 HECM volume by the model's projected volume. This calibration factor (0.7270) was applied to all future years among simulated future economic scenarios.

Exhibit E-3 presents the demand forecasts based on alternative scenarios used in the 2014 Actuarial Review for the HECM program.

**Exhibit E-3. Forecasts of HECM Loan Counts for Simulated Economic Scenarios**

| Fiscal Year | Mean Stochastic Simulation | 10th Best Path in Simulation | 25th Best Path in Simulation | 25th Worst Path in Simulation | 10th Worst Path in Simulation | The Worst Path in Simulation | Moody's Baseline Path | Moody's Protracted Slump |
|---|---|---|---|---|---|---|---|---|
| **2015** | 54,052 | 53,924 | 53,876 | 53,836 | 53,861 | 53,805 | 54,048 | 50,789 |
| **2016** | 59,206 | 58,904 | 58,651 | 58,322 | 58,956 | 57,706 | 59,205 | 50,565 |
| **2017** | 62,625 | 62,406 | 61,901 | 61,075 | 62,915 | 58,970 | 62,699 | 55,271 |
| **2018** | 65,580 | 65,876 | 65,034 | 63,504 | 66,091 | 59,356 | 65,672 | 60,637 |
| **2019** | 68,338 | 69,343 | 68,417 | 65,818 | 68,920 | 59,951 | 68,426 | 64,929 |
| **2020** | 70,734 | 71,922 | 71,517 | 68,230 | 71,229 | 62,988 | 70,846 | 68,444 |
| **2021** | 73,056 | 74,693 | 74,077 | 70,895 | 73,202 | 66,035 | 73,159 | 71,518 |

# Appendix F

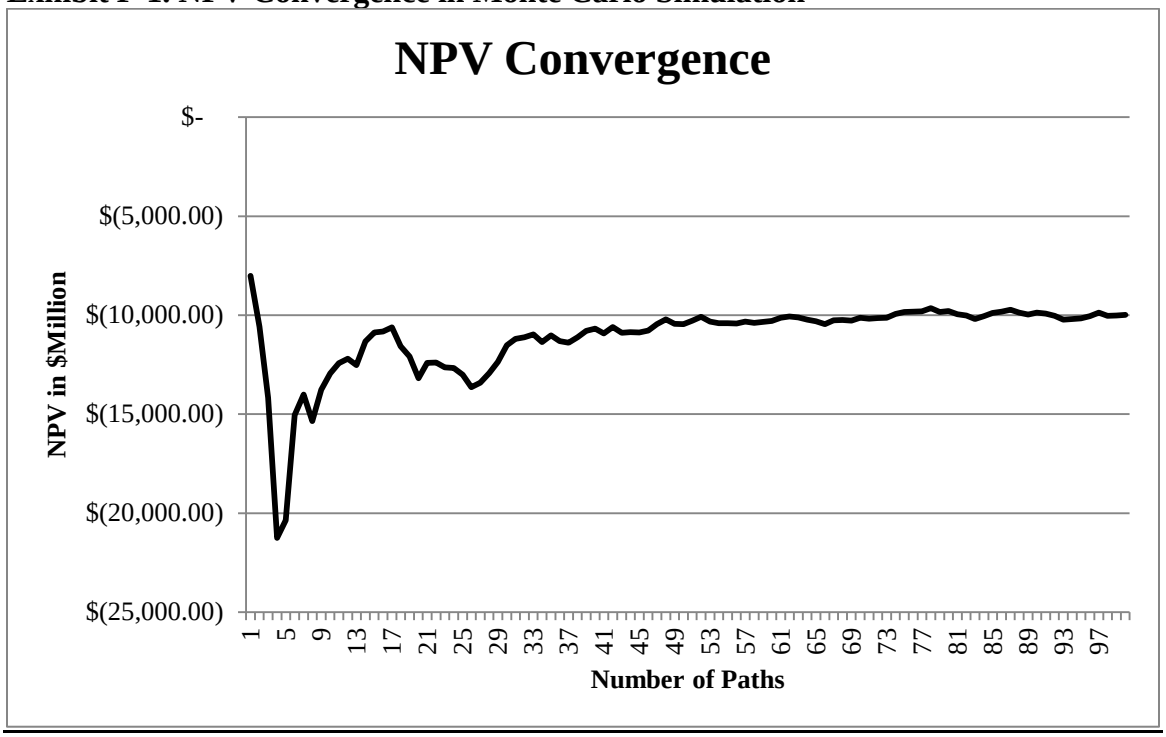
# Stochastic Processes of Economic Variables

## Appendix F: Stochastic Processes of Economic Variables

This appendix describes the stochastic processes assumed for the economic variables used in the Monte Carlo simulations of the 2014 HECM Actuarial Review. Starting from the 2012 Review, we computed the present value of expected cash flows from 100 possible paths of house price appreciation rates (HPAs) and interest rates. This interpretation is consistent with the industry best practice for pricing and measuring risks of mortgage portfolios. The concept (in terms on the "Monte Carlo" technique that we use in this Review) is to project a number of equally likely future paths of HPA and unemployment and interest rates, compute the net present value (NPV) of the projected cash flows for each path and, since each path is equally likely, compute the average NPV over all the paths as the expected present value.

We selected 100 simulated paths for the Monte Carlo simulations. With these 100 paths, the present value of the future cash flows converged to a constant value when we used 100 paths. This converged value is the expected present value of future cash flows. If we were to randomly draw a number of sets of 100 paths, we infer that the results will be essentially the same expected NPV of the future cash flows among individual sets. We obtain the economic value of the HECM portfolio by adding this expected present value to the capital resources of the HECM. Using more paths would increase the computation time required to conduct simulations with diminishing improvement of precision. Exhibit F-1 shows the convergence of the Monte Carlo simulation: after about the 82th path the NPV of future cash flows does not deviate measurably.

**Exhibit F-1. NPV Convergence in Monte Carlo Simulation**



The economic variables modeled herein as stochastic for computing expected values include:

- 1-year Treasury rates,
- 10-year Treasury rates,
- 1-year London interbank overnight rates (LIBOR),
- FHFA national Purchase Only house price index (HPI-PO), and
- Unemployment rates.

These stochastic variables have been modeled to project the "real world" or "physical" measure and hence were estimated using historical data. [31] This approach is appropriate for the Actuarial Review because the simulated rates are designed to approximate the actual future distribution. Since all status transition probability models were estimated using the historically observed interest rate and house price appreciation rates, estimating the interest rates and other economic variables using the real-world measure, versus risk-neutral measures used for security trading purposes, is consistent with this approach.

## F1. Historical Data

### F1.1. Interest Rates

With the high inflation rate caused by the global oil crisis in the late 1970's, interest rates rose to an historical high in early 1980's. Since then, the Federal government shifted its monetary policy from managing interest rates to managing the money supply. Interest rates generally decreased since this policy shift. Exhibit F-2 shows historical interest rates since 1962. The 1-year Treasury rate was around 3% in 1962 and increased steadily to its peak of 16.31% in 1981 Q3. After that, it followed a decreasing trend and reached an all-time low of 0.11% in 2011 Q4. Also shown are the 10-year Treasury rate (cmt10), and the 1-year LIBOR rate (LIBOR_1y).

[31] For valuing options, "theoretical" or "risk-neutral" future paths of interest rates, e.g., are postulated and developed that permit estimation of option values based on observed option prices and the prices of the underlying asset upon which the options are based. These paths do not resemble actual historical movements in interest rates and are not suitable for the actuarial review purpose.

**Exhibit F-2. Historical Interest Rates (%)**

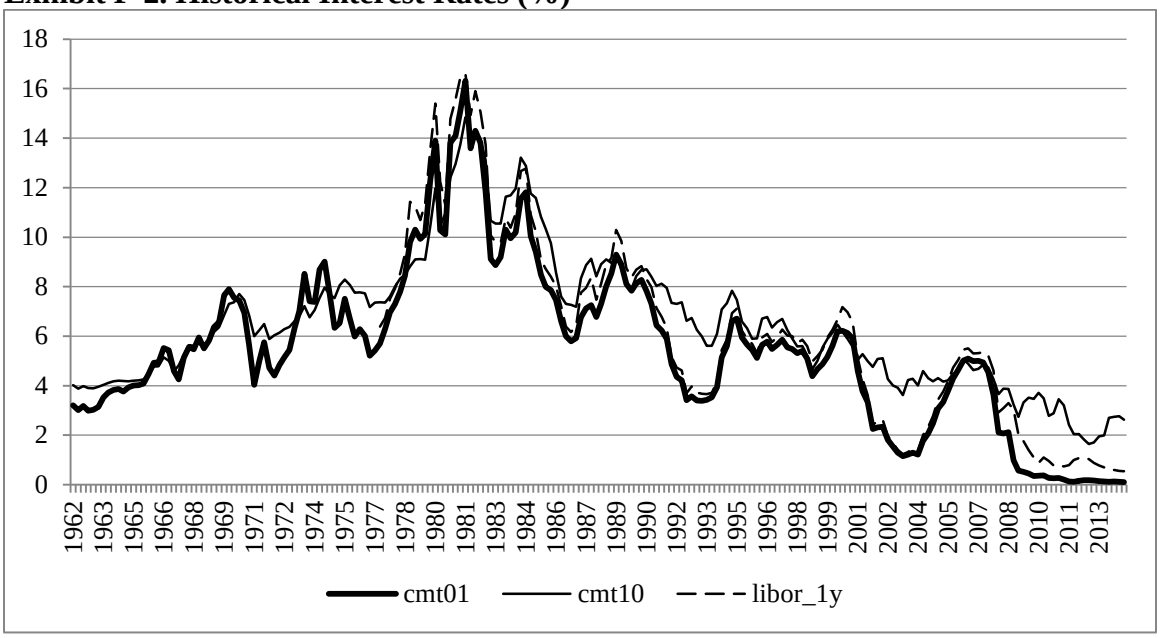
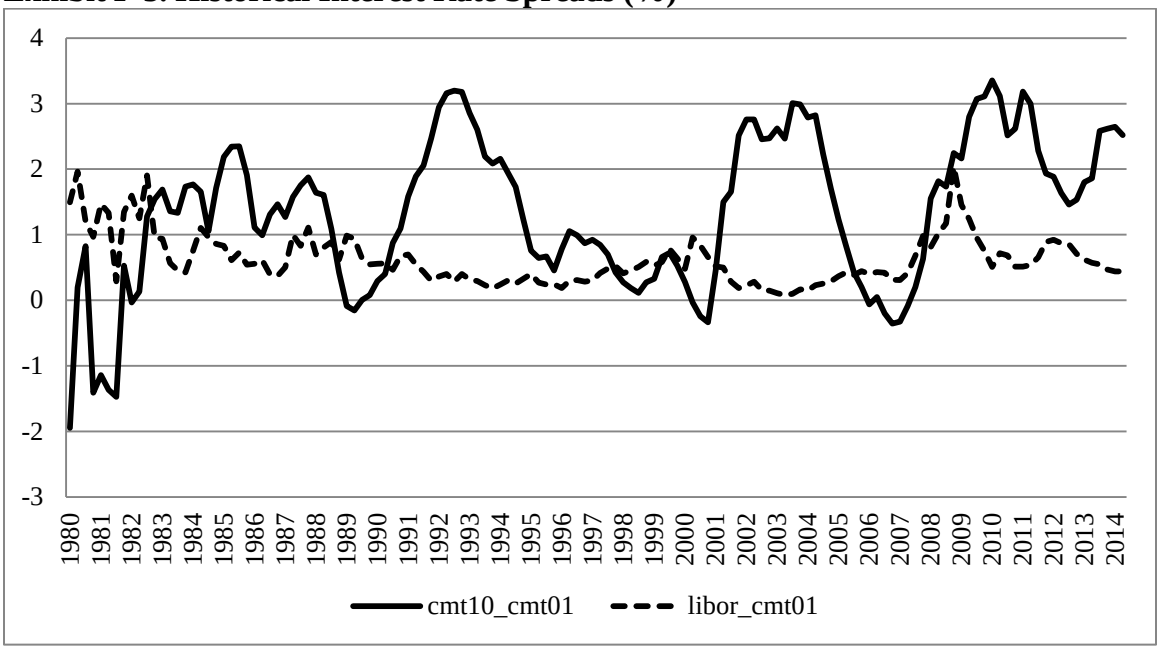



Exhibit F-3 shows historical interest rate spreads, including the spread between the 10-year and the 1-year Treasury rates, , and the spread between the 1-year LIBOR and the 1-year Treasury rate. The spread between the 10-year and 1-year Treasury rates appears to have long cycles and the spread is not always positive. However, the spread of the mortgage rate over the 10-year Treasury rate and the spread of LIBOR over the 1-year Treasury rate are always positive, reflecting the premium for credit risk.

**Exhibit F-3. Historical Interest Rate Spreads (%)**



## F1.2. House Price Appreciation Rates

The national house price appreciation rate (HPA) is derived from FHFA repeat sales house price indexes (HPIs) of purchase-only transactions. The PO Index provides a more reliable measure of housing market conditions, since it is based on repeat sales at market prices and does not use any appraised values.

Since the PO HPI index started from 1991, we used the HPI data from 1991 Q1 through 2014 Q1 to build our model. The HPA series being modeled is defined as

$$HPA_t = \ln\left(\frac{HPI_t}{HPI_{t-1}}\right)$$

Exhibit F-4 shows the National HPI and quarterly HPA from 1991 Q1 to 2014 Q1. The long-term average quarterly HPA is around 0.796 % (3.22$ annual rate).

The PO HPI increased steadily before 2004, and the quarterly appreciation rate was around 1.14%. Then house prices rose sharply starting 2004. The average quarterly house price appreciation rate was 1.88% during the subprime mortgage expansion period from 2004 to 2006, and reached its peak of 2.59% in 2005 Q2. After 2006, the average growth rate became negative. Exhibit F-4 shows the average quarterly HPA by selected historical time periods.

**Exhibit F-4. National HPI and HPA**

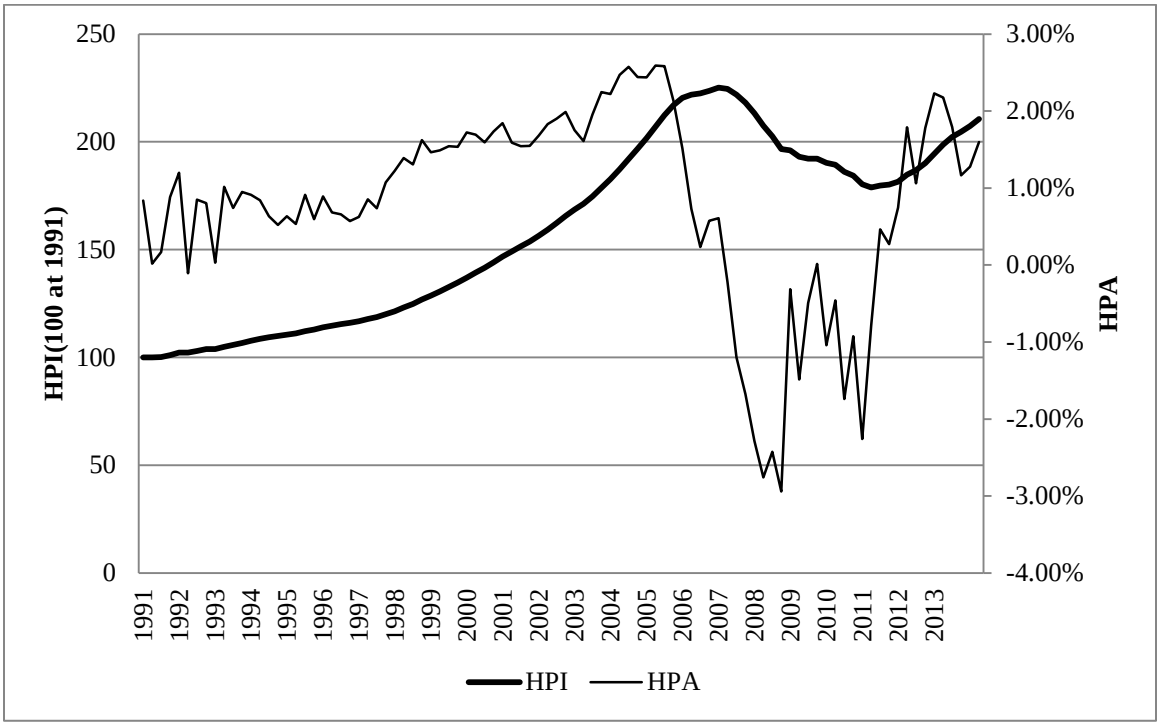


**Exhibit F-5. Average Quarterly HPA by Time Span**

| Period | Average Quarterly HPA |
|---|---|
| 1991 – 2003 | 1.13% |
| 2004 – 2006 | 1.88% |
| 2007 – 2010 | -1.21% |
| 2011 – 2013 | 0.87% |

## F2. 1-Year Treasury Rate

In this section, we present some historical statistics on the one-year Treasury rate, and then describe the model we used in our simulations, and finally report the parameter estimates and their standard errors. Exhibit F-6 shows the summary statistics of the historical 1-year Treasury rates since for two periods, one started in 1962 and the other started in 1980.

**Exhibit F-6. Statistics for the 1-Year Treasury Rates**

| Statistics | Since 1980 | Since 1962 |
|---|---|---|
| **Mean** | 5.28% | 5.51% |
| **Standard Deviation** | 3.78% | 3.29% |
| **Max** | 16.31% | 16.31% |
| **95- Percentile** | 13.62% | 11.70% |
| **90- Percentile** | 10.14% | 9.82% |
| **50- Percentile** | 5.51% | 5.46% |
| **10- Percentile** | 0.27% | 0.57% |
| **5- Percentile** | 0.15% | 0.18% |
| **Min** | 0.10% | 0.10% |

We used a generalized GARCH(1,1) parameterization to model the 1-Year Treasury rate ($r_1$) and estimated it using data from 1980 Q1 to 2014 Q2[32]. The process takes the following form:

$$r_{1,t} = A + B * r_{1,t-1} + \sigma_t dZ_1 \qquad (1)$$

where $Z_1$ is the independent Wiener random process with distribution N(0,1).

The variance (σ) of the residual term follows a generalized GARCH (1,1) process:

$$\sigma_t{}^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2 + \gamma_1 r_{1,t-1} \qquad (2)$$

where ε is the error term, which equals $\sigma_t dZ_1$ from equation (1)

[32] Example of using a GARCH model for fixed income analysis includes Heston and Nandi (2003).

The Full Information Maximum Likelihood (FIML) method was used to estimate the parameters in equations (1) and (2). The estimated results are presented in Exhibit F-7.

**Exhibit F-7. Estimation Results for 1-Year Treasury Rate Model**

| Parameter | Estimate | Std Dev | t-value | prob>t |
|---|---|---|---|---|
| A | 1.09E-04 | 3.15E-04 | 0.3 | 0.728 |
| B | 0.981 | 0.01 | 93.4 | 0.000 |
| $\beta_0$ | -2.01E-07 | 8.21E-08 | -2.4 | 0.014 |
| $\beta_1$ | 0.150 | 0.08 | 1.8 | 0.075 |
| $\beta_2$ | 0.573 | 0.11 | 5.1 | 0.000 |
| $\gamma_1$ | 1.65E-04 | 5.41E-05 | 3.0 | 0.002 |
| Adj. $R^2$ | 0.958 | | | |

The model based on these parameters is used to simulate FY 2014 Q3 and future 1-year Treasury rates. When the simulation is implemented, the "constant" term A is actually calibrated to a different value to match Moody's baseline forecast in each forecasted quarter. The values were chosen so that the median value among 100 simulations matches Moody's July 2014 baseline forecast of the 1-year Treasury rate quarter by quarter. We applied the same procedure for the "constant" terms in the interest rate and HPA equations below.

Note that Moody's July forecast only covers the period until 2044 Q4. After 2044, we repeated Moody's last 4-quarter forecasts for all remaining quarters. All the other interest rates and HPA series are expanded to the year 2100 using the same methodology. A lower bound of 0.01 percent was applied to the simulated future 1-year Treasury rates to avoid negative rates in the simulation.

### F3. 10-Year Treasury Rate

The 10-year Treasury rate is modeled by adding a stochastic spread term to the 1-year rate. We estimate the dynamics of the spread between 10-year Treasury rate and 1-year Treasury rate from the historical data. The spread term is assumed to depend on the one-year rate, the lagged value of the spread term and a random component. The model for the spread is

$$s_{10,t} = \alpha_{10,t} + \beta_{10} r_{1,t} + \gamma_{10} s_{10,t-1} + \varepsilon_{10,t} \quad (3)$$

where $s_{10,t}$ is the spread between the 10-year and 1-year Treasury rates at time $t$ and $r_{1,t}$ is 1-year Treasury rate at time $t$. The variance of the residual term follows an ARCH (1) process:

$$\sigma_t{}^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 \quad (4)$$

FIML was used to estimate the parameters $\alpha_{10}$ and $\beta_{10}$. The estimated parameters are shown in the following Exhibit F-8.

**Exhibit F-8. Estimation Results for 10-Year Treasury Rate Spread Model**

| Parameter | Estimate | Std Dev | t-value | prob>t |
|---|---|---|---|---|
| $\alpha_{10}$[33] | 0.004 | 0.001 | 2.82 | 0.006 |
| $\beta_{10}$ | -0.023 | 0.014 | -1.68 | 0.095 |
| $\gamma_{10}$ | 0.840 | 0.045 | 18.89 | 0.000 |
| $\beta_0$ | 1.30E-05 | 2.89E-06 | 4.47 | 0.000 |
| $\beta_1$ | 0.527 | 0.275 | 1.92 | 0.058 |
| Adj. $R^2$ | 0.833 | | | |

We used the estimated parameters to simulate the spread between the 10-year and 1-year Treasury rates, and added the simulated spread to the simulated 1-year Treasury rate. Then we adjusted the constant term $\alpha_{10,t}$ to calibrate the series such that the median value among 100 simulated paths matched Moody's July 2014 base forecast of the 10-year Treasury rates quarter by quarter (with the same logic of expanding the forecast series to year 2100). We also set a floor value at 0.01 percent to the simulated 10-year Treasury rates.

## F4. LIBOR

The 1-year LIBOR rate was modeled as a constant term plus a term proportional to the 1-year Treasury rate and a random term:

$$r_{L,t} = \alpha_{L,t} + \beta_L r_{1,t} + \varepsilon_{L,t} \quad (5)$$

where $r_{L,t}$ is the LIBOR rate and $r_{1,t}$ is 1-year Treasury rate.

Ordinary Least Squares was used to estimate the parameters $\alpha_L$ and $\beta_L$. The estimated parameters are shown in Exhibit F-9.

**Exhibit F-9. Estimation Results for the LIBOR Rate Model**

| Parameter | Estimate | Std Dev | tValue | Prob>t |
|---|---|---|---|---|
| $\alpha_L$[34] | 0.005 | 0.001 | 10.160 | 0.000 |
| $\beta_L$ | 0.997 | 0.012 | 86.400 | 0.000 |
| Adjusted $R^2$ | 0.986 | | | |

We used the estimated parameters to simulate the LIBOR rate. Then we adjusted the constant term $\alpha_{L,t}$ to calibrate the series such that the median value among 100 simulations will match Moody's July 2014 base forecast of the LIBOR rates quarter by

[33] The intercept term is calibrated each time period so that the median simulated spread matches Moody's baseline forecast.

[34] The intercept term is calibrated each time period so that the median simulated spread matches Moody's baseline forecast.

quarter. As with the other interest rates, we also set a floor value at 0.01 percent to the simulated LIBOR rate.

## F5. House Price Appreciation Rate (HPA)

### F5.1. National HPA

We specified the national HPA to depend on its own lags, seasonal dummy variables, the level of short rates and on various spreads and their lags. After considerable experimentation the model we adopted was

$$HPA_t = \mu_t + \beta_1 HPA_{t-1} + \beta_2 HPA_{t-2} + \beta_3 HPA_{t-3} + \beta_4 r_{1,t} + \beta_5 r_{1,t-1} + \beta_6 s_{10,t} + \beta_7 s_{10,t-1} + \beta_8 s_{m,t} + \beta_9 s_{m,t-1} + \sigma_{h,t} dZ_h \quad (6)$$

where, $r_{1,t}$ is the 1-year Treasury rate,

$s_{10,t}$ is the spread between the 10-year and 1-year Treasury rates,

$s_{m,t}$ is the spread between mortgage rate and 10-year Treasury rate, and

$Z_h$ is independent Wiener random process with distribution N(0,1)

The variance of the residual term follows a GARCH (1,1) process:

$$\sigma_{h,t}{}^2 = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 \sigma_{h,t-1}{}^2 \quad (7)$$

The lags and variable inclusions were determined by achieving appropriate coefficient signs and significance and overall model fit. FIML was used to estimate parameters in equations (6) and (7). The results are shown in Exhibit F-10.

**Exhibit F-10. Estimation Results the National HPA Model**

| Parameter | Estimate | Std Dev | t-value | prob>t |
|---|---|---|---|---|
| $\mu$ | 0.002 | 0.002 | 1.01 | 0.311 |
| $\beta_1$ | 0.632 | 0.094 | 6.72 | 0.000 |
| $\beta_2$ | 0.231 | 0.093 | 2.47 | 0.014 |
| $\beta_3$ | -0.086 | 0.085 | -1.01 | 0.313 |
| $\beta_4$ | 0.059 | 0.083 | 0.71 | 0.477 |
| $\beta_5$ | -0.173 | 0.119 | -1.46 | 0.145 |
| $\beta_6$ | 0.150 | 0.122 | 1.23 | 0.219 |
| $\beta_7$ | 0.014 | 0.174 | 0.08 | 0.938 |
| $\beta_8$ | 0.074 | 0.158 | 0.47 | 0.640 |
| $\gamma_0$ | 2.86E-07 | 4.51E-07 | 0.63 | 0.526 |
| $\gamma_1$ | 0.372 | 0.156 | 2.39 | 0.017 |
| $\gamma_2$ | 0.649 | 0.109 | 5.96 | 0.000 |
| Adj. $R^2$ | 0.654 | | | |

We used these parameters to simulate future HPA from 2014 Q3 onwards. Also, we calibrated the mean of HPA ($\mu_t$ in the equation) by matching the median value across 100

simulated paths to Moody's July base forecast. Moody's July forecast extends only to year 2044 Q4, so again we repeat the last four quarters for the subsequent quarters.

### F5.2. Geographic dispersion

The MSA-level HPA forecasts were based on Moody's forecast of local and the national HPA forecasts. Specifically, at each time *t*, there is a dispersion of HPAs between the $i^{th}$ MSA and the national forecast:

$$Disp_{i,t}^{Base} = (HPA_{i,t}^{Base} - HPA_{national,t}^{Base})$$

This dispersion forecast under Moody's base case is preserved for all local house price forecasts under individual future economic paths. That is, for economic path *j*, the HPA of the $i^{th}$ MSA at time t was computed as:

$$HPA_{i,t}^{j} = (HPA_{national,t}^{j} + DISP_{i,t}^{Base})$$

This approach retains the relative current housing market cycle among different geographic locations and it allows us to capture the geographical concentration of FHA's current endorsement portfolio. This approach is also consistent with Moody's logic in creating local market HPA forecasts relative to the national HPA forecast under alternative economic scenario forecasts.[35] We understand this approach is equivalent to assuming perfect correlation of dispersions among different locations across simulated national HPA paths, which creates a systematic house price decrease during economic downturns and vice versa during booms. Due to Jensen's Inequality, this tends to generate a more conservative estimate of claim losses of the Fund.

## F6. Unemployment Rate

### F6.1. National Unemployment Rate

In our unemployment rate model, the unemployment rate depends on the prior unemployment rate, house prices, mortgage rates and Treasury rates.

We used quarterly data from CY 1975 to CY 2014Q1 to estimate the national unemployment rate. The model we adopted was:

$$ue_t = \mu_t + \beta_1 ue_{t-1} + \beta_2 ue_{t-2} + \beta_3 r_{1,t} + \beta_4 r_{m,t} + \beta_5 HPA_t + \varepsilon_t \qquad (8)$$

where, $r_{1,t}$ is the 1-year Treasury rate,

[35] The dispersion of each MSA remains the same as Moody's baseline scenario among all alternative Moody's forecast scenarios.

$r_{m,t}$ is the 30-year mortgage rate,
$HPA_t$ is the annualized house price growth rate at the national level, and
$ue_t$ is the unemployment rate.

**Exhibit F-11: Estimation Results for the National Unemployment Rate Model**

| Parameter | Estimate | Std Dev | t-value | prob>t |
|---|---|---|---|---|
| $\mu$ | 0.185 | 0.095 | 1.95 | 0.053 |
| $\beta_1$ | 1.502 | 0.064 | 23.35 | 0.000 |
| $\beta_2$ | -0.574 | 0.061 | -9.47 | 0.000 |
| $\beta_3$ | -1.482 | 0.461 | -3.22 | 0.002 |
| $\beta_4$ | -0.049 | 0.020 | -2.48 | 0.014 |
| $\beta_5$ | 0.072 | 0.023 | 3.11 | 0.002 |
| Adj. $R^2$ | 0.981 | | | |

From the simulated interest rates and house prices, we applied the parameters shown in Exhibit F-11 to calculate the corresponding national unemployment rate. Based on historical statistics, the national unemployment rate was capped at 20 percent with a floor of 2%.

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