Actuarial Review of the Federal Housing Administration Mutual Mortgage Insurance Fund HECM Loans For Fiscal Year 2016

November 15, 2016

Prepared for

U.S. Department of Housing and Urban Development

By

Integrated Financial Engineering, Inc.

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November 15, 2016

The Honorable Golding, Edward
Principal Deputy 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 Dr. Golding:

IFE Group has completed and, along with this letter, is submitting the fiscal year 2016 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 2016 was *negative* $7,721 million and the insurance in force was $111.92 billion. We project that at the end of fiscal year 2023 the HECM Fund's economic value will be *negative* $12,537 million and the insurance in force will be $212.56 billion.

The financial estimates presented in this Review require projections of events as long as 74 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 2016

I have reviewed the "Actuarial Review of the Federal Housing Administration Mutual Mortgage Insurance Fund, HECM Loans, for Fiscal Year 2016". 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.

Phelim Boyle, Ph.D., FCIA
Fellow of the Canadian Institute of Actuaries
November 15, 2016

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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 awareness, 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.

At the beginning of 2014, the HECM Standard and HECM Saver programs were replaced with HECMs that reduced the initial and total allowable drawdowns in order to strengthen the financial condition of the program.[2] Also in 2014, FHA allowed a Non-Borrowing Spouse to be younger than 62[3] years of age and implemented corresponding principal limit factors for those younger ages.[4] In 2015, FHA introduced the Life Expectancy Set-Aside (LESA) Growth Rate and related requirements to address tax and insurance defaults; additional guidance on HECM "Due and Payable" policies and timing requirements; and permissible loss mitigation options when property charges are not paid.

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 2016 through FY 2023 MMI HECM portfolios. A fiscal year's MMI HECM portfolio is defined as the loans that survive to the end of the fiscal year and were endorsed in FY 2009 or later. In addition to the initial capital resources, 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).

IFE Group's projections indicate that, as of the end of FY 2016, the HECM portion of the MMI fund has an economic value of *negative* $7,721 million. Two primary reasons for this decrease from last year's estimate of *positive* $6,778 million are the adverse impacts of incorporating deeper house price sale discounts and additional property disposition expenses, both of which were

[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 a non-borrowing spouse and also revised 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).

identified with new datasets provided by FHA this year. These two changes are responsible for a decrease of $8,706 million to the reported economic value of the MMI HECM Fund.

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, IFE Group analyzed all HECM historical terminations and associated recoveries using loan-level HECM performance data maintained by FHA through March 31, 2016. We updated loan-level Tax & Insurance termination and recovery models using various economic and loan-specific factors. The base mortality, refinance, and mobility termination models remain the same as those used in the FY 2015 Review because the Social Security Administration no longer supplies FHA with the dates of death of HECM borrowers. We then estimated the future loan performance of the FY 2016 through FY 2023 MMI HECM portfolios using various assumptions, including macroeconomic forecasts by Moody's Analytics, 100 simulated possible future economic scenarios, and projected HECM portfolio characteristics.

Based on our evaluation of the HECM loans in the FY 2016 portfolio, we estimated the economic value of the HECM Fund to be *negative* $7,721 million. We also estimated that the economic value of the HECM portfolio will subsequently decrease over time, as future books of business would continue to bring negative values. The newly available information on house price sale discounts and property disposition expenses negatively impacts the reported financial strength of future endorsements as well as the existing books of business.[6] The economic value of the HECM Fund as of the end of FY 2023 is estimated to be *negative* $12,537 million.

The maximum claim amount (MCA) of a HECM loan serves as the cap on the amount of insurance claims that FHA will pay the lender for unassigned loans. 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 of the active portfolio. As new endorsements are added to the portfolio, projected HECM IIF increases from $111,919 million in FY 2016 to $212,560 million in FY 2023. Exhibit ES-1 provides the projected baseline economic values, IIF, and new endorsements of the HECM Fund for FY 2016 through FY 2023.

[6] Details of these items are provided in Section II of this Review.

Exhibit ES-1. Baseline Economic Value, Insurance-in-Force, and Endorsements for FY 2016-FY 2023 ($ 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
2016	-7,721	111,919	14,598	-1,209	
2017	-8,640	113,279	18,468	-799	-120
2018	-9,230	127,108	20,829	-383	-207
2019	-9,817	142,491	22,534	-317	-271
2020	-10,524	158,918	24,055	-391	-315
2021	-11,206	176,082	25,561	-327	-355
2022	-11,875	193,965	27,100	-277	-393
2023	-12,537	212,560	28,643	-233	-429

*All values are expressed as of the end of the fiscal year.
**Insurance-in-force is estimated as the sum of the MCAs of the remaining loans in the insurance portfolio.
*** Projections are based on the HECM volume model in Appendix E times the average MCA. The volume number in FY 2016 reflects the outstanding loans at the end of the fiscal year and excludes loans endorsed and terminated in the same fiscal year.

B. Sources of Change in the Status of the Fund

The reported economic value of the HECM Fund decreased by $14,499 million from the estimated FY 2015 economic value of positive $6,778 million as estimated in the FY 2015 Review. This change was driven primarily by five main factors:

- Actual data performance and portfolio status update reduces the FY 2016 economic value by $1,764 million.
- The FY 2016 model update lowers the FY 2016 economic value by $918 million.
- Based on a new dataset collected by HUD, the house price sale discount (haircut) applied to HECM properties that become claims is much higher than that applied in prior Reviews. Revising the sales discount lowers the FY 2016 economic value by $6,452 million.
- FHA provided another new dataset on the expenses claimed when disposing the underlying properties. These items (especially Management and Operation expenses[7]) make the property disposition expenses dramatically higher than what was applied in previous Reviews. After incorporating the additional expenses, the FY 2016 economic value decreases by $2,254 million.
- In prior Reviews, it was assumed that lenders assign 100 percent of all loans that reach 98 percent of the MCA. As MMI HECM loans started reaching that assignment criterion during

[7] Management & Operations account for REO-conveyed property, and includes expenses for disaster repairs, mold treatment, property management fees, homeowners' association fees, demolition, clean-up, debris removal, yard maintenance and winterizing and snow removal fees.

the last two years, data showed that about 60 percent of those loans were ineligible to be assigned. With this information, we now assume that only 40 percent of those loans will be assigned. This change decreases the FY 2016 economic value by $4,449 million.

C. Impact of Economic and Loan Factors

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

- House Price Appreciation (HPA): HPA rates impact the recovery FHA receives upon loan terminations and the rate at which borrowers will refinance or move out of their property. HPA rates are generated in our stochastic simulation of economic variables. These rates for the Monte Carlo simulation are centered on Moody's July 2016 forecast.
- 1-year and 10-year Treasury interest rates and 1-year London Interbank Offered Rate (LIBOR) rate: 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 centered on Moody's July 2016 forecast.
- Mortality Rates: Mortality rates are either directly obtained or derived from the U.S. Decennial Life Table for the 1990-1991, 1999-2001, and 2001-2009 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 to account for borrower characteristics and the economic environment.
- House Price Sale Discount: The sales price of the houses underlying HECM loans tend to be lower than the market price of otherwise identical houses. A deeper discount in the sale price would negatively impact the economic value of the Fund.

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, five scenarios from our simulated paths, two scenarios from Moody's Analytics, and a low rate scenario. The baseline case of the Review is the mean of the economic values of the MMI HECM portfolio over 100 simulated paths. Each alternative scenario estimates the performance of the Fund under the specific future path of interest, unemployment and house price appreciation rates. According to the results, there is approximately a 50 percent chance that the economic value would fall in the range of *negative* $13 billion to *positive* $0.6 billion, and approximately an 80 percent chance that it would fall within the range of *negative* $20 billion to positive $3 billion. From the worst path simulation, we infer that there is approximately a 99 percent probability that the FY 2016 economic value will be better than *negative* $45,118 million.

Exhibit ES-2. Economic Values of the HECM 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	Moody's Protracted Slump	Low Rate Scenario
2016	-7,721	3,402	-555	-13,374	-19,693	-45,118	-6,831	-20,168	-6,238
2023	-12,537	16,000	1,732	-34,393	-31,531	-76,553	-8,725	-37,650	-10,512

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

We also applied two of Moody's alternative scenarios and a low rate scenario in this Review. Moody's baseline scenario as a deterministic path produces an economic value of about $890 million higher than the baseline Monte Carlo result. Under the most stressful scenario projected by Moody's, the protracted slump scenario, the FY 2016 economic value of the Fund is *negative* $20,168 million. This is similar to the 8th worst path in our simulation. Under the low rate scenario, where we keep the current low interest rates for two years and recover to Moody's forecast in another two years, the FY 2016 economic value of the Fund is *negative* $6,238 million.

Note that the 10th and the 25th best and worst paths presented in Exhibit ES-2 may not correspond to the same paths that generate the 10th and the 25th best and worst economic values in the case of the forward loans in the MMI Fund. This is due to substantially different risk drivers of 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 path of the combined HECM and forward portfolios will not equal the sum of the 25th worst HECM portfolio economic value and the 25th worst forward portfolio economic value that is reported in a separate Actuarial Review of the forward portfolio.

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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] IFE Group was engaged by the Department of Housing and Urban Development (HUD) to conduct the independent actuarial review to estimate the economic value and insurance-in-force of the HECM MMI portfolio for FY 2016.

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 2016 and as projected through FY 2023. This review also provides the HECM portion of the insurance-in-force (IIF) that can be 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), insures reverse mortgage loans 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 985,288 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 there is an existing mortgage, the outstanding balance must be paid off with the HECM proceeds and (c) the borrower(s) 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 underlying homes, and there is no required repayment as long as the borrowers continue to live in the home and meet HUD guidelines on requirements for paying property taxes and homeowner's insurance premiums and for maintaining the property in a reasonable condition. 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 including death, moving out of the home and refinance. The existence of negative

[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.

equity does not require borrowers to pay off the loan and it does not prevent the borrowers from receiving additional cash draws if available per their HECM contract.

The reverse mortgage insurance provided by FHA through the HECM program protects lenders from losses due to insufficient recovery of terminated loans. When a loan terminates and the loan balance is greater than the net sale price of the home, the lender can file a claim for loss up to the maximum claim amount (MCA). The MCA is defined as the minimum of the home's appraised value and the FHA HECM loan limit, both measured at origination. A lender can assign the mortgage note to FHA if the loan meets the eligibility requirements when the loan balance reaches 98 percent of the MCA and is reimbursed for the balance of the loan (up to the MCA). When note assignment occurs, FHA switches from being the insurer to the holder of the note and controls the servicing of the loan until termination. At loan termination (post-assignment), FHA attempts to recover the loan balance including any expenses, accrued interest, property taxes and insurance premiums. In prior Reviews, it was assumed that all loans that reach 98 percent of the MCA were assigned to FHA, but new data demonstrates that about 60 percent of loans were ineligible to be assigned. Thus, we assume that 60 percent of the loans reaching 98 percent of the MCA will not be eligible for assignment going forward. In such cases, the lender continues its ownership of the loan.

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 upfront premium charged by the Standard HECM program.

Starting at the beginning of FY 2014, the Standard and Saver programs were replaced by a more conservative program to improve the financial viability of the HECM program. This new program had lower principal limit factors than the Standard program, and also had initial disbursement limitations. Furthermore, the initial MIP, as a percentage of the MCA, varied depending on whether the percentage of the sum of the mortgagor's initial disbursement and other required disbursements was larger than 60 percent of the Principle Limit.

Starting from August 4, 2014, the HECM program was modified to allow non-borrowing spouses younger than 62 years of age, and Special Principal Limit Factors (PLFs) were promulgated to deal with the longevity risk. Also, more conservative PLFs were imposed for borrowers of age 62 and above. Note that the younger non-borrowing spouse gets the benefit of staying in the house until deceased or when moves out. The Special PLFs of HECM is based on the age of the younger spouse, whether or not he/she is a borrower. Thus, the risk of longevity is addressed programmatically, especially given the newly applicable Special PLFs. Also note that our models capture the longevity risk in the mortality variable and that FHA's projections of the composition of future HECMs include spouses as young as 38 years old (see Appendix A). Appendix E incorporates the impact of this new product on HECM volume.

Starting from April 27, 2015, HUD introduced the Life Expectancy Set-Aside (LESA) requirements for HECM loans, attached with the HECM Financial Assessment and Property Charge Guide. LESA is a specified portion of the unused principle that is set aside at the origination of HECM loans to be used only for the payment of property taxes, and hazard and flood insurance premiums. It reduces the amount of draw-downs otherwise available to the borrowers by the amount of the set-aside.

Starting from July 13, 2016, HUD established a revised growth rate for Servicing Fee Set-Asides, authorized mortgagees to pass costs of obtaining third party verification of an applicant's property tax payment history to the mortgagor, and transmitted a revised HECM Financial Assessment and Property Charge Guide.

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 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 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 selected PLFs published in October 2010 and PLFs from the new program which started in FY 2014 (FY 2014 Program) and replaced the Saver and Standard programs.[11] It also presents special PLFs for a new program that started on August 4, 2014 and allowed younger non-borrowing spouses; these are the Special PLFs to address the longevity risk of these younger spouses. This Current Program superseded the FY 2014 Program. It further restricted the PLFs for new borrowers.

For a given HECM applicant, the MCA is multiplied by the PLF, which is determined according to the HECM program features and the borrower's age and gender. The result is the maximum HECM principal limit available to be drawn by the applicant. The PLF increases with the borrower's age at HECM origination[12] and decreases with the expected mortgage interest rate

[10] Net sales proceeds are the proceeds from selling the home minus transaction costs.
[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 one is used to determine the corresponding PLF.

(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 the PLFs in the comparable Standard program. 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. Borrowers can continue to draw cash as long as the loan balance is below the current principal limit (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			
	Special PLFs				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

* The age of the younger borrower or spouse.

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:

[13] For adjustable rate mortgages, "expected" interest rates are calculated by the lender as the sum of an index rate 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. These PLF values have remained the same since then.

- 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.

Under the current 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 forward mortgage products as they require no repayment as long as the borrowers continue to reside in their homes and follow FHA guidelines on property maintenance, 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 available to the borrower. These costs include origination fees, closing costs, upfront MIP and pre-charged annual servicing fees. For all loans endorsed prior to October 4, 2010, the insurance premiums comprised an upfront premium of 2 percent of the MCA and an annual premium of 0.5 percent of the unpaid principal balance. After October 4, 2010, the upfront premium remained at 2 percent for the Standard program but was set as 1 basis point of the MCA for the Saver program. 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.

5. Loan Terminations

HECM loans typically terminate when borrowers die, move out of their homes, refinance the HECM or sell their houses. Loans can also terminate under foreclosure if borrowers fail to pay property taxes or homeowner's insurance premiums. Appendix D describes how we modeled the tax and insurance defaults.

[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.

When a HECM loan terminates, the current loan balance becomes due. If the net sales 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 full 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 or the income 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 and meets other assignment requirements, the lender can choose to terminate the FHA insurance by redeeming the mortgage note with FHA at face value, a transaction referred to as loan assignment. FHA will pay an assignment claim in the full amount of the loan balance (up to the MCA) and will continue to hold the note until termination. During the note holding period, the loan balance will continue to grow by accruing interest, additional draws, premiums, unpaid taxes 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 FHA 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, and loan limits. 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 footnotes.

Exhibit I-2 indicates that the PLFs 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 the 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, because 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 is more conservative than the previous Standard program, because the principal limit factors for the new program are 85 percent of the Standard program. The most recent policy change[17] effective on August 14, 2014 further reduces the principal limit factors and applies Special PLFs for co-borrowers or spouses less than 62 years of age.

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

Exhibit I-2. Selected Principal Limit Factors 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 FY 2013	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	0.440	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	0.540	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%	0.660	0.594	0.531	0.451	0.414

* The age of the younger borrower or 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, 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, 2013-43, 2014-25, 2015-29 again extended the same loan limit to December 31, 2013, December 31, 2014, December 31, 2015, and December 31, 2016, respectively.

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

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, unemployment and interest rates. This distribution is calibrated to center on Moody's July 2016 baseline forecasts in the sense that our projected values are just as likely to be above Moody's forecast values as below them.

1. House Price Growth Rate

The house price growth rate trend forecasts for the nation, states and Metropolitan State Areas (MSAs) were obtained from Moody's July 2016 forecast of the FHFA Purchase-Only (PO) repeat-sales House Price Index (HPI). The Purchase-Only Index is based on actual transaction prices of repeat sales and does not use any appraised values. As such, it provides a direct 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 2016 forecast provides estimates from 2016 Q3 to the end of 2046. We derive the House Price Appreciation (HPA) rates from the local HPI, and apply the HPA forecasts during 2046 to the years beyond 2046.

Exhibit I-3a presents the July 2016 Moody's baseline national quarterly HPA forecast as compared to the one used in the 2015 Review. According to this year's forecast, the annual national house price growth rate is 3.98 percent for FY 2016. Then the annualized rate declines to positive 1.52 percent by FY 2018, representing a temporary slowdown in the house price growth rate. After that, the house price growth rate gradually rises to a long-run average annual rate of around 3.13 percent.

Exhibit I-3b presents the HPI comparison between the July 2016 Moody's baseline national HPI forecast and that for July 2015. The updated forecast of the HPI level grows faster during the first three forecasted years, and then remains lower than the 2015 forecast in all future years, with the gap smaller between FY 2028 and FY 2032.

Exhibit I-3a. Quarterly House Price Appreciation Rates: Actual and Forecast from Year 2007 to 2044

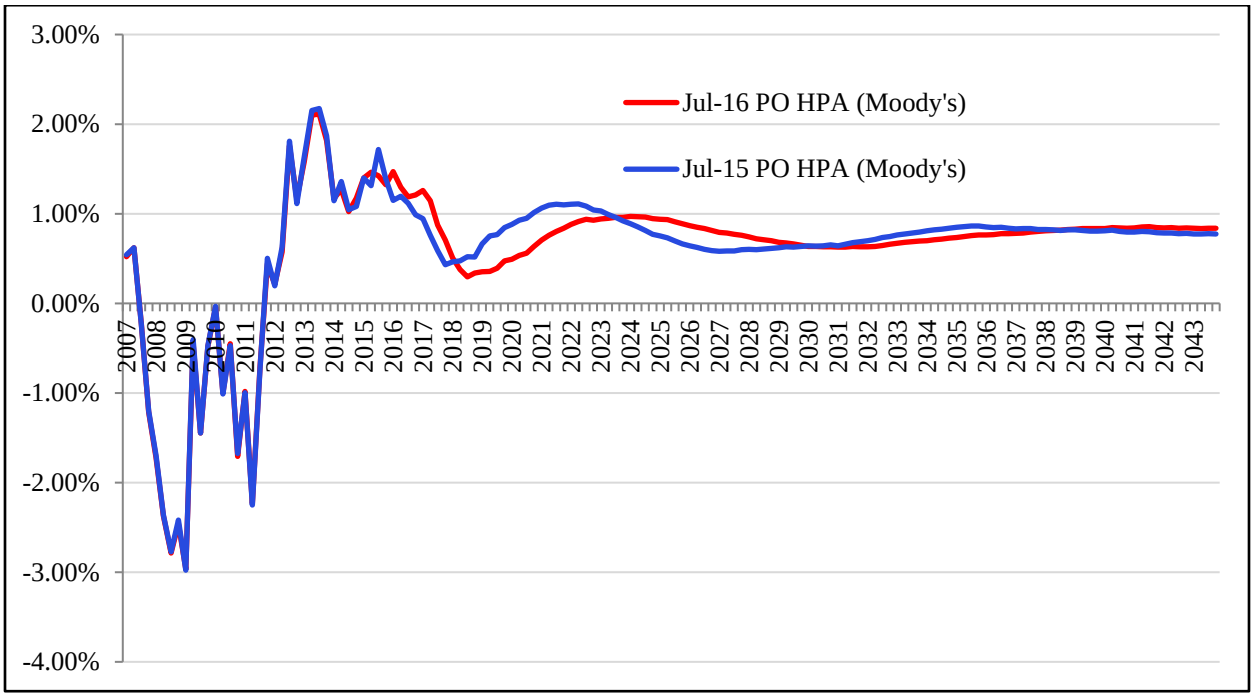
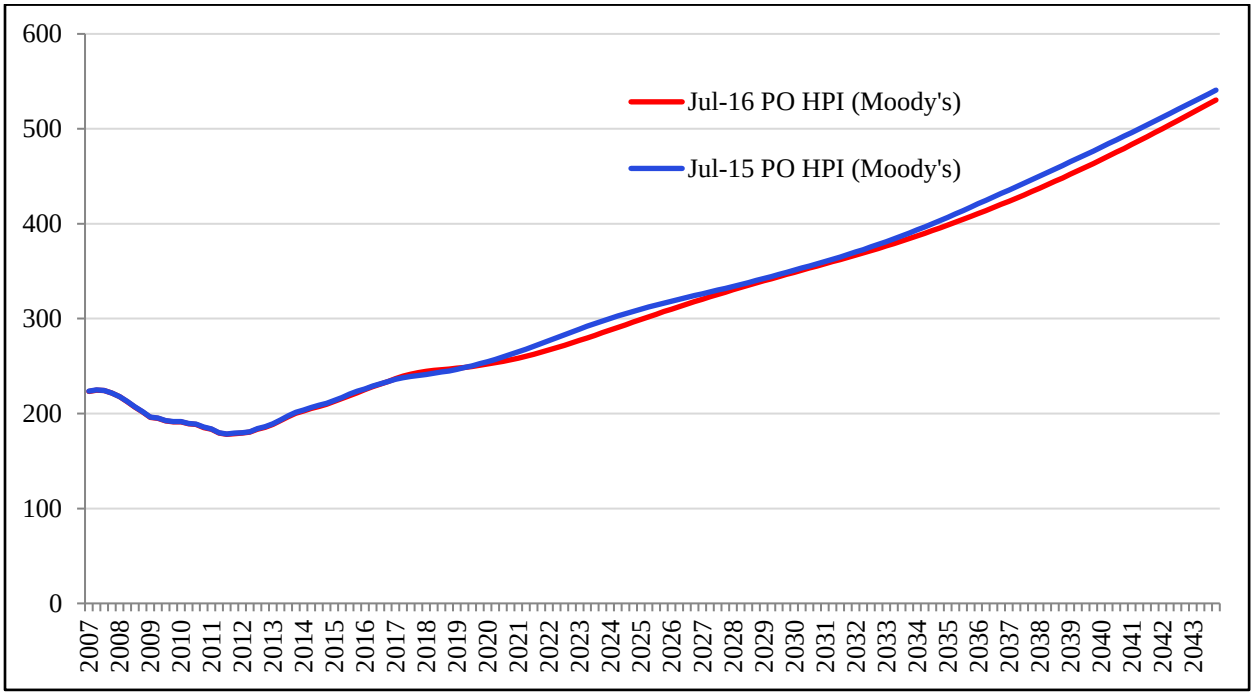


Exhibit I-3b. House Price Indices: Actual and Forecast from Year 2007 to 2044



The house price projections for individual states and MSAs differ from the overall national level. The HECM portfolio active at the end of FY 2016 is concentrated in California, Florida, New York and Texas. Near-term strong growth rates were forecasted for California and Texas, while moderate increases were forecasted for New York and a weak growth rate was forecasted for Florida. The long-term trend of house price growth for California is predicted to be higher than last year's Moody's forecast, while those for Texas, Florida and New York are predicted to be slightly lower. The differences compared to last year's Review are shown below in Exhibit I-3c for these large states and the national average.

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

State	Percent of FY 2016 Portfolio	House Price Growth Forecast			
		Short-Term Trend [20]		Long-Term Trend	
		Forecast in FY 2016 Review	Forecast in FY 2015 Review	Forecast in FY 2016 Review	Forecast in FY 2015 Review
California	17.84%	7.62%	8.67%	4.69%	4.39%
Texas	10.24%	11.08%	5.16%	2.78%	2.98%
Florida	5.42%	1.95%	4.09%	3.35%	3.44%
New York	6.57%	4.94%	2.72%	2.00%	2.22%
National Average		5.30%	4.55%	3.11%	3.15%

The difference of short-term and long-term growth rates in house price affects the HECM portfolio in two ways. First, we observe strong short-term recovery in states like Texas. The higher forecasted housing value may lead to more refinancing and lower claim payments. The improved house price growth rates in FYs 2014-2018 also increase the recovery revenue of HECM loans. On the other hand, the lower long-term trend will impair the HECM portfolio since most extant loans in the FY 2016 Review will be terminated in FY 2025 or later. The lower HPI in the long term has a negative impact on the HECM portfolio through lower recoveries and thus higher claim amounts.

Second, a near-term strong house price forecast increases the additional equity available to a borrower through refinancing. However, this benefit is offset by the lower PLFs imposed in the FY 2014 and the August 14, 2014 policy change. The benefit from the effect of house price appreciation for FY 2013 and prior books are vastly offset by the lower PLFs of the current HECM program. Appendix A provides a detailed analysis of HECM refinancing behavior.

[20] Short-term trend means the growth rate over Calendar Year (CY) 2016 Q3-CY 2017 Q3. Long-term trend means the annualized growth rate from CY 2016 to CY 2046.

2. Interest Rates

According to Federal Reserve Board statistics, the 1-year U.S. Treasury rate has stayed at a 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 2012. Since then, it rose slowly, and reached 2.77% in 2014 Q1. After a temporary drop to 1.97% in 2015 Q1, the rate rallied somewhat. However, the rate started dropping again in 2015 Q3 from 2.22% to 1.75% at 2016 Q2. The 1-year London Interbank Offered Rate (LIBOR) has risen for the last two years, similarly to the 1-year Treasury rate, as shown in Exhibit I-4a.

Exhibit I-4a. Selected Historical Interest Rates

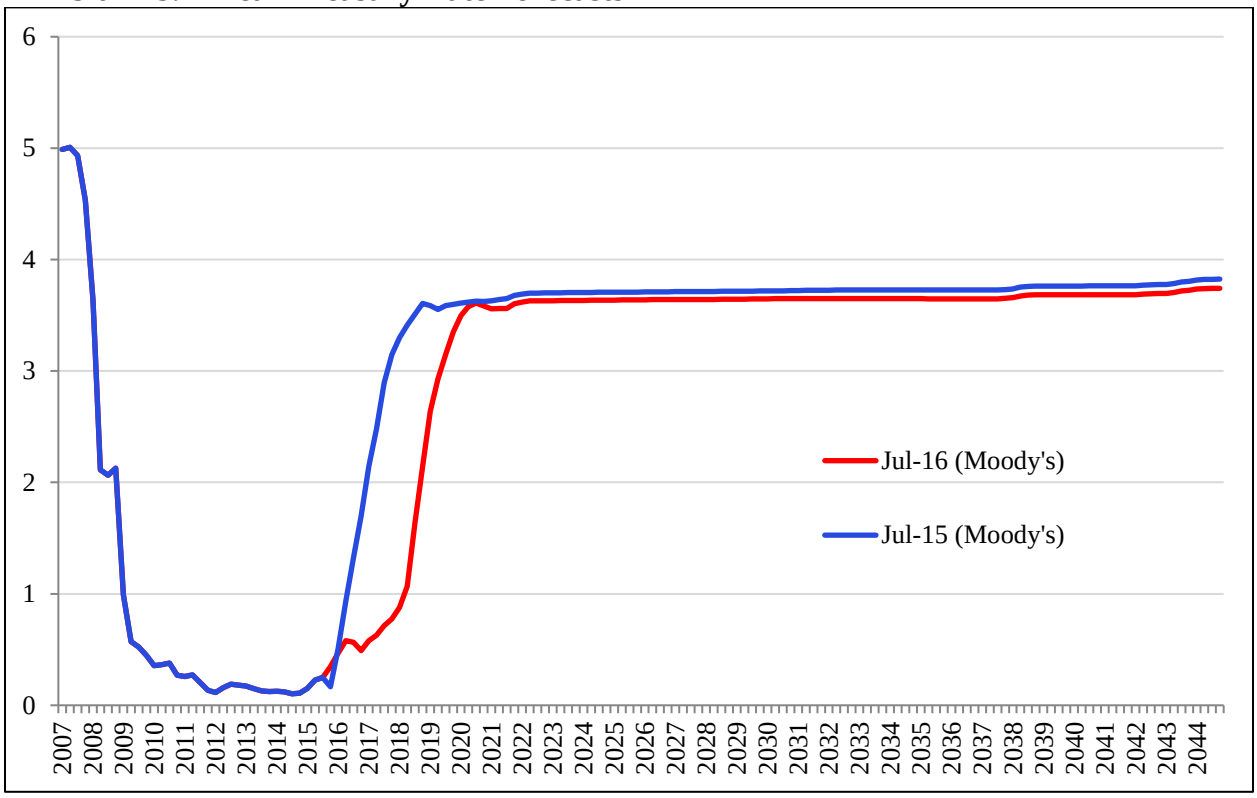
Rate type	Interest Rate		
	2014 Q3	2015 Q3	2016 Q2
1yr CMT	0.11%	0.35%	0.57%
10yr CMT	2.50%	2.22%	1.75%
1yr LIBOR	0.56%	0.82%	1.20%

Approximately 89 percent of loans in the FY 2016 book of business are adjustable rate loans (see Section IV for a detailed breakdown). The mortgage interest rate for adjustable-rate HECMs is the sum of the base rate and the lender's margin. The base rate can be the 1-year Treasury rate or the 1-year LIBOR rate. The expected HECM mortgage interest rate[21] affects the amount of equity available to borrowers. The PLF increases as the expected rate declines for a given borrower age. Moody's has forecasted the 1-year Treasury rate to rise steadily to 3.6 percent by FY 2020 and to stabilize to a long-run rate of around 3.8 percent. This forecast of 1-year Treasury rate implies a continued low interest rate environment, which enables borrowers to access a large percentage of their home equity. However, even though 1-year Treasury rates remain at a low level, lender margins have increased from an average of 1.5 percent during 2008 and prior years to 2.5 percent from 2009 to 2011. In 2012, lender margins increased further to 3.0 percent. Among FY 2016 originations, the margin remained high, at 2.46 percent for adjustable rate loans.

Exhibit I-4b shows the comparison of the 1-year Treasury rate forecasts in the 2015 and 2016 Reviews. The realized 1-year Treasury rates in 2016 was lower than what was forecasted by Moody's in July 2015. The July 2016 projection forecasts a longer low-rate window than the July 2015 forecast until FY 2019. Also the forecast of the long-term level of the 1-year Treasury rate is adjusted downward this year, compared to Moody's July 2015 forecast.

[21] The expected HECM mortgage interest rate for Fixed-Rate products is the embedded coupon rate. For Adjustable-Rate products, the expected mortgage interest rate can be indexed to LIBOR or the 1-year CMT with a constant spread.

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



3. HECM Volume

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. Volume remained steady during the financial crisis with 114,413 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 volume since FY 2009. The initial disbursement limitation and reduction of PLFs in FY 2014 further significantly decreased HECM volume compared with the endorsement volume of FY 2013. Exhibit I-5 shows the actual numbers and dollars of endorsements in FY 2009 through FY 2015 as well as the estimated whole-year for FY 2016 (based on data as of June 30, 2016). The exhibit also presents the volume projections for FY 2017 through FY 2023 based on our updated HECM volume model described in Appendix E. The projection has included possible younger non-borrowing spouses brought in by Mortgagee Letter 2014-12.

Exhibit I-5. Actual and Forecasted FY 2009 to FY 2023 Endorsements

Fiscal Year	Number of Endorsements	Average MCA per Endorsement	Total Endorsements ($millions)
2009	114,413	$262,848	$30,073
2010	79,055	$266,565	$21,073
2011	73,108	$249,134	$18,214
2012	54,818	$240,146	$13,164
2013	59,922	$245,006	$14,681
2014	51,616	$261,948	$13,521
2015	57,986	$278,143	$16,128
2016	49,142	$297,076	$14,598
2017	60,175	$306,904	$18,468
2018	66,719	$312,167	$20,829
2019	71,467	$315,239	$22,534
2020	75,178	$319,835	$24,055
2021	78,227	$326,556	$25,561
2022	80,824	$335,070	$27,100
2023	83,082	$344,518	$28,643

HECM borrowers represent about 1 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 of the senior population. In FY 2016, 19 percent of the population (approximately 57 million) was 62 or older. According to the U.S. Census Bureau's projection, 21 percent of the population (approximately 69 million) will be 62 or older in 2020 and this will grow to 24 percent of the population (approximately 86 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 volume for HECMs.

4. HECM Secondary Market

The secondary market enhances HECM 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 had been the largest portfolio investor of HECM loans. However, new secondary market investors have emerged, replacing Fannie Mae as the predominant outlet for this business. Fannie Mae's share of the reserve mortgage market dropped

from over 90% in early 2009 to less than 1% in the third quarter of 2010. Since December 2010, Fannie Mae ceased acquisitions of newly originated reverse mortgages, and continues to manage the existing HECM books of business.[22] As of June 31, 2016, Fannie Mae held for investment $39 billion in HECMs, with all originations from FY 2010 and prior.

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 HMBSs compared to $5.1 billion in FY 2009. The issuance[23] level dropped to $10.8 billion in FY 2011, to $8.5 billion in FY 2012, to $9.2 billion in FY 2013, to $7.1 billion in FY 2014, to $9.5 billion in FY 2015 and to $4.4 billion in the first two quarters of FY 2016.

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 currently consists of the loans from FY 2009 through FY 2016 endorsement cohorts that were active at the end of FY 2016. All available 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 from 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 accrued by 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, 2016. 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 Analytic economy.com website. These data include the 1-year and 10-year Treasury rates, 1-year LIBOR rates, the median house price, the unemployment rate and the Federal Housing Finance Agency (FHFA) purchase-only house price index. The composition of borrower characteristics for future endorsements is assumed to be consistent with the most recent one-year actual endorsements, adjusted for FHA's projections regarding younger borrowers or spouses. We used an annual cash flow model by fiscal years to estimate the present value of HECM future cash flows.

[22] Selling guide updates, Announcement SEL-2011-05, Fannie Mae, June 28,2011
[23] http://www.ginniemae.gov/media_center/Pages/monthly_issuance_reports.aspx

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 2016 through FY 2023 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 FYs 2009 through 2016.
- 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 eight 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 Volume Model – presents a technical description of the HECM volume 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.

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Section II. Summary of Findings

This section presents the projected economic values and insurance-in-force of the FY 2016 through FY 2023 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 the capital resources as of the end of the fiscal 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 in future fiscal years.

A. The FY 2016 Actuarial Review

The FY 2016 Actuarial Review assesses the actuarial soundness of the HECM portfolio in the MMI Fund (the HECM Fund) as of the end of FY 2016 and projects the status of the HECM Fund through FY 2023. In this Review, we:

- Analyzed all HECM historical termination experience and the associated recoveries using loan-level HECM data maintained by FHA through June 2016. Some critical new data were made available to the Review for the first time this year. Incorporating these newly available data yielded a significant negative impact on the economic value of the HECM Fund.
- Updated the tax and insurance default model to estimate the impact of mandatory termination or extra cash out flow burden of HECM loans. We also updated the conveyance/payoff selection equation.
- Due to data limitations, the base models for mortality, refinance and mobility terminations cannot be updated and remain the same as those in the FY 2015 Review.
- Constructed a stochastic simulation model for 100 possible economic scenarios of interest rates, unemployment rates and house price appreciation rates. These economic paths were calibrated to center around the baseline macroeconomic forecasts published by Moody's Analytics in July 2016.
- Estimated future cash flows associated with the projected FY 2016 to FY 2023 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 2016 through FY 2023, using expected cash flows from the Monte Carlo simulation and discount factors prescribed by the Office of Management Budget (OMB).
- Investigated the sensitivity of the economic value of the Fund among eight future possible economic scenarios from our Monte Carlo simulation paths and Moody's alternative forecasts, as well as with respect to changes in the major economic factors.

The following is a summary of the major findings in this Review, as shown in Exhibit II-1. These findings come from the stochastic simulation of the 100 economic paths around Moody's baseline economic trend forecast. Our estimate of the economic value of the future HECM cash flows is derived from the expected or average cash flows over these 100 paths.

- The economic value of the HECM Fund as of the end of FY 2016 was estimated to be *negative* $7,721 million.
- The economic value of the HECM Fund was projected to decrease over the next seven years and become *negative* $12,537 million by the end of FY 2023.
- 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 may exceed the MCA). The estimated IIF reflects the combined, cumulative impacts of loan terminations and new endorsements. The IIF was estimated to be $111,919 million at the end of FY 2016 and was estimated to increase to $212,560 million by the end of FY 2023.

Exhibit II-1. Baseline Economic Value, Insurance-In-Force, and Endorsements for FY 2016 through FY 2023 ($ 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
2016	-7,721	111,919	14,598	-1,209	
2017	-8,640	113,279	18,468	-799	-120
2018	-9,230	127,108	20,829	-383	-207
2019	-9,817	142,491	22,534	-317	-271
2020	-10,524	158,918	24,055	-391	-315
2021	-11,206	176,082	25,561	-327	-355
2022	-11,875	193,965	27,100	-277	-393
2023	-12,537	212,560	28,643	-233	-429

* All values 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 volume model in Appendix E multiplied by the average MCA. This volume number in FY 2016 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 2015 HECM Review estimates that the HECM portfolio had an economic value of *positive* $6,778 million at the end of FY 2015 compared to the estimate of this year's Review of *negative* $7,721 million at the end of FY 2016. Exhibit II-2 summarizes the major results. The total HECM capital resources were reported to be $9,632 million at the end of FY 2015. Based on actual performance and projections to August 31, 2016, the HECM capital resources have decreased to $4,022 million. We estimate the net present value of future cash flows for surviving loans at the end of FY 2016 to be *negative* $11,743 million. The economic value at the end of FY 2016 is therefore estimated to be *negative* $7,721 million, with insurance-in-force of $111.9 billion

Exhibit II-2. Projected Economic Value of the HECM Portfolio in the MMI Fund at the End of FY 2016 ($ Millions)

Item	End of FY 2015[(1)]	End of FY 2016
Total Capital Resources as of EOY	$9,632	**$4,022[(2)]**
+ NPV of Future Cash Flows on Outstanding Business		-11,743
Economic Value		**($7,721)**
Insurance- In- Force		$111,919

(1) Source: Audited Financial Statements for FY 2015
(2) Source: Audited Financial Statements for FY 2016

C. Decomposition of the Differences in the FY 2016 Economic Value as Reported in the FYs 2015 and 2016 Reviews

The economic value of the HECM portfolio in the MMI Fund changed from *positive* $6,778 million in FY 2015 as estimated in the FY 2015 Review to *negative* $7,721 million in FY 2016 as reported in this year's Review, as taken from the first and last lines of the second column of Exhibit II-3, representing a *decrease* in value of $14,499 million. In additional to incorporating realized actual performance of the Fund over the past two years and updating economic forecasts, main reason for the decrease in economic value is due to updated assumptions resulting from new data that became available for the first time this year.

Exhibit II-3 presents the step-by-step changes from the FY 2015 economic value to this year's estimate of the FY 2016 economic value. A similar analysis for FY 2022 is also included. Note that FY 2022 is the last projected fiscal year common to both Reviews. Also note that the order of the decomposition may affect the magnitude of the changes in value due to individual attributions.

The second row of Exhibit II-3 adjusts the FY 2015 estimate of economic value by the estimated time value of cash flows from FY 2009 to FY 2015 books of business during FY 2016. The third row of Exhibit II-3 further includes the present value of the FY 2016 book as estimated in the FY

2015 Review. After these two adjustments, the economic value as of end of FY 2016 estimated in the FY 2015 Review is positive $7,429 million. The projected economic values of the Fund as of the end of both FYs 2016 and 2022 are reported below.

Exhibit II-3. Sources of the Change in Economic Value for the HECM Portfolio in the MMI Fund between FY 2015 and FY 2016 ($ Millions)

Decomposition Steps	Change in FY 2016 Economic Value	FY 2016 Economic Value	Change in FY 2022 Economic Value	FY 2022 Economic Value
FY 2015 Economic Value Presented in FY 2015 Review		6,778		
FY 2016 Economic Value Presented in the FY 2015 Review Excluding the FY 2016 Book-of-Business	76	6,854		
Plus: Forecasted Value of FY 2016 Book-of-Business Presented in the FY 2015 Review	575			
Equals: FY 2016 Economic Value Presented in the FY 2015 Review		**7,429**		**13,665**
plus: a. Origination Volume Update for FY 2015 and later Books	-32	7,397	756	14,421
plus: b. Update Performance and Future Book Compositions	-1,764	5,633	-2,462	11,959
plus: c. 2016 Model Update	-918	4,715	-2,591	9,368
plus: d. Economic Scenario Update	684	5,399	909	10,277
plus: e. Discount Factor Update	35	5,434	41	10,318
Equals: f. 2016 Model Update, Economic Scenario and Discount Factor Update		5,434		10,318
plus: g. Assumption Adjustment - Sale Price Discount	-6,452	-1,018	-10,509	-191
plus: h. Assumption Adjustment - Expenses Claimed from HUD at Property Sale	-2,254	-3,272	-3,735	-3,926
plus: i. Assumption Adjustment – Non-assignment Assumption	-4,449	-7,721	-7,949	-11,875
Equals: Estimate of Economic Value	**-15,150**	**-7,721**	**-25,540**	**-11,875**

a. Origination Volume Update for FY 2015 and Later Books

In the FY 2016 Review, both volumes of realized endorsements occurring in FY 2015 and the projected FY 2016 endorsements were lower than the FY 2015 and FY 2016 projections, respectively in FY 2015 Review. Since the economic values of the FY 2015 and FY 2016 books were both positive in the 2015 Review, the net effect of updating downward origination volumes

is a decrease in economic value of the FY 2016 portfolio by $32 million. Also, the volume of FY 2017 and later books projected by HUD is higher than the endorsement projection used in the 2015 Review. This volume update increases the economic value of the FY 2022 portfolio by $756 million.

b. Update Performance and Future Book Compositions

When we use FY 2016 actual data to replace estimated FY 2016 performance estimated in the FY 2015 Review, the change in the FY 2015 portfolio value in this step mainly consists of three parts: (i) Update actual compositions for the FY 2015 and FY 2016 books, and the forecasted compositions for FY 2016 and later books; (ii) the books for FYs 2009-2015 are updated with actual termination and assignment data for the past year and (iii) the update of capital resources. The combined effect is a $1,764 million decrease in the economic value for FY 2016 and a decrease of $2,462 million for FY 2022.

c. 2016 Model Update

In this year's Review, the T&I default and the conveyance/payoff choice models are updated, which produced a $918 million decrease in the FY 2016 economic value and a decrease in the FY 2022 economic value by $2,591 million. The base models for terminations due to mortality, refinance and mobility were not updated, because the Social Security Administration no longer provides information regarding the deaths of HECM borrowers. So, there is no change in economic value from termination model.

d. Economic Scenario Update

The macroeconomic forecast changes have a positive impact on the forecasted FY 2016 economic value. The primary driver is lower interest rates. The lower 1-year Treasury rate over the long term will reduce the accrual rate for unpaid mortgage balances, resulting in lower Claim Type I and delays in the timing of assignments. The impact of economic scenario changes may be inferred from the sensitivity tests shown in Section V.D. The combined effect from economic scenario updates is a $684 million increase in the economic value for FY 2016 and an increase of $909 million for FY 2022.

e. Discount Factor Update

This decomposition step shows the effect of updating the discount factors. As shown in Appendix C, up to 2041, the latest OMB published discount factors are slightly higher than the factors used in the FY 2015 Review. The higher discount factors increase the present value of positive cash flows and also increase the absolute size of the present value of negative cash flows. In the HECM portfolio the main cash flows consist of a stream of premiums, claim payments and recoveries. The premiums and recoveries are positive cash flows while the claims represent negative cash flows. The impact of higher discount factors depends on the duration and magnitude of these cash

flows. The net effect of the higher discount factor leads to an increase of $35 million in the FY 2016 HECM economic value and an increase of $41 million in the FY 2022 HECM economic value.

g. Sale Price Discount, or "Haircut" Update

For this 2016 Review, we received additional sale price datasets from FHA, which enable an analysis of maintenance risk, as measured by the magnitude of the sales price discount, by different disposition types.

The source data are the FHA Single Family Acquired Asset Management System (SAMS) and the FHA Home Equity Reverse Mortgage Information Technology (HERMIT) System. The SAMS dataset is not part of the FHA data warehouse, which has been the primary source of data for the Actuarial Reviews. The new dataset shows that the sale price discounts or "haircuts" from normal market prices are much higher than the discount assumed in prior reviews. Because the actual sales prices were not available in previous years, sample sales prices for properties underlying HECMs were collected from CoreLogic. That dataset has been used to estimate the discounts for the FY 2014 and 2015 Reviews. Both the SAMS database and the new data from HERMIT showed that the actual sale prices are lower than those in the CoreLogic sample. It appears that the prices collected from CoreLogic may be either the price that the property is sold to a third party or the price paid by FHA or the lender to acquire the title of the house through foreclosure sales. The CoreLogic sample data enabled the estimation of an average discount rate among different claim cases. The SAMS dataset and the additional data collected from HERMIT clearly identified the eventual price of the property when it is disposed by FHA or the lender to a third party. It also identifies whether a property is sold by FHA or by the lender. As a result, these newly provided datasets offer more precise and reliable data of the disposition prices of the houses underlying terminated HECM loans.

The discount or haircut of a HECM property is the reduction in price that it would sell for compared to an otherwise identical property on the market. The specific definition is described in Appendix B. This haircut reflects the condition of these properties, which is inferior to those normally being sold, presumably because there is lack of resources or incentive to maintain a HECM property relative to non-HECM properties. It also includes the typical price discount when a property is sold by a lending institution or by a government entity like FHA. As described in Appendix B, we estimate the sale price discount for Claim Type I (a loan not assigned to HUD) and Claim Type II (an assigned loan) with conveyance based on an econometric model. The model includes various risk factors, including loan balance, house price appreciation rate, loan age, etc. For Claim Type I in the FY 2015 Review, the sales discount was around 20 to 25 percent of the sales price at disposition. With this new data, the discount for this Review is showed to be around 45 to 50 percent. The historical data from the new dataset show that the haircut for Claim Type II conveyance cases in later policy years is around the 45 to 50 percent level, instead of the 20 to 25 percent level estimated based on the external CoreLogic sample dataset.

In a Claim Type II payoff case, the borrower or his/her estate pays 95 percent of the appraised value to keep the property. As these properties do not go through foreclosure auction process, and the CoreLogic sample data appears to be accurate. By using an exponential decay function, the FY 2016 estimate of the haircut for Claim Type II payoff starts out low for initial policy years and rises at a decreasing rate to stabilize at the 18 to 20 percent levels, instead of the 20 to 25 percent levels estimated in previous years.

Due to the higher haircuts observed this year, the economic value for FY 2016 decreases by $6,452 million and for FY 2022 by $10,509 million.

h. Expenses Claimed from HUD at Property Sale Update

The newly available datasets from SAMS and HERMIT also record all expenses associated with claims. The data show that the other sales expenses were much higher than estimated in previous Reviews. The primary component of this increase is the Management and Operation (M&O) expenses for claim Type II conveyance properties. This expense item consists of 64 possible components, including disaster repairs, mold treatment, property management fees, homeowners' association fees, demolition, clean-up and debris removal, yard maintenance and winterizing and snow removal fees.

To reflect the expenses recorded by FHA upon disposition, the FY 2016 Review adds Other Expense equivalent to 18 percent of the sales price on top of the average 7 percent sale expense for HECMs terminated with Claim Type I (pre-assignment). This is a total expense of 25 percent, up from 7 percent in previous Reviews.

For Claims Type II conveyance cases, with the new data, extra Other Expenses are about 19 percent of the sale price. Combined with the 7 percent sales expense, the total expense is estimated to be about 26 percent of the sale price, up from 19 percent assumed in previous years.

Consequently, accounting for the higher total expenses, the FY 2016 economic value decreases by $2,254 million and the FY 2022 economic value decreases by $3,735 million.

i. Non-assignment Assumption Update

In the FY 2015 and prior Reviews, it was assumed that once the UPB of a HECM loan reaches 98 percent of the MCA, the loan is assigned to FHA. However, data over FY 2007 to FY 2016 show that only approximately 40 percent of the loans that reached 98 percent of the MCA were assigned to FHA. Additional information was provided regarding the reasons those 60 percent of loans were not assigned: they did not meet eligibility requirement promulgated by FHA. Examples of reasons for not allowing assignments include ongoing bankruptcies, foreclosures, and loss mitigation activities. Consequently, we revised the assumption that only 40 percent of loans that reach the 98 percent UPB/MCA ratio are eligible for assignment. The remaining ineligible loans will remain unassigned through their termination. At the termination, if the net sale price of the house is

insufficient to cover the loan balance, the lender will file a Claim Type I. As the loan balance is compounded at a rate much higher than the growth rate of the underlying house, this claim amount will grow exponentially after the balance reaches 98 percent of the MCA. Nevertheless, the claim amount cannot exceed the MCA.

This update in the non-assignment assumption reduces the FY 2016 economic value by $4,449 million, and the FY 2022 economic value by $7,949 million.

Section III. Current Status of HECMs in the MMI Fund

This section presents the components of the economic value for FY 2016 and also the projections through FY 2023. The HECM portion of the MMI Fund has an estimated economic value of *negative* $7,721 million at the end of FY 2016. While the insurance-in-force of the HECM program is projected to increase over time, the economic value is estimated to decrease over time under the baseline assumptions applied in the stochastic simulation.

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 2016. Exhibit III-1 presents the components of the economic value for FY 2016.[24] Data through June 2016 was annualized to estimate the total capital resources and the loan performance to the end of FY 2016. The total economic value consists of the following components:

- *Total Capital Resources* equals assets less liabilities in the Fund's balance sheet. The total capital resources are projected to be $4,022 million at the end of FY 2016.

- *Net Present Value of Future Cash Flows on Outstanding Business* consists of discounted 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 net present value of future cash flows is estimated to be *negative* $11,743 million as of the end of FY 2016.

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

Exhibit III-1. Projected Economic Value of the HECM Portfolio in the MMI Fund at the End of FY 2016 ($ Millions)

Item	End of FY 2015[(1)]	End of FY 2016
Total Capital Resources as of EOY	$9,632	**$4,022[(2)]**
+ NPV of Future Cash Flows on Outstanding Business		-11,743
Economic Value		**($7,721)**
Insurance- In- Force		$111,919

(1) Source: Audited Financial Statements for FY 2015
(2) Source: Audited Financial Statements for FY 2016

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 2016. 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 insurance portfolio, using the current loan balances to estimate the IIF could 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 may be required to pay out at insurance termination, although it may not cap the possible exposure.

Exhibit III-2 presents the estimated net present value, survival loan count and insurance-in-force for FY 2009 to FY 2016 active endorsements at the end of FY 2016.

Exhibit III-2. Estimated Survival Loan Count and Insurance-in-Force

Endorsement Fiscal Year	Net Present Value of Future Cash Flows ($ Millions)	Survival Loan Count	Insurance-in-Force ($ Millions)
2009	-2,634	79,466	20,754
2010	-843	56,892	14,914
2011	-1,478	55,226	13,428
2012	-1,349	42,833	10,036
2013	-1,641	50,057	12,010
2014	-983	43,413	11,118
2015	-1,403	54,571	15,059
2016	-1,412	49,142	14,598

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

We present the forecasts of the future economic values and insurance-in-force projected for MMI HECMs. We estimated these future values by applying our termination and cash-flow models to the endorsements, which were forecasted by the HECM volume model described in Appendix E. The borrower characteristics of the most recent actual endorsed loans were used to project the composition of loan-level characteristics of future endorsements.

Exhibit III-3 shows the estimated economic values of future MMI HECM books of business and the corresponding insurance-in-force.[25] All values in the exhibit are discounted to the end of each corresponding fiscal year.

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 decrease from *negative* $7,721 million in FY 2016, to *negative* $12,537 million in FY 2023, as shown in the first column of Exhibit III-3. This decrease is primarily due to the projected negative economic value brought to the Fund by high expenses incurred in disposing the properties underlying the terminated HECM loans. Deep discounts on sale prices of those properties further impair the economic value.

With the new endorsements, the total insurance-in-force is estimated to increase from $111,919 million at the end of FY 2016 to $212,560 million in FY 2023. This represents an average net increase of $14,377 million per year.

[25] Note that Exhibit III-3 is the same as Exhibit II-1, reproduced in this section for convenience.

Exhibit III-3. Baseline 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
2016	-7,721	111,919	14,598	-1,209	
2017	-8,640	113,279	18,468	-799	-120
2018	-9,230	127,108	20,829	-383	-207
2019	-9,817	142,491	22,534	-317	-271
2020	-10,524	158,918	24,055	-391	-315
2021	-11,206	176,082	25,561	-327	-355
2022	-11,875	193,965	27,100	-277	-393
2023	-12,537	212,560	28,643	-233	-429

* All values are expressed 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 volume model in Appendix E multiplied by the average MCA. This volume number in FY 2016 reflects the outstanding loans at the end of the fiscal year, and excludes loans endorsed and terminated in the same fiscal year.

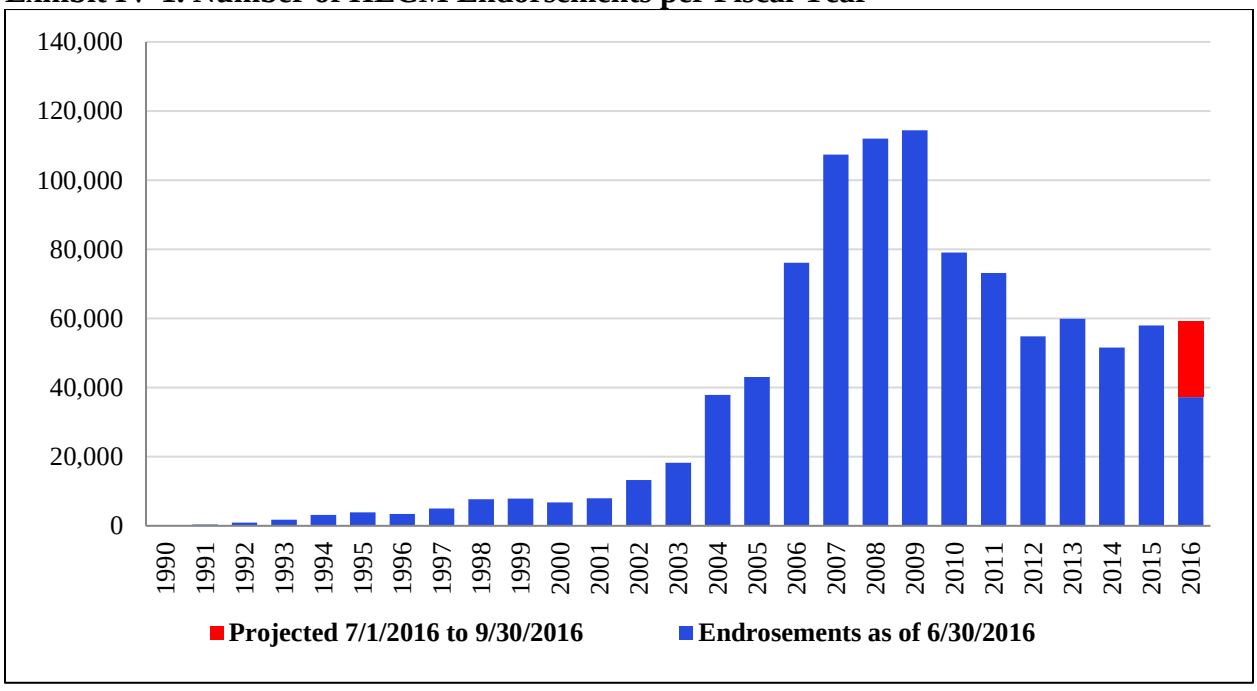
Section IV. Characteristics of the MMI HECM Books of Business

This section presents the characteristics of the HECM portfolio for the HECM loans endorsed from FY 2009 through FY 2016. 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 2016. A review of the characteristics of these books helps define the current risk profile of MMI HECMs. 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, 2016.

A. Volume and Share of Mortgage Originations

FHA endorsed 37,191 HECM loans from October 1, 2015 to June 30, 2016, with a total dollar value, measured by the MCA, of $11.05 billion. FHA estimates that the dollar value in FY 2016 total endorsements will be about $14.60 billion and the corresponding average MCA will be about $247,000. The total endorsement number of FYs 2009-2015 was 490,918. The corresponding dollar value was $126.85 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 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, *i.e.*, term, line of credit, tenure and combinations. Exhibit IV-2 presents the distributions of HECM endorsements for FYs 2009 through 2016 by payment plan. As of June 30, 2016, the majority of HECM borrowers selected the line of credit option. This option accounts for 89 percent of the FY 2016 endorsements.

Exhibit IV-2. Distribution of FY 2009-FY 2016 HECM Loans by Payment Type

FY	Loan Type	Term	Line of Credit	Tenure	Term + Line of Credit	Tenure + Line of Credit	Total
2009	Number of Loans	962	104,803	1,876	4,283	2,489	114,413
	Percentage	0.84%	91.60%	1.64%	3.74%	2.18%	100.00%
2010	Number of Loans	401	74,408	761	2,184	1,301	79,055
	Percentage	0.51%	94.12%	0.96%	2.76%	1.65%	100.00%
2011	Number of Loans	306	68,967	699	2,013	1,123	73,108
	Percentage	0.42%	94.34%	0.96%	2.75%	1.54%	100.00%
2012	Number of Loans	176	51,867	510	1,439	826	54,818
	Percentage	0.32%	94.62%	0.93%	2.63%	1.51%	100.00%
2013	Number of Loans	292	56,773	615	1,408	834	59,922
	Percentage	0.49%	94.74%	1.03%	2.35%	1.39%	100.00%
2014	Number of Loans	425	47,959	839	1,509	880	51,616[26]
	Percentage	0.82%	92.91%	1.63%	2.92%	1.70%	100.00%
2015	Number of Loans	498	53,932	816	1,453	1,000	57,986[27]
	Percentage	0.86%	93.01%	1.41%	2.51%	1.72%	100.00%
2016	Number of Loans	384	33,137	563	774	590	37,191[28]
	Percentage	1.03%	89.10%	1.51%	2.08%	1.59%	100.00%

[26] There are 4 observations in FY 2014 with missing information on payment type.
[27] There are 287 observations in FY 2015 with missing information on payment type.
[28] There are 1,743 observations in FY 2016 with missing information on payment type.

C. Interest Rate Type

HECM borrowers can select fixed or adjustable rate mortgages. Exhibit IV-3 shows the distribution of HECM endorsements for FYs 2009 through 2016 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 maintained that level in FYs 2011 and 2012. Then fixed-rate loans climbed further to 72 percent of endorsements in the first three quarters of FY 2013. After that, the share of fixed-rate HECM loans dropped sharply. In FY 2013 as a whole, it dropped to 61 percent, and by FY 2016, it had dropped down to 11 percent.

The LIBOR-indexed loans were in the 30 to 40 percent range over FYs 2009-2013. In FY 2014, they increased to 81 percent, as the fixed-rate option correspondingly declined in popularity. In FY 2016, they increased to an all-time high at 89 percent. Monthly adjustable LIBOR loans dominated in FY 2014. In FY 2015 monthly adjustable LIBOR loans were slightly more popular. However so far in FY 2016 the annually adjustable LIBOR loans are dominating.

Exhibit IV-3. Distribution of FY 2009-FY 2016 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	39,598	684	60,798	13,310	114,413
	Percentage	0.02%	34.61%	0.60%	53.14%	11.63%	100.00%
2010	Number of Loans	7	24,175	9	395	54,469	79,055
	Percentage	0.01%	30.58%	0.01%	0.50%	68.90%	100%
2011	Number of Loans	6	23,319	2	44	49,737	73,108
	Percentage	0.01%	31.90%	0.00%	0.06%	68.03%	100.00%
2012	Number of Loans	1	16,699	4	66	38,048	54,818
	Percentage	0.00%	30.46%	0.01%	0.12%	69.41%	100.00%
2013	Number of Loans	1	23,579	0	13	36,329	59,922
	Percentage	0.00%	39.35%	0.00%	0.02%	60.63%	100.00%
2014	Number of Loans	1,242	40,736	0	0	9,638	51,616
	Percentage	2.41%	78.92%	0.00%	0.00%	18.67%	100.00%
2015	Number of Loans	23,089	25,717	45	4	9,131	57,986
	Percentage	39.82%	44.35%	0.08%	0.01%	15.75%	100.00%
2016	Number of Loans	26,824	6,239	148	3	3,977	37,191
	Percentage	72.12%	16.78%	0.40%	0.01%	10.69%	100.00%

D. Product Type

Almost all the loans endorsed in FY 2009 through FY 2016 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 were never more than 4 percent of HECM endorsements for each subsequent year, as seen in Exhibit IV-4. In our analysis, the traditional and for-purchase HECMs are treated the same.

Exhibit IV-4. Distribution of FY 2009-FY 2016 HECM Loans by Product Type

FY	Product Type	Traditional HECMs	HECMs 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	113,855	84	474	114,413
	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	53,191	390	1,237	54,818
	Percentage	97.03%	0.71%	2.26%	100.00%
2013	Number of Loans	57,833	101	1,988	59,922
	Percentage	96.51%	0.17%	3.32%	100.00%
2014	Number of Loans	49,791	452	1,373	51,616
	Percentage	96.46%	0.88%	2.66%	100.00%
2015	Number of Loans	55,576	829	1,581	57,986
	Percentage	95.84%	1.43%	2.73%	100.00%
2016	Number of Loans	35,473	582	1,136	37,191
	Percentage	95.38%	1.56%	3.05%	100.00%

E. Endorsement Loan Counts by State

Among all endorsements in FY 2009 through FY 2016, approximately 35 percent were originated in California, Florida, Texas, and New York as measured by loan counts. California had the highest endorsement volume every year over this 8-year period at 13.7 percent, 14 percent, 13.5 percent, 12.7 percent, 14.1 percent, 17.5 percent, 20.3 percent and 21.6 percent, respectively. While Florida had the second highest endorsement volume in both FYs 2009 and 2010, the percentage in FY 2010 decreased by more than one-third, from 13.2 percent in 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 to 7 percent. In FY 2015 and FY 2016, it rose back and stayed as the second highest at 8.3 percent and 8.6 percent. The endorsement volume in Texas increased steadily from FY 2009 to FY 2011 and was the second highest state of endorsement volume for FYs 2011-2014. It dropped in recent years and was the third largest HECM state in FY 2015 and FY 2016. 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 2016 HECM Loans

FY	State	California	Florida	New York	Texas	Total
2009	Number of Loans	15,658	15,090	6,085	7,590	114,413
	Percentage	13.69%	13.19%	5.32%	6.63%	
2010	Number of Loans	11,059	7,109	4,625	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	6,961	3,369	3,943	4,900	54,818
	Percentage	12.70%	6.15%	7.19%	8.94%	
2013	Number of Loans	8,428	3,907	3,807	5,127	59,922
	Percentage	14.06%	6.52%	6.35%	8.56%	
2014	Number of Loans	9,048	3,584	3,028	3,845	51,616
	Percentage	17.53%	6.94%	5.87%	7.45%	
2015	Number of Loans	11,758	4,819	3,330	4,080	57,986
	Percentage	20.28%	8.31%	5.74%	7.04%	
2016	Number of Loans	8,043	3,179	1,774	2,852	37,191
	Percentage	21.63%	8.55%	4.77%	7.67%	

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 and appraised value, not to exceed the HECM loan limit). 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 from FYs 2009 through 2016 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 loans with MCA less than $300,000 increased to 70 percent in FY 2011, 72 percent in FY 2012, and started to drop to 71 percent in FY 2013, 67 percent in FY 2014, 64 percent in FY 2015 and 59 percent in FY 2016.

The percentage of endorsements with an MCA between $300,000 and $417,000 dropped from 18 percent in 2009 and has been around 13 percent for FY 2010 until FY 2014, but rose back to 15 percent in 2015. The percentage increased to 17 percent in 2016. The percentage of endorsements with an MCA greater than $417,000 has averaged 19.15 percent and ranged from a minimum of 15.6 percent to a maximum of 24.8 percent.

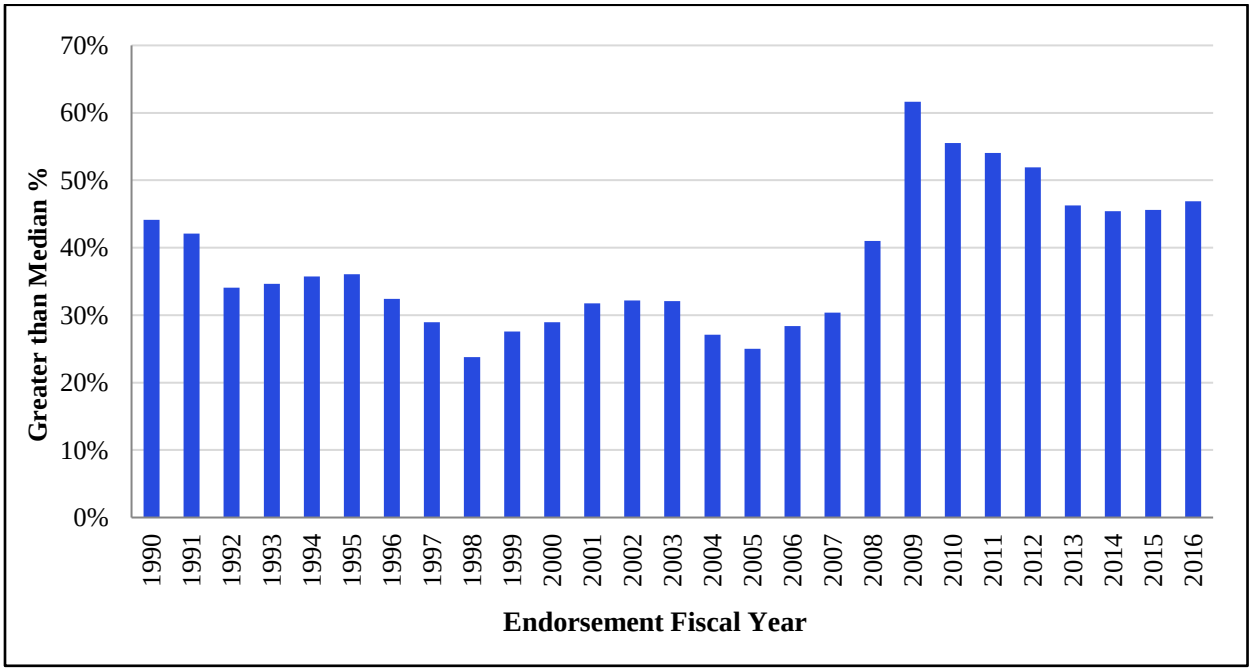
Exhibit IV-6. Distribution of FY 2009-FY 2016 HECM Loans by MCA Level

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%	15.56%	100%
2013	15.62%	36.29%	18.79%	13.08%	16.22%	100%
2014	13.00%	34.19%	19.74%	13.98%	19.10%	100%
2015	11.01%	31.37%	20.73%	15.24%	21.65%	100%
2016	8.19%	28.76%	21.65%	16.61%	24.80%	100%

G. Appraised House Value

FHA research has found, and our empirical findings reinforce, that loans associated with properties with an appraised value at origination greater than their area median tend to be maintained better than those with appraised value below the area median. Exhibit IV-7 shows the percentage of HECM loans 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, 62 percent of the HECM properties were appraised at higher than the area median. Over FY 2010 to FY 2016, the ratio dropped and stabilized at around 47 percent.

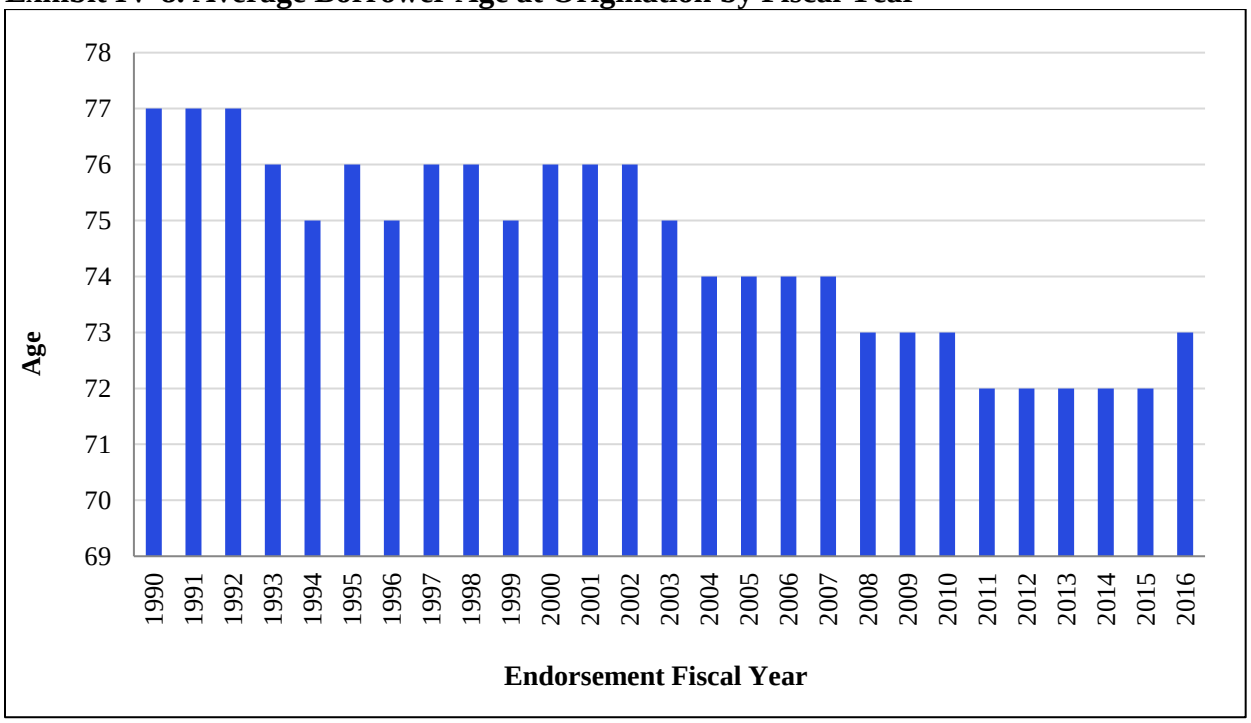
Exhibit IV-7. Percentage of Borrowers with Appraised House Value Greater than Area Median Value



H. Borrower Age Distribution

The borrower age profile of an endorsement year affects loan termination rates and the principal limit available to the borrower. Exhibit IV-8 presents the average borrower age at origination over FYs 1990-2016. 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 principal limit factors (PLFs), which limit the percentage of initial equity available to the borrower, are lower for younger borrowers, limiting their access to a smaller portion of the equity in the house. The average borrower age was about 73 years for FYs 2008-2010, and 72 years for FYs 2011-2015. It rose back to 73 years for FY 2016.

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 rates. The gender distribution of the HECM portfolio has remained steady over time. HECM loan behavior indicates that single males tend to terminate their loans the fastest, single females terminate the second fastest, and couples terminate the slowest. Exhibit IV-9 presents the gender distribution of HECM endorsements from FY 2009 through 2016. Single females comprise the largest gender cohort of the FY 2010 endorsements at 42 percent, followed by couples at 35 percent, and single males at 21 percent. A similar pattern is observed for FYs 2011 and 2012. In FYs 2013-2015, couples comprise 39 percent, surpassing single females to become the largest gender cohort. The single female share fell to around 37 percent while single males remain the lowest at 21 percent, about the same as in prior years. The concentration in couples further rose to 41 percent in FY 2016.

Exhibit IV-9. Distribution of FY 2009-FY 2016 HECM Endorsements by Gender

Endorsement Fiscal Year	Male	Female	Couple	Missing
2009	21.69%	40.92%	36.76%	0.63%
2010	21.47%	41.87%	35.25%	1.41%
2011	20.86%	40.25%	37.08%	1.82%
2012	21.22%	39.16%	37.35%	2.27%
2013	21.15%	37.56%	38.96%	2.34%
2014	20.63%	38.74%	38.65%	1.99%
2015	21.86%	38.53%	38.92%	0.69%
2016	21.78%	36.87%	40.96%	0.39%

J. Cash Draw Distribution

Data show that loans which have drawn a higher percentage of the initial amount of equity available tend to 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 2016.

Younger borrowers tend to draw a higher percentage of the initial amount of equity available than older borrowers. In FY 2009, 78 percent of the 62-65 age group drew over 60 percent of their initial principal limit, compared with 54 percent for the greater-than-85-year-old age group. The incidence of initial draws of above 60 percent of the principal limit rose sharply to above 80 percent over all age groups for FYs 2010-2013. This was mainly driven by the disproportionally high initial draws incurred by most fixed-rate HECMs during that period. In 2014 HUD limited the insurability of fixed interest rate mortgages under the HECM program to mortgages with the Single Disbursement Lump Sum payment option.[29] Also in the same year, HUD introduced a higher mortgage insurance premium charge of 2.50 percent if the initial draw amount exceeds 60 percent of the available principal limit, as compared to the 0.50 percent MIP if the initial draw amount is less than or equal to 60 percent of the available principal limit. The overall first-month draw over 60 percent fell from 80 percent in FY 2013 to 46 percent in FY 2016.

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 2016 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%	40-60%	60-100%	0-60%	60-100%
2009	62-65	20,722	11.84%	10.27%	64.28%	0.28%	13.33%
	66-70	28,474	14.30%	10.74%	61.85%	0.09%	13.02%
	71-75	25,387	18.37%	11.38%	58.60%	0.05%	11.60%
	76-85	30,186	24.28%	11.94%	53.76%	0.05%	9.97%
	85+	9,644	34.72%	10.79%	46.48%	0.09%	7.91%
	Total	114,413	19.11%	11.12%	58.14%	0.11%	11.53%
2010	62-65	15761	7.38%	4.38%	7.82%	0.26%	80.16%
	66-70	18,813	8.92%	5.18%	9.43%	0.18%	76.29%
	71-75	16,997	12.86%	6.40%	10.61%	0.18%	69.95%
	76-85	20,323	19.43%	7.64%	12.94%	0.15%	59.85%
	85+	7,161	30.95%	8.71%	14.31%	0.31%	45.72%
	Total	79,055	14.16%	6.23%	10.71%	0.20%	68.70%

[29] Mortgagee Letter 2014-11, June 18, 2014

2011	62-65	17,003	8.27%	5.05%	9.96%	0.29%	76.42%
	66-70	18,139	10.57%	5.64%	9.44%	0.21%	74.14%
	71-75	15,171	14.63%	6.58%	9.94%	0.15%	68.70%
	76-85	16,788	21.84%	7.82%	10.93%	0.14%	59.28%
	85+	6,007	35.11%	8.07%	10.44%	0.10%	46.28%
	Total	73,108	15.48%	6.40%	10.09%	0.19%	67.84%
2012	62-65	13,712	8.56%	5.45%	10.41%	0.18%	75.40%
	66-70	13,782	10.51%	5.57%	9.36%	0.14%	74.42%
	71-75	10,897	13.87%	6.38%	9.41%	0.12%	70.23%
	76-85	11,922	20.23%	7.10%	9.85%	0.17%	62.65%
	85+	4,505	32.21%	7.72%	10.06%	0.24%	49.77%
	Total	54,818	14.59%	6.21%	9.79%	0.16%	69.25%
2013	62-65	14,926	7.89%	5.78%	20.84%	0.18%	65.32%
	66-70	15,879	9.74%	5.87%	20.28%	0.18%	63.93%
	71-75	12,101	13.20%	6.15%	19.36%	0.23%	61.06%
	76-85	12,656	18.94%	6.97%	19.35%	0.21%	54.53%
	85+	4,360	30.00%	7.29%	16.19%	0.25%	46.26%
	Total	59,922	13.39%	6.24%	19.74%	0.20%	60.42%
2014	62-65	12,031	12.12%	26.86%	38.37%	1.75%	20.90%
	66-70	13,892	14.75%	24.67%	39.27%	1.72%	19.59%
	71-75	10,650	19.01%	25.17%	37.37%	1.65%	16.79%
	76-85	11,061	24.22%	25.91%	35.42%	1.94%	12.50%
	85+	3,982	35.51%	26.75%	27.95%	2.18%	7.61%
	Total	51,616	18.65%	25.71%	36.97%	1.80%	16.87%
2015	62-65	12,644	12.66%	35.46%	33.14%	0.59%	18.15%
	66-70	15,109	14.55%	32.78%	34.13%	0.60%	17.94%
	71-75	12,250	17.98%	31.58%	34.07%	0.51%	15.85%
	76-85	13,201	23.00%	32.04%	32.71%	0.63%	11.63%
	85+	4,782	33.42%	33.29%	26.24%	0.96%	6.09%
	Total	57,986	18.34%	32.98%	32.93%	0.62%	15.13%
2016	62-65	6,642	16.83%	35.91%	33.57%	0.78%	12.90%
	66-70	9,721	18.08%	31.84%	36.42%	0.49%	13.17%
	71-75	8,264	19.40%	31.21%	38.11%	0.18%	11.11%
	76-85	9,148	24.37%	31.22%	36.89%	0.36%	7.16%
	85+	3,416	33.49%	33.43%	29.60%	0.56%	2.93%
	Total	37,191	21.11%	32.42%	35.77%	0.45%	10.24%

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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 projections. In this section, we present the baseline economic value from the Monte Carlo simulation and eight alternative scenarios. The baseline case in the Review is the mean of the economic values of the MMI HECM portfolio over 100 equally likely simulated paths. The alternative scenarios estimate the performance of the Fund under the future interest rates, unemployment rates and house price appreciation rates specific to that scenario.

The eight alternative scenarios are: [30]

- 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 Baseline as a deterministic Scenario, as of July 2016.
- Moody's Protracted Slump Scenario, the most stressful alternative scenario forecasted by Moody's Analytics in July 2016.
- Low Rate Scenario, the path that assumes interest rates remain at the current low level for two years and gradually rise to the long-term projection of Moody's forecast in another two years.

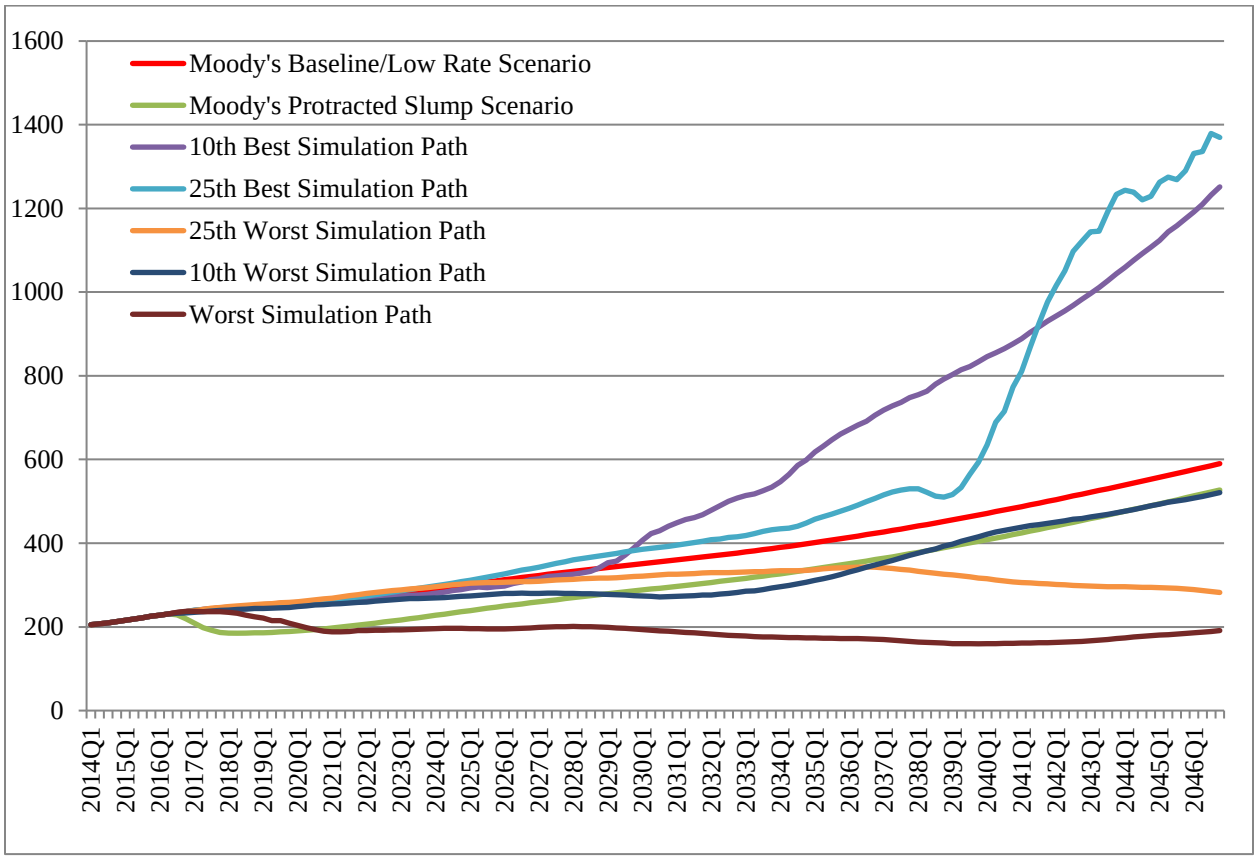
Under Moody's Protracted Slump Scenario, the levels of the house price indices converge to a long-term index level similar to its baseline forecast. As a result, this scenario shows low house price growth rates in the short-term, followed by higher-than-base-case growth rates after it passes the lowest point. We applied an adjustment by assuming that the growth rates converge to long-run growth rates, instead of Moody's methodology where the indices converge to their long-term levels. This adjustment avoids having the stress scenario showing 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.

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 (the Low Rate Scenario

[30] Detailed descriptions of these alternative scenarios are presented in Appendix B.

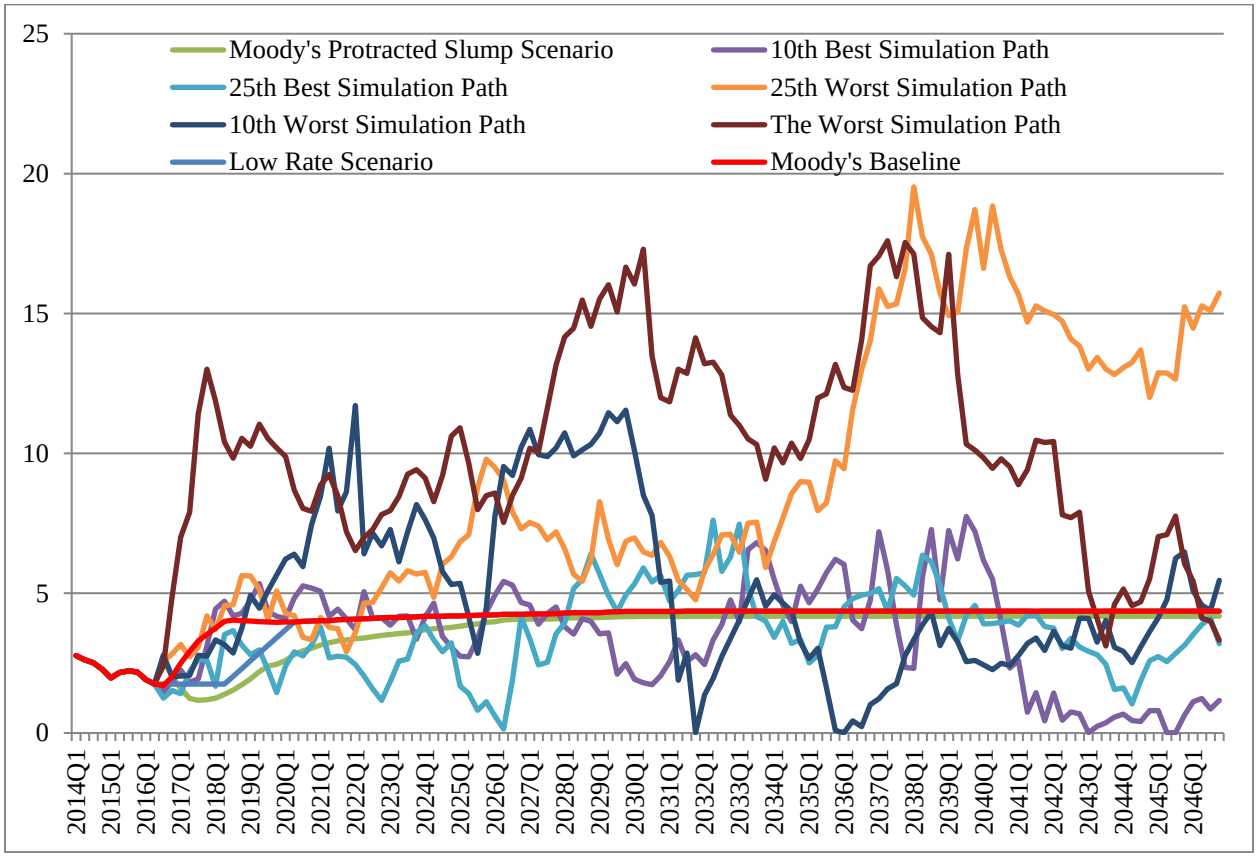
uses the HPI path of Moody's baseline scenario). Starting with the FY 2013 Review, we use the Purchase-Only HPI instead of the all-transaction HPI that was used in previous Reviews.

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



The market has seen low interest and mortgage rates for recent years after the recession. In order to assess the fund performance in a possible low interest rate market, this FY 2016 Review adds a Low Rate Scenario. Exhibit V-2 shows the 10-year Treasury rate for the eight scenarios.

Exhibit V-2. 10-year Treasury Rate for Eight Scenarios



The macroeconomic factors that serve as inputs to the HECM model include the FHFA national, state, and MSA house price indices, the national unemployment rate, 1-year and 10-year Treasury rates and the 1-year LIBOR rate. Moody's house price forecasts are part of its macroeconomic model which considers local area economic environments including unemployment rates.

Exhibit V-3 shows the projected expected economic values from FY 2016 through FY 2023 from our Monte Carlo simulation. This is our baseline stochastic case. Recall that this involves taking the average of 100 randomly simulated paths.[31] The estimated economic value of the HECM portfolio in the MMI Fund at the end of FY 2016 is *negative* $7,721 million, and its economic value is projected to drop to *negative* $12,537 million by the end of FY 2023.

[31] Note that Exhibit V-3 is the same as Exhibit II-1, reproduced in this section for convenience.

Exhibit V-3. 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
2016	-7,721	111,919	14,598	-1,209	
2017	-8,640	113,279	18,468	-799	-120
2018	-9,230	127,108	20,829	-383	-207
2019	-9,817	142,491	22,534	-317	-271
2020	-10,524	158,918	24,055	-391	-315
2021	-11,206	176,082	25,561	-327	-355
2022	-11,875	193,965	27,100	-277	-393
2023	-12,537	212,560	28,643	-233	-429

* All values are expressed 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 are based on the HECM volume model in Appendix E times the average MCA. This volume number in FY 2016 reflects the outstanding loans at the end of the fiscal year, and excludes loans endorsed and terminated in the same fiscal year.

The results of each of the alternative scenarios on the performance of the HECM portion of the MMI Fund are now presented.

A. Selected Scenarios from Monte Carlo Simulation

The Monte Carlo simulation approach provides additional information about the probability distribution of the economic value of the HECM Fund with respect to different possible future economic conditions and the corresponding claims. In addition to the estimation of the "expected" economic value of the HECM portfolio, the simulation also provides the economic value associated with each of the 100 possible future economic paths. The distribution of economic values based on these scenarios allows us to gain insights into the sensitivity of the Fund's economic value to different economic conditions. Ordering the 100 economic values from low to high represents the approximate percentiles from the worst to the best.

Exhibit V-4 presents the projected economic values for FY 2016 through FY 2023 under five different simulated future economic paths, two additional Moody's scenarios and one Low Rate Scenario. The 10th best economic value as of the end of FY 2016 is estimated to be $3,402 million. Compared with the baseline result (the mean across the 100 paths), the estimated economic value is $11,123 million higher in this scenario. There are 9 other paths of economic conditions that can be even more favorable and yield a higher economic value than $3,402 million, so an interpretation is that since each of the 100 paths are equally likely, there is a 10 percent likelihood that the HECM portfolio is higher than $3,402 million at the end of FY 2016.

The projected economic value for FY 2016 under the 10th worst simulated path is *negative* $19,693 million, which is $11,972 million lower than the mean stochastic result. There are 9 other paths of economic conditions that the economic value would be even more stressful than this path, resulting in an economic value worse than *negative* $19,693 million, so there is a 10 percent likelihood that the HECM portfolio is *negative* $19,693 million or worse.

These two alternative scenarios also suggest that there is an approximately 80 percent chance that the economic value of the HECM portfolio would be between *negative* $20 and *positive* $3 billion in FY 2016.

Under the 25th best path, the HECM economic value is projected to be *negative* $555 million in FY 2016, whereas the economic value under the 25th worst path is projected to be *negative* $13,374 million. These two paths suggest that there is approximately 50 percent chance that the economic value of the HECM portfolio would be between *negative* $13 billion and *negative* $0.6 billion in FY 2016.

Under the worst path, the economic values are lower than those projected under Moody's Protracted Slump scenario for all the projection years.

Exhibit V-4. HECM Economic Values 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	Moody's Protracted Slump	Low Rate
2016	-7,721	3,402	-555	-13,374	-19,693	-45,118	-6,831	-20,168	-6,238
2017	-8,640	3,937	-216	-15,652	-22,789	-48,879	-7,525	-22,094	-7,212
2018	-9,230	5,549	310	-17,670	-26,090	-51,570	-7,734	-24,294	-8,450
2019	-9,817	7,338	805	-19,787	-28,881	-55,007	-7,945	-26,860	-9,453
2020	-10,524	9,351	966	-22,735	-30,400	-59,311	-8,179	-29,336	-9,797
2021	-11,206	11,371	1,695	-26,415	-30,615	-64,071	-8,368	-31,996	-10,038
2022	-11,875	13,605	1,788	-30,634	-30,823	-70,498	-8,580	-34,735	-10,306
2023	-12,537	16,000	1,732	-34,393	-31,531	-76,553	-8,725	-37,650	-10,512

The detailed results of each of the simulated scenarios on the performance of the HECM portion of the MMI Fund are presented in Exhibits V-5 to V-12.

Exhibit V-5 presents the projected economic values for FY 2016 through FY 2023 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 2016 and FY 2023 are estimated to be positive $3,402 million and positive $16,000 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 2017. This creates low Claim Type I losses and high Claim Type II

recoveries. As a result, it leads to the highest economic value among the eight scenarios through FY 2023.

Exhibit V-5. 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
2016	3,402	110,981	14,990	408	
2017	3,937	112,146	18,496	482	53
2018	5,549	126,271	21,079	1,518	94
2019	7,338	141,442	23,042	1,626	163
2020	9,351	157,356	24,640	1,778	235
2021	11,371	174,171	26,026	1,704	316
2022	13,605	191,125	27,170	1,836	398
2023	16,000	208,173	28,110	1,903	491

Exhibit V-6 presents the projected economic values for FY 2016 through FY 2023 under the 25th best simulated path. The economic values at the end of FY 2016 and at the end of FY 2023 are estimated to be negative $555 million and positive $1,732 million, respectively. The FY 2016 economic value under this path is $3,957 million less than the FY 2016 economic value under the 10th best path. This path also has a faster house price appreciation rate than Moody's baseline after FY 2017, which results in higher-than-expected FY 2016 economic value.

Exhibit V-6. 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
2016	-555	109,055	13,981	271	
2017	-216	110,963	18,465	347	-9
2018	310	124,613	20,838	532	-5
2019	805	139,506	22,629	486	9
2020	966	155,183	24,360	135	26
2021	1,695	171,664	26,002	697	33
2022	1,788	189,064	27,587	34	59
2023	1,732	206,522	29,218	-121	65

Exhibit V-7 presents the projected economic values for FY 2016 through FY 2023 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 2023. The economic values at the end of FY 2016 and at the end of FY 2023 are estimated to be *negative* $13,374 million and *negative* $34,393 million, respectively.

Exhibit V-7. 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
2016	-13,374	113,972	14,417	-2,096	
2017	-15,652	116,460	20,004	-2,069	-208
2018	-17,670	131,540	22,805	-1,643	-375
2019	-19,787	148,280	24,897	-1,598	-519
2020	-22,735	165,730	26,636	-2,313	-635
2021	-26,415	183,999	28,337	-2,912	-767
2022	-30,634	202,672	30,010	-3,294	-925
2023	-34,393	221,379	31,351	-2,654	-1,105

Exhibit V-8 presents the projected economic values for FY 2016 through FY 2023 under the 10th worst simulated path. Under this path, house prices are at a low level and they steadily have negative growth rate between FY 2027 and FY 2031. However, after FY 2036 the house prices are higher than that under the 25th worst simulated path. Since most loans terminated after 14 years of loan origination, the future books of FY 2021 to FY 2023 start to show positive economic values. In addition, the 10-year Treasury rate is also higher than the baseline scenario between FY 2020 to FY 2035, which will increase the claim costs. As a result, the 10th worst path projects a low economic value through FY 2023. The economic values at the end of FY 2016 and FY 2023 are estimated to be *negative* $19,693 million and *negative* $31,531 million, respectively.

Exhibit V-8. 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
2016	-19,693	110,836	13,732	-3,019	
2017	-22,789	112,256	17,756	-2,790	-307
2018	-26,090	125,638	20,034	-2,755	-546
2019	-28,881	139,778	21,762	-2,025	-766
2020	-30,400	154,718	23,227	-593	-927
2021	-30,615	170,567	24,616	811	-1,026
2022	-30,823	186,902	25,775	865	-1,073
2023	-31,531	203,126	26,890	403	-1,112

Exhibit V-9 presents the projected economic values for FY 2016 through FY 2023 under the worst simulated path. This stress path has a long-lasting house price decrease up to FY 2040, and stays stagnant after FY 2044. This creates a severe claim loss frequency and very low recoveries. Also, the 10-year Treasury rate is much higher than the baseline scenario starting from FY 2023 all the way through FY 2043. As a result, it led to the lowest economic value by far among the 100 simulated paths for the HECM portfolio. The economic values at the end of FY 2016 and FY 2023 are estimated to be *negative* $45,118 million and *negative* $76,553 million, respectively.

Exhibit V-9. 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
2016	-45,118	116,469	15,000	-6,419	
2017	-48,879	117,322	18,135	-3,058	-703
2018	-51,570	130,516	19,738	-1,521	-1,170
2019	-55,007	143,416	19,687	-1,922	-1,514
2020	-59,311	154,028	18,810	-2,540	-1,765
2021	-64,071	161,229	18,216	-2,758	-2,002
2022	-70,498	166,804	19,227	-4,182	-2,245
2023	-76,553	172,202	20,062	-3,512	-2,544

Exhibit V-10 presents the estimated economic value of the HECM Fund based on Moody's baseline as a deterministic scenario. The result is very close to the 46th best simulation path.

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
2016	-6,831	111,919	14,598	-956	
2017	-7,525	113,082	18,468	-588	-106
2018	-7,734	126,732	20,845	-28	-180
2019	-7,945	141,662	22,583	16	-227
2020	-8,179	157,321	24,116	21	-255
2021	-8,368	173,327	25,622	87	-276
2022	-8,580	189,745	27,159	82	-293
2023	-8,725	206,505	28,674	164	-310

B. Moody's Alternative Scenarios

Exhibit V-11 presents the estimated economic value of the HECM Fund based on Moody's Protracted Slump Scenario. This scenario provides a reasonableness check on the range of results obtained from the Monte Carlo simulation. The economic value at the end of FY 2016 decreases from the base case of *negative* $7,721 million to *negative* $20,168 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 2023 value is about $25,113 million lower than in the baseline Monte Carlo result. The protracted slump scenario projects an economic value similar to the 8th worst economic value in the 100 simulated paths.

Exhibit V-11. 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
2016	-20,168	111,919	14,598	-1,881	
2017	-22,094	112,186	15,633	-1,612	-314
2018	-24,294	120,292	15,371	-1,671	-529
2019	-26,860	128,931	16,727	-1,853	-713
2020	-29,336	138,826	18,255	-1,614	-862
2021	-31,996	150,085	19,890	-1,669	-990
2022	-34,735	162,591	21,650	-1,618	-1,121
2023	-37,650	176,223	23,461	-1,661	-1,253

C. Low Rate Scenario

Exhibit V-12 presents the estimated economic value of the HECM Fund based on Low Rate scenario, which assumes that the interest rate in the next few years will not increase, and the HPI is the same as that used in the baseline scenario. The result is higher than the baseline scenario since the lower rate will decrease the claim costs.

Exhibit V-12. HECM Economic Value: Low Rate 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
2016	-6,238	111,919	14,598	-866	
2017	-7,212	112,762	18,468	-877	-97
2018	-8,450	125,799	20,845	-1,066	-173
2019	-9,453	140,595	22,583	-754	-248
2020	-9,797	156,383	24,116	-41	-303
2021	-10,038	172,601	25,622	90	-331
2022	-10,306	189,108	27,159	84	-352
2023	-10,512	205,980	28,674	166	-372

D. Sensitivity Tests for Economic Variables

The above scenario analyses were conducted to examine the uncertainty of the economic value of the Fund with different possible combinations of interest rates, unemployment rates and house price movements in the future. It is also useful to understand the marginal impact of each of the major economic factors on the economic value. Below, we show the sensitivity of the FY 2016 deterministic base-scenario economic value of the Fund with respect to changes in each of the following three sets of economic variables:

- National House Price Appreciation (HPA)
- Discount Rate
- Interest rates:
    - 10-year constant maturity Treasury rate
    - 1-year constant maturity Treasury rate
    - 1-year LIBOR rate
    - Mortgage rate

Exhibit V-13 reports in graphic form the sensitivity of the economic value with respect to changes in HPI forecasts, future interest rates and discount rates, respectively. The marginal impact is measured by the change in the economic value from the deterministic Moody's baseline scenario as of the end of FY 2016. The changes are parallel shifts in the path of each variable in the deterministic Moody's baseline scenario, where all three interest rates are shifted together and at the same magnitudes, but are kept from going negative.

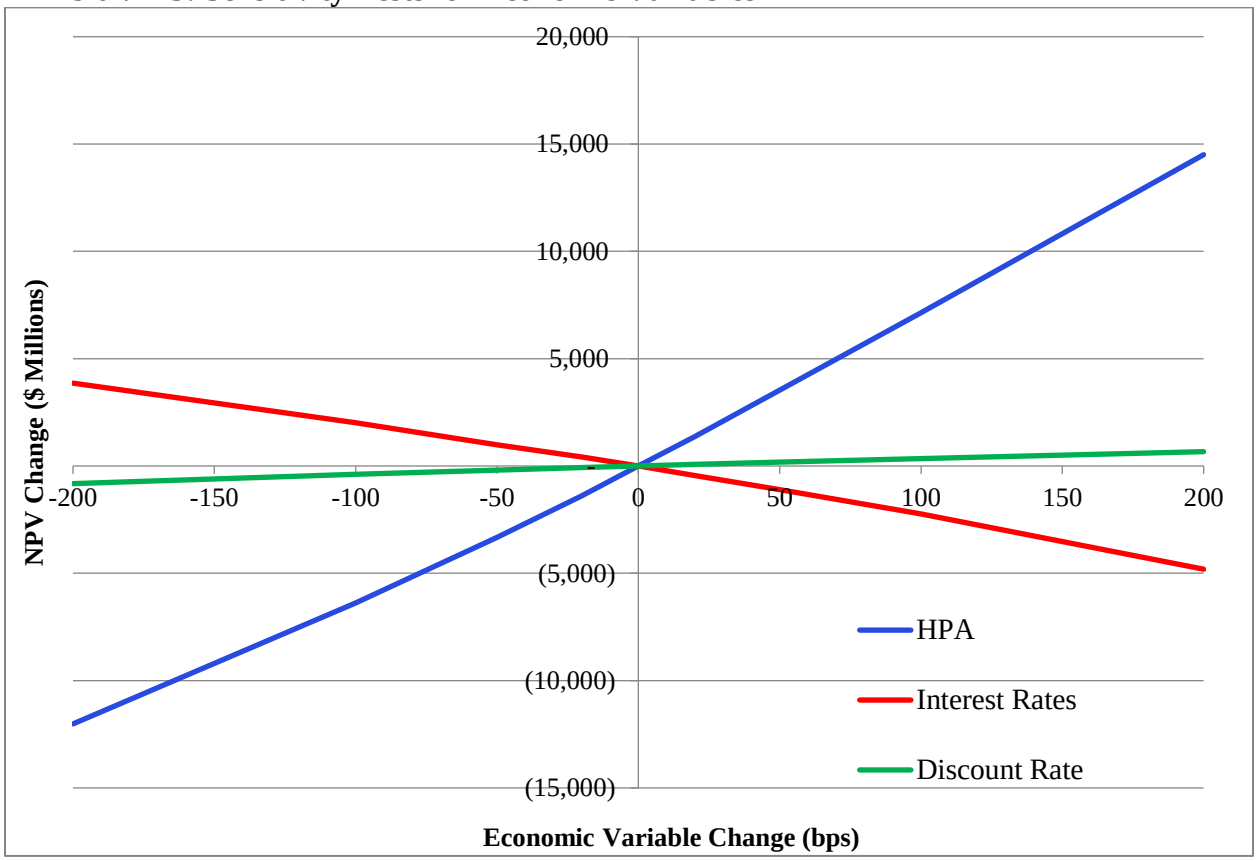
Specifically, we applied a parallel shift to the annualized house price appreciation rates (HPA) from the base scenario up and down by 20, 50, 100 and 200 basis points. The sensitivity to shifts in the annualized house price appreciation rates (HPAs) from the base scenario has a positive slope,

and a deeper effect from increases of higher HPAs than decreases of lower HPAs. The results show that adverse house price shifts reduce the economic value of the fund less than favorable house price shifts increase the economic value of the fund. A negative 100 basis points parallel shift in HPA will decrease economic value by $6,385 million, and a positive 100 basis points parallel shift in HPA will increase economic value by $7,145 million.

For the FY 2017 OMB discount factors, we first transform the discount factors into spot rates of different terms, which is the implied yield curve from the discount factors. We apply a parallel shift to the implied yield curve in the base scenario up and down by 20, 50, 100 and 200 basis points, but kept the discount rates from turning negative. Negative (positive) shifts in the implied yield curve produce higher (lower) discount factors. The lower discount factors, shown as positive shifts in the implied yield curve in Exhibit V-13, contribute to an increase in the economic value of the Fund. This is because the discount factor has greater impact on cash flows occurring in the more distant future. Lower discount factors would make the present value of Claim Type I losses less negative, while also making the recovery from Claim Type II less positive. As we observe that less than half of the loans will be assigned, the impact of the improvement in Claim Type I losses dominates. The economic value would increase with the lower discount factors. A downward 100 basis points parallel shift in the implied yield curve will decrease the economic value by $388 million, whereas the upward shift of the same magnitude in the implied yield curve will reduce the economic value by $349 million.

We applied parallel shifts to 1-year Treasury rates, 10-year Treasury rates, 1- year Libor rates and mortgage rates series up and down by 20, 50, 100 and 200 basis points from the base scenario, but kept these interest rates from turning negative. The economic value curve has a negative slope. A negative 100 basis points parallel shift in interest rates will increase economic value by $2,013 million, and a positive 100 basis points parallel shift in interest rates will decrease economic value by $2,241 million. This is because lower interest rates will slow the accrual of unpaid balances, causing lower Claim Type I losses. Thus, lower interest rates will benefit the status of the HECM portfolio.

Exhibit V–13: Sensitivity Tests for Economic Variables



Section VI. Summary of Methodology

This section describes 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)

There was a policy change by the Social Security Administration which affects the FY 2016 Review. Previously the Social Security Administration supplied the FHA with the dates of death of HECM borrowers. This data is no longer being made available. Without access to such data, we were not able to distinguish separate mortality, refinance and mobility terminations. As a result, the mortality, refinance and mobility termination models cannot be re-estimated using updated data. Consequently, the termination model and its estimates remain the same as those of the FY 2015 HECM Review. The following describes the methodology of the termination models used in FY 2016 Review.

No repayment of principal is required on a HECM loan while 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 nature of the different termination events.

The termination model incorporates four main categories of explanatory variables:

- Fixed initial borrower characteristics, such as borrower age at origination and gender.
- Fixed initial loan characteristics, such as 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 the HECM national loan limit at the time of origination.
- Dynamic variables based on loan/borrower characteristics, such as loan age and updated borrower's age.
- Dynamic variables derived by combining loan characteristics with external macroeconomic data, such as 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.[32] 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 are assumed to impact the occurrence of that event. For example, the mobility model includes an estimate of the updated loan-to-value ratio over time to model the impact of equity value in the property 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 to measure 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 endorsed portfolio, we project termination rates for the outstanding insurance policies beyond the end of FY 2016. For future books' economic values, we also project the composition and volume of future books of business. Each loan creates annual observations from its origin to the policy year when the borrower reaches 109 years old, the maximum age available in the mortality table published by Census. Since the non-borrowing spouse can be as young as 38, the projection period for the analysis extends to FY 2094. The assumed characteristics of the future HECM endorsements for FY 2017 through FY 2023 are based on the distribution of the HECM loans observed from FY 2015 Q4 through FY 2016 Q3, with estimates from FHA regarding the borrower and spouse age distributions and the percentage of couples.

At the time of HECM loan termination, borrowers or their heirs have the option to convey the property to HUD or pay off the outstanding loan balance. The decision is highly dependent on the house price at the time of loan termination compared to the accrued loan balance. Thus, both the house price appreciation and current loan-to-value ratio are major determinants of the outcome. The conveyance/payoff 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 2023 books of business. For the books through the FY 2016 book, the economic values are computed on the projected cash flows from the end of FY 2016. The economic values are the net present value of future cash flows for these books of business plus capital resources. The HECM cash flow model consists of four components: upfront and annual HECM mortgage insurance premiums;

[32] FY 2016 Review has the same termination model with FY 2015 Review due to limited data received on death file.

lender insurance claims and cost paid for loan assignments; note holding expenses (post-assignment); and recoveries on assigned notes in inventory. The cash flows are discounted according to the most up-to-date Federal credit subsidy present-value conversion factors published by OMB.

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 for defaults to occur before loan assignment. After loan assignment, this Review assumes a constant 25 percent of assigned loans would go T&I defaults. The HECM portfolio of active loans as of the end of FY 2016 has a base-case projected lifetime cumulative tax and insurance default rate of 18.16 percent.

E. HECM Volume Model (Appendix E)

We updated the HECM 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 2017 through FY 2023. Adequate non-borrowing younger spouse data is not available. Therefore, the 2016 model used the assumption that couple borrower share will be 3.89%, according to FHA internal research. 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 2016. 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 volume in each of the stochastic simulation paths and in 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 when there were material changes in market structure, regulatory policy, or technology advancement.

One example of data limitations is the fact that the HECM program has a relatively short 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, a limited number of HECM loans are observed with performance information for more than nine years. The lack of long-run performance data potentially limits the robustness of the models' predictive capacity for later policy years.

This year, we have observed material impacts from the risk of insufficient or inaccurate data. The data upon which past Reviews were based did not include actual sale prices and "other expenses" for property dispositions, which have been included in the FY 2016 model. Also, the prior assumption that all loans are assigned as soon as their UPB reach 98 percent of the MCA was not accurate. Updated data revealed that approximately 60 percent of these loans were not eligible for assignment and still belong to the lenders.

For this year's Review, another major data limitation is the following. Due to a policy change at the Social Security Administration, the information about the deaths of HECM borrowers was not provided to FHA. This information was used to distinguish mortality, refinance and mobility terminations. Consequently, we were not able to update the statistical estimation of the mortality, refinance and mobility termination models. Thus, the base termination model and its estimates remain the same as those of the FY 2015 HECM Review.

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 2016 baseline economic forecast. Hence the estimated results capture the impact of future deviations from Moody's baseline 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 was based on our stochastic economic factor 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 may 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 termination behavioral assumptions.

At the start of FY 2014, the 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 prior Standard program. It reduced the allowable initial disbursement, where mortgagors are subject to an initial 12-month disbursement limitation 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. The new origination requirements tended to defer cash outflows and increase cash inflows.

On August 4, 2014, HUD adjusted the HECM program by allowing non-borrowing spouses younger than 62 years old. This adjustment was accompanied by reductions in the PLFs for this younger age group, while extending the eligibility of the 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. LESA, announced in 2015, introduced additional guideline and assumptions for handling T&I defaults. However, it created further uncertainty about the future effectiveness of policy.

Appendix A

HECM Base Termination Model

Appendix A. HECM Base Termination Model

In previous years, FHA was able to collect information regarding the death of HECM borrowers from the Social Security Administration. Such information enabled the estimation of separate mortality, refinance and mobility termination models. However, such information is no longer provided to update these separate models. Instead of changing to a simpler, less precise modeling framework, the decision was made that the competing risk models estimated using data up to 2015 would be able to generate more detailed projections of HECM performance and more accurately capture the associated future cash flow projections. As a result, the HECM termination projection models used in this 2016 Review remain the same as those of the FY 2015 Review. The models are described in this appendix in detail, the substance of which is identical to that described in last year's Review.

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 terminated under foreclosure when borrowers fail to pay their real estate taxes and/or property insurance premiums as required by the HECM contract. Building upon last year's econometric model of tax and insurance (T&I) defaults, the specification of T&I defaults was refined and the estimation was updated as discussed in Appendix D. When necessary, the "base" termination model discussed in this Appendix is distinguished from the T&I default termination model described in Appendix D. To clarify another possible confusion, HECM insurance terminates upon a 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 are not modeled as HECM loan terminations. The T&I default after mortgage note assignments are not modeled as loan terminations (discussed in Appendix D). Also note that the HECM model is an annual model, whereas the models 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 2015.[33] Only loans endorsed under the MMI Fund, however, are included to determine the economic value of the MMI Fund in this Review.

[33] The estimation data is only available through March of 2015 due to the lack of death file and updated refinance information from FY 2016.

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 2015), 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 α_D, α_R and α_M and the coefficient vectors β_D, β_R and β_M are parameters estimated by the multinomial logistic model. The subscripts D, R and M denote death, refinance and mobility, respectively. The vectors of independent 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 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,[34] 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

[34] For loans with multiple borrowers, the date of death of the last surviving borrower is used. The same holds for spouses even if one of them is not a borrower.

model as a special aggregation of individually estimated binomial logistic regression models. For more details, please refer to the FY 2016 Actuarial Review (IFE Group 2016, Appendix A) 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. The most updated mortality data available for this Review are up to March of 2015.[35] 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 possible time lags between the dates of the recorded termination and the actual death.

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

The *Mortality* variable accounts for expected mortality rates. It is based on the gender- and age-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 or couples, the joint mortality table calculates the likelihood of both borrowers or spouses not surviving to the end of a period. Equation 4 below defines the *Mortality* [*M(t)*] calculation.

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

where $M(t)$ represents the mortality rate at t ;
$m_g(t)$ represents the conditional mortality rate (gender and age specific) for a 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 borrower j dying before time $t-1$ and borrower i surviving up to time $t-1$. The notation here is that $i= b$ *(borrower),* $j=co$ *(co-borrower),* or $i=co$, $j=b$; 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, equation (5) transforms $M(t)$ into $xbetaM(t)$, which is the input explanatory variable for the regression:

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

[35] FHA is not able to disclose more updated Social Security Administration mortality data to IFE Group.

This variable is called the transformed mortality rate. A piece-wise linear spline function was used to capture possible non-linearity of the mortality rate with respect to the age of the borrower.

The HECM program now has more than 25 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, various life tables from the Census were used to calculate the corresponding mortality rate. The life tables include the CDC 1989-1991,[36] 1999-2001, and 2001-2009[37] mortality rates. These defined the mortality rate for these specific years, with interpolations for the years in between and with an extrapolation of the mortality rate from 2009 to the end of the estimation dataset in 2013. For forecasts after 2014, mortality rates are 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 observation.

Prior HECM experience also indicates that the likelihood of death terminations increases with policy year, even after controlling for borrower age-induced mortality increases. A piece-wise linear spline function of the time-dependent variable *PolicyYear* was used to capture variations in the trend (see the details in the next section). HECM loans have been endorsed over the past 26 years, but most of the loans were endorsed in the last 12 years. Due to the limited number of loan observations in late policy years, the estimation sample was restricted 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 first month draw-down of their total eligible draw amount. Therefore, the variable *CashDraw* captures this self-selection of borrowers within the HECM program. Two dummy variables were included: one for the Term product and the other for the Term product with a Line of Credit feature, to reflect additional self-selection effects.

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. The estimation dataset restricted the loan observations to less than or equal to 18 policy years due to the limited number of observations beyond 18 years.

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

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* variable as defined in the mortality model is included. The series of piece-wise linear spline functions for loan age are defined as follows:[38]

$$Pol_{yr1} = \begin{cases} loan\ age & if\ loan\ age \le k_1 \\ k_1 & if\ loan\ age > k_1 \end{cases} \tag{6}$$

$$Pol\_yr2 = \begin{cases} 0 & if\ loan\ age \le k_1 \\ loan\ age - k_1 & if\ k_1 < loan\ age \le k_2 \\ k_2 - k_1 & if\ loan\ age > k_2 \end{cases} \tag{7}$$

$$Pol\_yr3 = \begin{cases} 0 & if\ loan\ age \le k_2 \\ loan\ age - k_2 & if\ k_2 < loan\ age \le k_3 \\ k_3 - k_2 & if\ loan\ age > k_3 \end{cases} \tag{8}$$

$$Pol\_yr4 = \begin{cases} 0 & if\ loan\ age \le k_3 \\ loan\ age - k_3 & if\ loan\ age > k_3 \end{cases}$$

where $k_1 = 3$, $k_2 = 6$ and $k_3 = 11$. (9)

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

$$PolicyYear \text{ function} = \beta_1 * Pol\_yr1 + \beta_2 * Pol\_yr2 + \beta_3 * Pol\_yr3 + \beta_4 * Pol\_yr4 \tag{10}$$

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 (so it is

[38] All piece-wise linear functions for other variables are defined in a similar way. The boundary values or knot points are specified in the exhibits for each estimated model.

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. This variable was modeled as a piece-wise linear function.

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 a larger dollar amount of benefits if the borrower choses to refinance, thus implying a higher probability of refinance.

The model includes two house value related variables: the two-year HPI change that captures the short-term housing price 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 variable was designed to model HECM borrowers' potential benefit of refinancing a loan. The refinance incentive variable represents the net increase in the principal limit for a borrower upon refinancing relative to refinance costs. Equation 10 defines the refinance incentive variable:

$$rfi_t\_new = \frac{\min\left(MCA_0 \times \Delta H, LoanLimit_t\right) \times PLF_t - C - PL_t}{C} \tag{11}$$

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

At loan origination, the relative value of the property affects the future house price appreciation. In the HECM program, properties with relatively higher values tend to have a larger appreciation and therefore lead to a higher probability of refinance. The indicator variable Home Value above Area Median measures whether the house price is above the local area median house price. The local median house price data was obtained from the 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 as explanatory variables. For the same reason as the refinance model, the estimation sample is limited 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 this mobility model, to make the model better fit the data.

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* and *pol_yr* to capture the borrowers' age in the ongoing years.

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.

Two loan-type dummy variables are included: Term HECMs and loans with Term and Line of Credit (LOC). The pure Term loans seem to have mobility rates greater than for the Term loans with a LOC, which may indicate a self-selection effect for borrowers with different mobility preferences.

A1.3.3. Economic Variables for the Mobility Model

In order to capture HECM program changes, *pre2004* indicates whether the HECM loan was originated before Calendar Year (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.

Two additional economic variables are updated loan-to-value ratio and house price volatility. Historical experience indicates that HECM borrowers with lower updated loan-to-value ratios are more likely to move out of their homes than borrowers with higher loan-to-value ratios. The economic incentive may come from the fact that with little equity in the house, the incentive to maintain the property is low, so the effective rental rate is low; this is not easy to give up by moving. The house price dispersion parameter estimated by FHFA was used to capture the variability among local house price appreciation rates. Also included is the 2-year HPI change to capture the short-term effect caused by house price changes.

A1.4. Combining the Three Risks

The joint termination hazard rate can be defined as

$$P(t) = \sum_{j=1}^{3} P_j(t) \tag{12}$$

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 (multinomial) 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 nine 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 an increasing rate and becomes the 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 and the goodness-of-fit statistics for the binomial logistic regression models.

Exhibit A-1. Mortality Termination Model Estimation Results[39]

Analysis of Maximum Likelihood Estimates*						
Description	**Parameter**	**Boundary Values**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	**Intercept**		-3.1820	0.0422	5697.4925	<.0001
Policy Year	**pol_yr_d1**	**[1,2]**	1.4016	0.0207	4587.5790	<.0001
	pol_yr_d2	**(2,3]**	0.1219	0.0118	106.4741	<.0001
	pol_yr_d3	**(3, 8]**	-0.1201	0.00292	1696.1616	<.0001
	pol_yr_d4	**(8,74]**	0.1048	0.00889	139.0066	<.0001
If Borrower is Couple	**Gender_Couple**		-0.3571	0.0127	794.5296	<.0001
Transformed Mortality Rate	**mortality_d1**	**(-∞,-2]**	0.8883	0.00576	23766.4999	<.0001
	mortality_d2	**(-2, ∞)**	1.0962	0.0176	3858.0499	<.0001
Cash Drawdown Percentage	**pct_cashdd**		-1.0409	0.0125	6884.5030	<.0001
Term Product	**TERM**		0.2538	0.0269	88.7440	<.0001
Term Product with Line of Credit	**TMLC**		0.1586	0.0137	134.2711	<.0001

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	79.3	**Somers' D**	0.613
Percent Discordant	18.0	**Gamma**	0.630
Percent Tied	2.7	**Tau-a**	0.018
Pairs	306263194769	**c**	0.806

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

[39] The model coefficients are estimated based on data up to March 2015.

Exhibit A-2. Refinance Termination Model Estimation Results[40]

Analysis of Maximum Likelihood Estimates						
Description	**Parameter**	**Boundary Values**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	**Intercept**		-7.2271	0.1593	2058.0415	<.0001
Policy Year	**pol_yr_r1**	**[1,3]**	0.6919	0.00941	5410.4548	<.0001
	pol_yr_r2	**(3,6]**	-0.1945	0.00596	1067.1533	<.0001
	pol_yr_r3	**(6,11]**	-0.1447	0.00731	391.9643	<.0001
	pol_yr_r4	**(11,74]**	-0.3340	0.0248	180.9907	<.0001
Borrower Age at Origination	**Orig_Age**		-0.0107	0.00152	49.8497	<.0001
Home Value above Area Median	**hp_above_med**		0.2563	0.0105	595.8077	<.0001
Transformed Mortality Rates	**mortality_r1**	**(-∞,-1.5]**	0.1595	0.0107	221.6141	<.0001
	mortality_r2	**(-1.5,+∞)**	0.2127	0.1748	1.4801	0.2238
Refinance Incentives	**RFI_new1**	**(-∞,0]**	0.0504	0.00196	663.4094	<.0001
	RFI_new2	**(0,+∞)**	0.2770	0.00332	6959.0396	<.0001
Cash Drawdown Percentage	**pct_cashdd_r1**	**(0,0.7]**	1.6838	0.0403	1745.5276	<.0001
	pct_cashdd_r2	**(0.7,1]**	1.6200	0.0623	676.6029	<.0001
One Year Change in 10-Year Treasury Rate	**int_change1**	**(-∞,0]**	0.1792	0.0132	184.5926	<.0001
	int_change2	**(0,+∞)**	-0.1482	0.0170	76.2928	<.0001
Area Median House Price to Origination Loan Limit	**limit1**	**[0,1]**	2.4271	0.0206	13913.2912	<.0001
	limit2	**(1,+∞)**	0	.	.	.
Borrower's Gender	**Gender_Couple**		0.1410	0.0182	59.8274	<.0001
	Gender_Male		0.0648	0.0144	20.1687	<.0001
	Gender_Missing		-0.2405	0.0854	7.9228	0.0049
Line of Credit	**LOC**		-0.0904	0.0159	32.3056	<.0001
2-Year HPI Change	**HPA_2Y_r**		-1.2465	0.0430	841.8718	<.0001
Current LTV	**CLTV1**	**[0,0.5]**	2.0619	0.0686	2058.0415	<.0001

[40] The model coefficients are estimated based on data up to March 2015.

Analysis of Maximum Likelihood Estimates						
Description	**Parameter**	**Boundary Values**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
	CLTV2	**(0.5,0.8]**	-5.6017	0.0695	5410.4548	<.0001
	CLTV3	**(0.8, +∞)**	-4.4766	0.1420	1067.1533	<.0001

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	79.4	**Somers' D**	0.632
Percent Discordant	16.2	**Gamma**	0.661
Percent Tied	4.4	**Tau-a**	0.012
Pairs	209379835660	**c**	0.816

Exhibit A-3. Mobility Termination Model Estimation Results[41]

Analysis of Maximum Likelihood Estimates						
Description	**Parameter**	**Boundary Values**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Intercept	**Intercept**		-9.4743	0.1360	4855.9736	<.0001
If One Year Change in 1-Year Treasury Rate Less than -10%	**OneYrCmt_bucket1**		-0.0927	0.00991	87.5353	<.0001
If One Year Change in 1-Year Treasury Rate More than 10%	**OneYrCmt_bucket3**		-0.0993	0.0115	75.1527	<.0001
Policy Year	**pol_yr_n1**	**[1,2]**	1.4217	0.0226	3960.0252	<.0001
	pol_yr_n2	**(2,3]**	0.3033	0.0127	572.0981	<.0001
	pol_yr_n3	**(3,72]**	0.0381	0.00339	126.4811	<.0001
Borrower's Gender	**Gender_Couple**		0.2881	0.0111	673.8539	<.0001
	Gender_Male		-0.0577	0.0104	30.7501	<.0001
	Gender_Missing		0.1301	0.0486	7.1772	0.0074

[41] The model coefficients are estimated based on data up to March 2015.

Analysis of Maximum Likelihood Estimates						
Description	**Parameter**	**Boundary Values**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
Transformed Mortality Rates	**mortality_n1**	**(-∞,-6]**	-0.1277	0.0172	55.2425	<.0001
	mortality_n2	**(-6, -0.5)**	0.3783	0.01000	1431.3377	<.0001
	mortality_n3	**(-0.5,+∞)**	-1.2644	0.4109	9.4686	0.0021
Age at Origination	**Orig_Age**		0.0133	0.00125	114.2509	<.0001
If Origination Year is before 2004	**pre2004**		0.3515	0.00833	1781.6386	<.0001
Appraised Value to Area Median House Price	**rel_hp**		0.2383	0.00623	1463.9959	<.0001
Current LTV	**CLTV1**	**[0,0.5]**	0.1570	0.0332	22.3720	<.0001
	CLTV2	**(0.5,1.0]**	-2.5555	0.0259	9706.3717	<.0001
	CLTV3	**(1.0,+∞)**	0	.	.	.
House Price Volatility	**Sigma**		-1.0484	0.1853	32.0195	<.0001
2-Year HPI Change	**hpa_2y_n1**	**(-∞,-0]**	3.4080	0.0829	1688.4319	<.0001
	hpa_2y_n2	**(0,+∞)**	2.4836	0.0384	4174.4933	<.0001
Term Product	**TERM**		0.1307	0.0230	32.3077	<.0001
Term Product with Line of Credit	**TMLC**		-0.0706	0.0131	28.9292	<.0001

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	73.8	**Somers' D**	0.503
Percent Discordant	23.5	**Gamma**	0.516
Percent Tied	2.7	**Tau-a**	0.021
Pairs	445681905480	**c**	0.751

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, numbers above the shaded numbers are historically

observed termination rates; the FY 2016 termination year (shaded) was estimated based on partial year actual data. Mortgage Letter 2014-12 allowed co-borrowers and spouses to be as young as 35. This aspect of the composition of future books was projected by FHA, and it contains co-borrowers and spouses as young as age 38 (See Appendix B.B5 for how the future composition was forecasted). Correspondingly, the future in Exhibit A-4 extends to policy year 72.

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	2022	2023
1	1.7%	0.9%	0.9%	1.0%	1.2%	1.3%	1.9%	0.8%	1.4%	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%
2	2.9%	3.4%	3.1%	4.4%	4.4%	8.8%	4.0%	4.7%	4.4%	4.2%	4.2%	4.2%	4.3%	4.3%	4.3%
3	2.9%	3.4%	5.0%	5.7%	6.8%	6.6%	6.1%	6.0%	5.7%	5.8%	5.8%	5.9%	5.9%	5.8%	5.8%
4	3.2%	4.7%	5.2%	7.2%	5.2%	5.9%	5.3%	5.4%	5.5%	5.7%	5.7%	5.7%	5.7%	5.7%	5.6%
5	4.7%	4.8%	7.4%	5.5%	4.2%	5.0%	4.7%	5.0%	5.4%	5.7%	5.7%	5.6%	5.6%	5.6%	5.5%
6	4.8%	8.3%	5.6%	4.3%	3.7%	4.5%	4.5%	4.9%	5.3%	5.6%	5.6%	5.5%	5.5%	5.4%	5.3%
7	9.1%	6.0%	4.6%	3.8%	3.4%	4.3%	4.4%	4.8%	5.3%	5.6%	5.5%	5.5%	5.5%	5.4%	5.3%
8	6.0%	4.5%	4.0%	3.5%	3.3%	4.3%	4.3%	4.7%	5.2%	5.5%	5.5%	5.4%	5.4%	5.3%	5.2%
9	5.3%	4.2%	3.9%	3.7%	3.6%	4.5%	4.6%	4.9%	5.5%	5.8%	5.8%	5.6%	5.6%	5.6%	5.5%
10	5.1%	4.2%	4.1%	4.0%	3.9%	4.8%	4.9%	5.2%	5.8%	6.1%	6.1%	5.9%	5.9%	5.9%	5.9%
11	5.1%	4.5%	4.5%	4.3%	4.2%	5.1%	5.2%	5.6%	6.1%	6.4%	6.4%	6.3%	6.3%	6.3%	6.3%
12	5.5%	5.0%	4.9%	4.7%	4.6%	5.4%	5.6%	5.9%	6.3%	6.6%	6.7%	6.6%	6.6%	6.7%	6.8%
13	6.0%	5.5%	5.3%	5.2%	5.0%	5.8%	6.0%	6.3%	6.7%	7.0%	7.1%	7.0%	7.1%	7.2%	7.2%
14	6.7%	6.1%	5.9%	5.6%	5.5%	6.3%	6.4%	6.8%	7.2%	7.5%	7.6%	7.5%	7.7%	7.7%	7.7%
15	7.4%	6.8%	6.4%	6.2%	6.0%	6.8%	7.0%	7.4%	7.7%	8.0%	8.1%	8.1%	8.2%	8.2%	8.3%
16	8.2%	7.5%	7.1%	6.8%	6.6%	7.4%	7.7%	8.1%	8.3%	8.7%	8.9%	8.8%	8.9%	8.9%	9.0%
17	9.1%	8.3%	7.8%	7.5%	7.3%	8.1%	8.4%	8.9%	9.1%	9.5%	9.6%	9.5%	9.6%	9.7%	9.7%
18	10.0%	9.1%	8.5%	8.3%	8.1%	8.9%	9.4%	9.9%	10.1%	10.3%	10.4%	10.3%	10.5%	10.5%	10.6%
19	11.0%	10.0%	9.4%	9.2%	9.0%	9.9%	10.4%	11.0%	11.1%	11.2%	11.3%	11.3%	11.4%	11.5%	11.6%
20	12.2%	11.1%	10.4%	10.2%	10.0%	11.0%	11.6%	12.3%	12.2%	12.3%	12.4%	12.3%	12.6%	12.6%	12.6%
21	13.4%	12.3%	11.6%	11.4%	11.2%	12.3%	13.0%	13.7%	13.4%	13.5%	13.7%	13.6%	13.8%	13.8%	13.9%
22	14.8%	13.6%	12.9%	12.7%	12.6%	13.7%	14.4%	15.2%	14.8%	14.9%	15.0%	15.0%	15.1%	15.1%	15.2%
23	16.4%	15.1%	14.4%	14.2%	14.1%	15.3%	16.1%	16.9%	16.4%	16.4%	16.6%	16.4%	16.6%	16.6%	16.7%
24	18.1%	16.8%	16.1%	15.9%	15.8%	17.1%	18.0%	18.9%	18.1%	18.1%	18.1%	18.1%	18.2%	18.2%	18.3%
25	20.1%	18.8%	18.0%	17.8%	17.7%	19.1%	20.0%	21.0%	19.9%	19.9%	20.0%	19.9%	20.0%	20.0%	20.1%
26	22.4%	20.9%	20.1%	19.9%	19.8%	21.3%	22.4%	23.4%	21.9%	21.8%	21.9%	21.9%	21.9%	21.9%	22.0%
27	24.8%	23.2%	22.4%	22.2%	22.2%	23.8%	24.9%	25.9%	24.1%	24.0%	24.0%	23.9%	24.0%	24.0%	24.1%
28	27.4%	25.8%	25.0%	24.9%	24.9%	26.5%	27.6%	28.7%	26.3%	26.2%	26.2%	26.2%	26.2%	26.2%	26.3%
29	30.4%	28.7%	27.9%	27.8%	27.8%	29.5%	30.7%	31.8%	28.7%	28.5%	28.5%	28.5%	28.6%	28.6%	28.6%
30	33.5%	31.8%	31.0%	31.0%	30.9%	32.7%	34.0%	35.1%	31.0%	30.8%	30.9%	30.9%	30.9%	30.9%	31.0%
31	37.0%	35.3%	34.4%	34.4%	34.4%	36.2%	37.4%	38.5%	33.3%	33.1%	33.2%	33.2%	33.2%	33.2%	33.2%
32	40.7%	38.9%	38.1%	38.1%	38.1%	39.9%	41.1%	42.1%	35.5%	35.3%	35.3%	35.4%	35.4%	35.4%	35.4%
33	44.5%	42.8%	42.0%	42.0%	42.0%	43.7%	45.0%	45.9%	37.3%	37.2%	37.2%	37.3%	37.2%	37.2%	37.2%
34	48.5%	46.8%	46.1%	46.1%	46.1%	47.7%	48.9%	49.8%	38.7%	38.6%	38.6%	38.7%	38.6%	38.6%	38.6%
35	52.7%	51.1%	50.3%	50.4%	50.3%	51.8%	53.0%	53.8%	39.4%	39.4%	39.4%	39.6%	39.5%	39.4%	39.3%
36	56.9%	55.3%	54.6%	54.7%	54.6%	55.9%	57.1%	57.8%	39.4%	39.4%	39.4%	39.6%	39.5%	39.5%	39.3%

37	61.0%	59.5%	58.9%	59.0%	58.9%	60.1%	61.1%	61.7%	38.9%	38.8%	38.9%	39.2%	39.1%	39.0%	38.9%
38	65.1%	63.7%	63.2%	63.3%	63.2%	64.1%	65.1%	65.6%	38.0%	37.9%	38.0%	38.3%	38.2%	38.1%	38.0%
39	69.0%	67.8%	67.3%	67.4%	67.3%	68.0%	68.9%	69.3%	37.1%	36.8%	37.0%	37.3%	37.2%	37.1%	37.1%
40	72.7%	71.7%	71.2%	71.3%	71.2%	71.8%	72.5%	72.9%	36.3%	35.9%	36.3%	36.5%	36.4%	36.3%	36.4%
41	76.2%	75.3%	74.9%	75.0%	74.9%	75.3%	75.9%	76.3%	36.0%	35.5%	35.9%	36.1%	35.9%	35.9%	36.2%
42	79.4%	78.7%	78.3%	78.3%	78.3%	78.6%	79.1%	79.4%	36.1%	35.5%	35.9%	36.0%	35.8%	35.9%	36.4%
43	82.3%	81.7%	81.4%	81.4%	81.3%	81.6%	82.0%	82.2%	36.7%	36.0%	36.4%	36.5%	36.3%	36.4%	37.0%
44	84.9%	84.4%	84.1%	84.2%	84.1%	84.3%	84.6%	84.8%	37.9%	37.2%	37.6%	37.6%	37.5%	37.5%	38.3%
45	87.2%	86.8%	86.6%	86.6%	86.5%	86.6%	86.9%	87.1%	39.8%	39.2%	39.4%	39.4%	39.3%	39.3%	40.1%
46	89.2%	88.9%	88.7%	88.7%	88.7%	88.7%	89.0%	89.1%	42.3%	41.7%	41.8%	41.7%	41.7%	41.7%	42.5%
47	90.9%	90.7%	90.5%	90.5%	90.4%	90.5%	90.7%	90.7%	45.4%	44.9%	44.9%	44.8%	44.8%	44.7%	45.4%
48	92.3%	92.1%	91.9%	91.9%	91.8%	91.9%	92.0%	92.0%	48.9%	48.5%	48.4%	48.3%	48.3%	48.2%	48.8%
49									52.8%	52.5%	52.3%	52.2%	52.2%	52.0%	52.6%
50									56.8%	56.6%	56.5%	56.3%	56.3%	56.1%	56.6%
51									61.0%	60.9%	60.7%	60.5%	60.5%	60.4%	60.7%
52									65.2%	65.2%	65.0%	64.8%	64.8%	64.7%	64.9%
53									69.3%	69.3%	69.2%	69.0%	68.9%	68.8%	69.0%
54									73.3%	73.4%	73.2%	73.1%	73.0%	72.9%	73.0%
55									77.1%	77.2%	77.1%	77.0%	76.9%	76.9%	76.9%
56									80.6%	80.7%	80.6%	80.5%	80.4%	80.4%	80.4%
57									83.7%	83.7%	83.7%	83.6%	83.6%	83.5%	83.5%
58									86.4%	86.4%	86.4%	86.3%	86.3%	86.3%	86.3%
59									88.7%	88.8%	88.7%	88.7%	88.7%	88.7%	88.6%
60									90.7%	90.7%	90.7%	90.7%	90.7%	90.7%	90.7%
61									92.4%	92.4%	92.4%	92.4%	92.4%	92.4%	92.3%
62									93.8%	93.8%	93.8%	93.8%	93.8%	93.8%	93.8%
63									94.9%	95.0%	95.0%	94.9%	94.9%	94.9%	94.9%
64									95.9%	95.9%	95.9%	95.9%	95.9%	95.9%	95.9%
65									96.7%	96.7%	96.7%	96.7%	96.7%	96.7%	96.7%
66									97.3%	97.3%	97.3%	97.3%	97.3%	97.3%	97.3%
67									97.8%	97.9%	97.9%	97.9%	97.8%	97.8%	97.8%
68									98.3%	98.3%	98.3%	98.3%	98.3%	98.3%	98.3%
69									98.6%	98.6%	98.6%	98.6%	98.6%	98.6%	98.6%
70									98.9%	98.9%	98.9%	98.9%	98.9%	98.9%	98.9%
71									99.1%	99.1%	99.1%	99.1%	99.1%	99.1%	99.1%
72									99.3%	99.3%	99.3%	99.3%	99.3%	99.3%	99.3%

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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. The economic scenarios for interest rates and house prices that were used in the projections are summarized. The adjustments to house prices to account for deferred maintenance are also presented. Finally, this Appendix describes how assumptions about the future cohort characteristics along with the HECM loan volume forecasts are used to generate new loan-level endorsements during the future fiscal years 2017-2023.

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 the maximum possible policy year is 72. To illustrate the initial conditions of the forecast, a loan endorsed in FY 2009 and still active in FY 2016 has its first full-year termination rate estimated in policy year nine, because the first eight policy years have already elapsed by the end of FY 2016 (the of date of this report). Active loans were originated from FY 2009 through FY 2016. Future endorsements are generated for FY 2017 through FY 2023 as described in Section B6 below.

The variables used in the analysis are derived from loan characteristics and economic forecasts. Moody's July 2016 forecasts of interest and unemployment rates and house price indices are combined with the loan-level data to simulate the stochastic economic paths and create the necessary forecasted 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 rates.

For each loan during future policy years, the derived loan variables serve as independent variables to the logistic termination models described in Appendix A. The termination projections by types 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 2016 to generate the expected present values. We also applied eight alternative economic scenarios for sensitivity analysis, including five economic paths from our

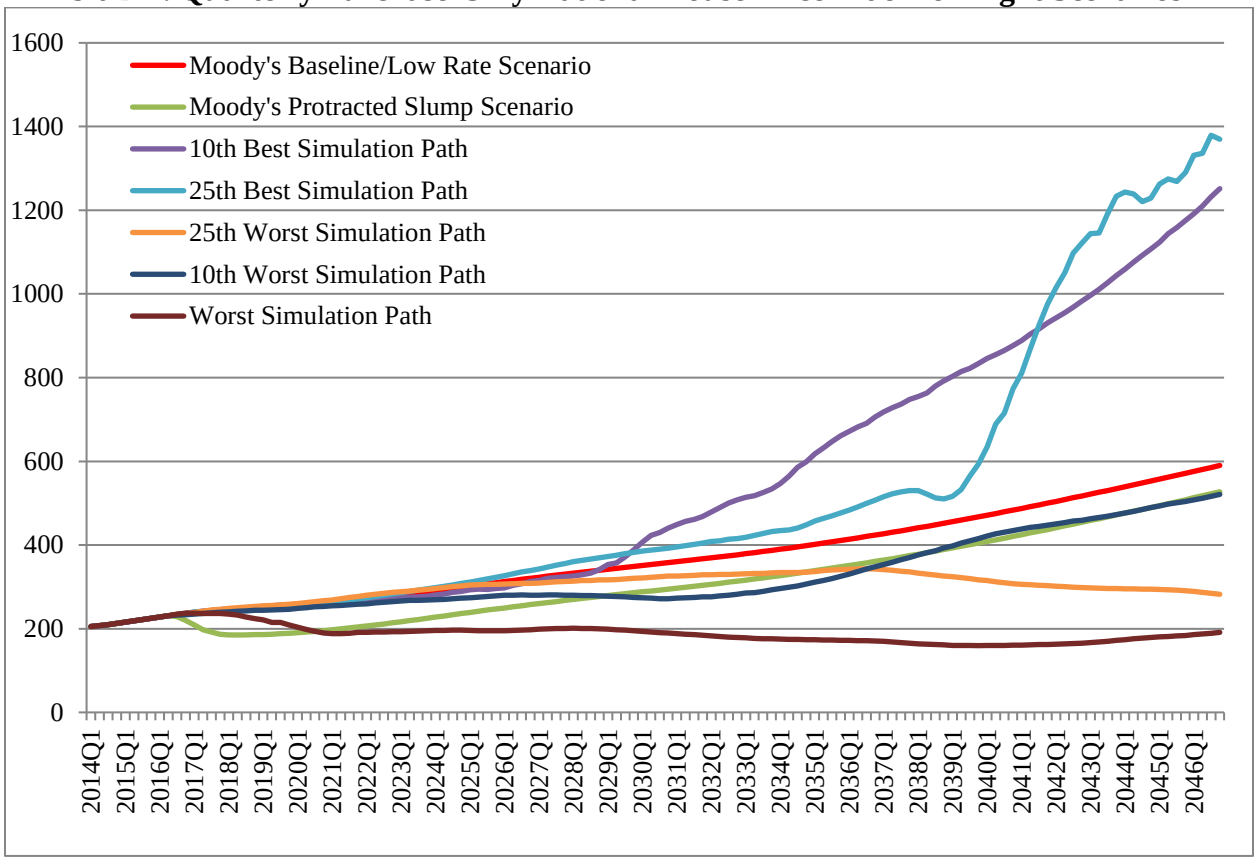
stochastic simulation, the Moody's baseline as a deterministic scenario, the "Protracted Slump Scenario" suggested by Moody's economy.com as of July 2016, and a low interest rate scenario. The economic factors include the FHFA national, state and MSA purchase-only house price indices; the national unemployment rate; the 10-year Treasury rate, the 1-year Treasury rate and the 1-year LIBOR rate.

The eight alternative scenarios are:

- Moody's July 2016 baseline forecast as a deterministic scenario;
- 10^{th} Best Path in the simulation, the path that resulted in the 10^{th} highest economic value in the Monte Carlo simulation;
- 25^{th} Best Path in the simulation;
- 25^{th} Worst Path in the simulation, the path that resulted in the 25^{th} lowest economic value in the Monte Carlo simulation;
- 10^{th} 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;
- Moody's Protracted Slump Scenario and
- Low Interest Rate Scenario.

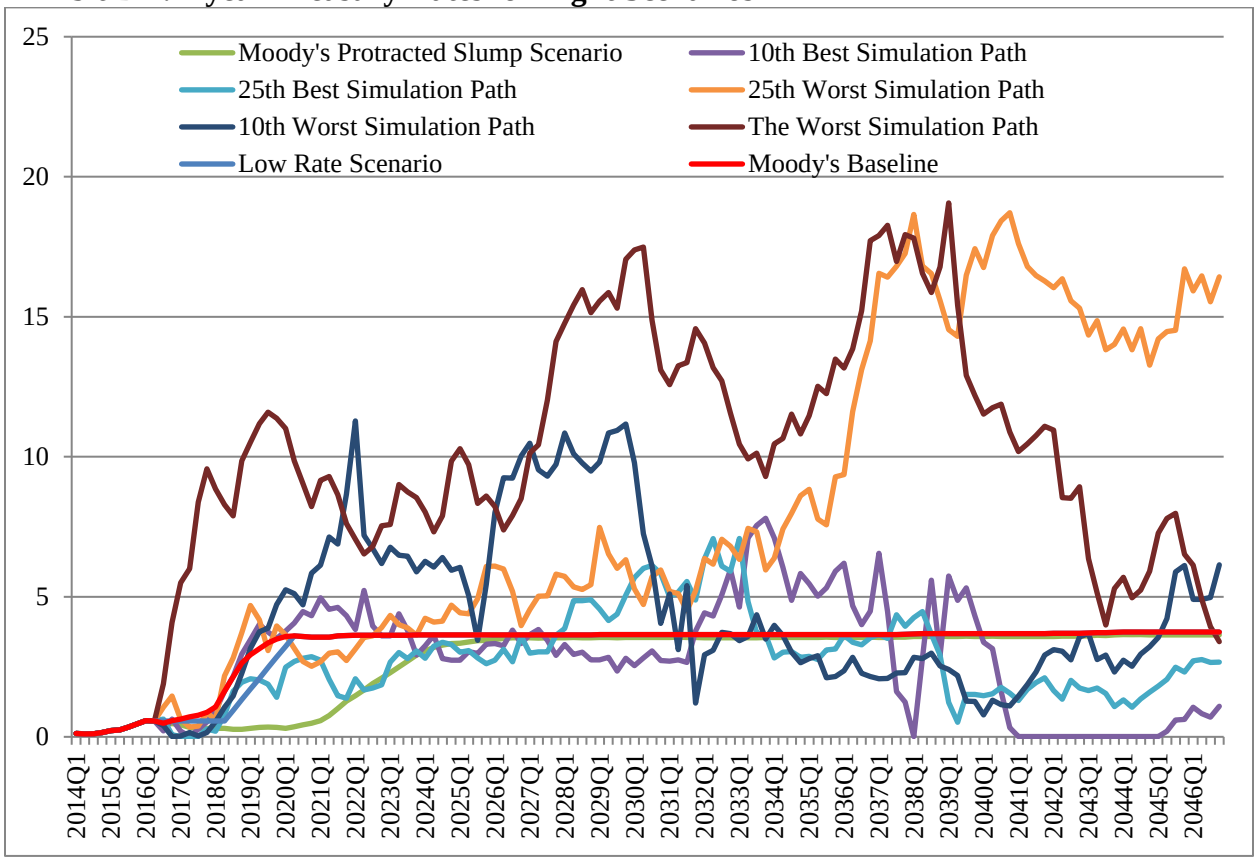
Under Moody's forecast methodology, the levels of the house price indices for any scenario converge to the base-case long-term index levels. As a result, a stress scenario always shows faster house price growth after the index bottoms out. As in the corresponding Actuarial Review for forward mortgages,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

Exhibit B-1. Quarterly Purchase-Only National House Price Index for Eight Scenarios



A similar chart for the 1-year constant maturity Treasury (CMT) rates appears in Exhibit B-2 below. The Federal Reserve has kept interest rates low for the past few years, but public discussion focuses on when this will ease up. In Moody's alternative economic scenarios, the future paths of interest rates all rise rapidly in the near term. The 1-year LIBOR rate tends to reflect a small, positive and time-varying credit spread over the 1-year Treasury rates. The LIBOR series is not shown for brevity. For this FY 2016 Actual Review, a Low Rate scenario is added.

Exhibit B-2. 1-year Treasury Rates for Eight Scenarios



B3. Maintenance-Risk Adjustments

Research[42] on the HECM portfolio indicates the need to account for the house 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. We reflect this risk by computing the discount or haircut that a HECM loan property would sell for compared to other similar properties.

For this year's Review, FHA provided additional data on the sale price of FHA-owned houses underlying HECM loans. This additional information allows the derivation of a more accurate estimate for the adjustment of maintenance risk by different disposition types. To model the maintenance risk, we derived the cumulative house price discount factor by using the HECM

[42] Capone, C. A., K. L. Chang and C. A. Cushman (2010). *Identification of Home Maintenance Risk in Reverse Mortgages: An Empirical Examination of Home Price Appreciation among HECM Borrowers.* American Real Estate and Urban Economics Association 2010 Mid-Year Conference: Washington, D.C

property sale price for Claim Type I,[43] Claim Type II terminated with conveyance[44] (REO sales), and Claim Type II terminated with a payoff,[45] respectively. The formula for the discount factor is

$$House\ Price\ Discount\ Factor = 1 - \frac{HP_t}{HP_0 * \frac{HPI_t}{HPI_0}} \quad (13)$$

where HP_t is the sale price of the house underlying a HECM loan at time *t*;

HP_0 is the appraised value of the same house at the time of the HECM loan origination; and

HPI_t is the local FHFA purchase-only house price index at time *t*.

We observe that the discount factors have similar patterns for Claim Type I and Claim Type II conveyance, whereas Claim Type II payoffs are not sensitive to loan characteristics and the housing market condition. Thus, we use an ordinary least squares (OLS) model to estimate the house price discount factor for Claim Type I and Claim Type II conveyance, and use an exponential decay function to fit the historical discount factors for Claim Type II payoff loans. The following describes the modeling details.

In this year's Review, we used the new sale price data to model the house price discount factor for Claim Type I and Claim Type II conveyance. The sale price data FHA provided include Claim Type I endorsed from 1993 through 2014 and terminated from 2013 to 2015, and Claim Type II terminated with conveyance endorsed from 1991 through 2011 and terminated from 2001 to 2016. There are 36,427 observations used to estimate the OLS regression model.

The explanatory variables in the regression model includes: policy year, current LTV, UPB, appraised value relative to the local median price, predicted conveyance probability, whether the property is located in a deficiency judgment state, 1-year local HPI growth rate prior to the termination time, and an interaction term of the Claim Type I indicator with the policy year. The definitions of the variables are as follows:

House Price discount factor: this variable is calculated by equation (13) using historical data. (Dependent variable)
Policy Year: current loan age in years. A spline function is applied to this variable.
Current LTV: current UPB divided by the estimated current property value, splined at 0.1 and 0.4.
UPB: the unpaid principal balance, subjected to a range between $50,000 and $400,000.
Relative house price to median: ratio of the appraised home value to the local area median home value at origination.

[43] Sale prices are provided by FHA.
[44] Sale prices are provided by FHA.
[45] Sale prices are obtained from Core Logic.

Predicted conveyed percentage: the predicted probability of conveyed loans in post-assignment. This variable is derived from the conveyance and payoff selection model (details in Appendix B.B4), and is used to capture other unobservable borrower behaviors.
Deficiency: an indicator to show whether the property is located in states that allow lenders to go after the personal property of the borrowers for their losses above and beyond the collateral property.[46] Value is 1 if the property is in a deficiency judgment state; 0 otherwise.
HPA: 1-year local HPI growth rate prior to the termination year.
CT1_Pol_yr: interaction term between an indicator (equals 1 if Claim Type I; 0 if Claim Type II terminated with conveyance) and the policy year. These interaction terms capture the different baseline profile of discount factors between the two types of claims. A spline function is applied to this variable as well.

Exhibit B-3 shows summary statistics of the estimation sample dataset.

Exhibit B-3. Descriptive Statistics

Variable	Number of Observations	Mean	Standard Deviation
Policy Year	36,427	8.381	2.750
UPB	36,427	165,308	91,387
Deficiency	36,427	0.222	0.415
HPA	36,427	0.070	0.053
Conveyed Percentage	36,427	0.358	0.261
Relative house price to median	36,427	0.884	0.420
Current LTV	36,427	0.915	0.250
House Price Discount Factors for Claim Type I	31,531	0.526	0.197
House Price Discount Factors for Claim Type II terminated with conveyance	4,896	0.420	0.228

[46] http://www.foreclosurelaw.org/

Regression results are presented below in Exhibit B-4.

Exhibit B-4. OLS Estimates of the Maintenance Model

Analysis of OLS Estimates					
Description	**Parameter**	**Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
	Intercept	0.50253	0.03774	13.32	<.0001
loan age <=7	**pol_yr1**	0.00631	0.00187	3.37	0.0008
7<loan age <=10	**pol_yr2**	-0.0029	0.00272	-1.06	0.2877
10<loan age <=15	**pol_yr3**	0.01002	0.00145	6.89	<.0001
UPB	**upb_amt**	-7.19E-07	1.73E-08	-41.65	<.0001
Indicator for a deficiency state	**deficiency**	-0.02821	0.00272	-10.38	<.0001
Annual growth rate of the local HPI	**hpa**	-0.07806	0.02	-3.9	<.0001
Predicted conveyed percentage <=0.2	**convey_percent1**	-0.20474	0.02664	-7.69	<.0001
0.2< Predicted conveyed percentage <=0.6	**convey_percent2**	0.03058	0.00983	3.11	0.0019
Predicted conveyed percentage >0.6	**convey_percent3**	0.44783	0.01846	24.26	<.0001
relative house price <=0.4	**rel_hp1**	0.32435	0.04834	6.71	<.0001
0.4< relative house price <=1	**rel_hp2**	-0.13531	0.00592	-22.84	<.0001
relative house price >1	**rel_hp3**	0.05396	0.00397	13.61	<.0001
updated loan to value ratio <= 0.1	**CLTV1**	-3.32397	0.39264	-8.47	<.0001
0.1<updated loan to value ratio <= 0.4	**CLTV2**	0.77047	0.06163	12.5	<.0001
updated loan to value ratio >0.4	**CLTV3**	-0.05085	0.00775	-6.56	<.0001
Claim Type I and loan age <=7	**Ct1 _pol_yr1**	0.02634	0.00106	24.81	<.0001
Claim Type I and 7<loan age <=10	**Ct1 _pol_yr2**	-0.02759	0.00292	-9.45	<.0001
Claim Type I and 10<loan age <=15	**Ct1 _pol_yr3**	0.00581	0.00316	1.84	0.0656

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	18	357.258	19.84767	620.26	<.0001
Error	36408	1165.008	0.032		
Corrected Total	36426	1522.266			
Root MSE	0.17888	**R-Square**	0.2347	**Number of Observations Used**	36427
Dependent Mean	0.51194	**Adj R-Sq**	0.2343		
Coeff Var	34.94223				

Based on the regression results in Exhibit B-4, properties with higher unpaid balances have lower haircuts than those with lower unpaid balances, holding everything else the same. Houses with value similar to the local median level at origination have a lower haircut than others. The haircut is lower when the local house price growth rate in the year prior to the termination is higher. Houses in deficiency judgment states tend to have a lower discount in sale prices, indicating that they are better maintained. The haircut is lower if the predicted probability of conveyance is less than or equal to 0.2. The haircut is higher if the updated loan to value ratio is less than or equal to 0.4. For Claim Type II Conveyance, the haircut decreases during policy years 8, 9 and 10, but otherwise increases. Claim Type I haircuts have the same pattern, but with larger magnitudes of increases and decreases.

Due to limited samples of Claim Type II terminated with a payoff, we apply an exponential decay function to fit the historical discount factors for these payoff loans. We first compute the average house price discount factor for those houses underlying terminated HECM loans with payoffs. Then, we apply an exponential decay function of the policy year to fit the historical average discount factor as shown. The function is estimated separately depending on whether the appraisal value at origination is above the metropolitan median house price (and the indicator *hp_above_med* equals one) or below it. The functional forms are as follows:

$$House\ price\ discount\ factor\ at\ loan\ age\ t\ for\ Claim\ Type\ 2\ terminated\ with\ a\ payoff$$

$$= \begin{cases} -0.15 + 0.018 * age & if\ age < 20 \\ 0.2 & if\ age \geq 20 \end{cases} \quad if\ hp\_above\_med = 0 \qquad (14)$$

and

$$= \begin{cases} -0.15 + 0.018 * age & if\ age < 20 \\ 0.18 & if\ age \geq 20 \end{cases} \quad if\ hp\_above\_med = 1 \qquad (15)$$

We used the regression model in Exhibit B-4 to project the House Price Discount Factors for Claim Type I and Claim Type II terminated with conveyance and equations (14) and (15) for Claim Type II terminated with a payoff. Equation (16) uses these estimated discount factors to estimate the sales prices of the properties:

$$Estimated\ Property\ Sale\ Price = HP_0 \times \frac{HPI_t}{HPI_0} \times (1 - House\ Price\ Discount\ Factor) \quad (16)$$

The maintenance-risk adjustment factors help project the property recovery revenue at the projected HECM loan termination date. The projected recovery from property disposition also includes other expenses at the sale, which are discussed in Appendix C.

B4. Conveyance and Payoff Selection Model in Post-Assignment

For loans terminated with Claim Type II, borrowers or their heirs can pay off their HECM loans by paying HUD 95 percent of the appraisal house value or convey the mortgaged house to HUD; in latter case, HUD will sell the conveyed property to recover up to the loan balance. In this year's Review, we used HECM loans terminated with payoff and conveyance types from FY 2005 through FY 2016 to model the borrower's conveyance and payoff selection choice. There are 11,562 observations for the logistic model.

A binomial logistic model is estimated based on an indicator variable that is 1 for a conveyance and 0 for a payoff. Exhibit B-5 shows the estimation results.

Most variables in the equation have the same specification in the termination models described 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 during a bad economy.

The results also indicate that HECM borrowers in areas with higher house prices relative to the national loan limit are more likely to pay off. This inference comes from the variable that is the ratio of the area median house price to the national HECM loan limit, which has a negative coefficient. As this ratio increases, the HECM loans are less likely to convey and hence more likely to payoff. This ratio is capped at one.

Furthermore, HECM borrowers with higher appreciated house value, with higher house price relative to local median price, or with lower current 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. Also, the higher is the loan age, the more likely is the loan to convey.

Exhibit B-5. Conveyance and Payoff Selection Model Coefficients

Analysis of Maximum Likelihood Estimates					
Description	**Parameter**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
	Intercept	-13.7805	0.7177	368.6415	<.0001
loan age <=7	**pol_yr1**	0.8489	0.0673	159.1568	<.0001
loan age >7	**pol_yr2**	0.3023	0.0126	574.9704	<.0001
borrower's age at origination	**Orig_Age**	0.0816	0.00505	261.1353	<.0001
ratio of median local house price to national loan limit at origination <= 1	**limit1**	-3.0557	0.1136	723.0284	<.0001
ratio of unemployment rate to past 10y average at termination, at national level	**rel_ue_usa**	0.5726	0.0803	50.8814	<.0001
first month cash draw	**pct_cashdd**	0.5763	0.0835	47.6232	<.0001
relative house price	**rel_hp**	-1.0315	0.0748	190.2061	<.0001
Cumulative HPA between termination and origination	**Cumulative HPI_Change**	-0.0199	0.000998	397.7379	<.0001
Updated loan to value ratio	**CLTV**	2.4781	0.1347	338.4633	<.0001

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	88.0	**Somers' D**	0.761
Percent Discordant	11.9	**Gamma**	0.762
Percent Tied	0.1	**Tau-a**	0.375
Pairs	32900120	**c**	0.881

B5. Forecasted Endorsement Volume and Portfolio Composition

Exhibit B-6 shows the forecasted HECM endorsement volumes and MCAs for the FY 2017 through FY 2023 books, which are based on HECM loan data observed through June 2016, the Moody's July 2016 baseline economic forecast, and the HECM total volume count model in

Appendix E. The projected loan compositions of these future books were based on the HECM loans observed from FY 2015 Q4 through FY 2016 Q3. Adopting the composition of the most recent cohorts from the available data can capture the characteristics of loans and the recent changes in policies. A detailed comparison follows.

Starting in FY 2014, FHA replaced the Standard and Saver programs with a new program which has an initial disbursement cap of 60 percent, and a principal limit at 85 percent of the original Standard product. We assume that the maximum claim amount (MCA) of individual loans will grow by Moody's July 2016 forecast of national HPI from FY 2017 through FY 2023.

Exhibit B-6. HECM Volume and MCA Projections for Future Endorsements (allowing younger spouses)

FY	Average MCA	Total Count	Total Dollar Volume ($m)
2017	$306,904	60,175	$18,468
2018	$312,167	66,719	$20,829
2019	$315,239	71,467	$22,534
2020	$319,835	75,178	$24,055
2021	$326,556	78,227	$25,561
2022	$335,070	80,824	$27,100
2023	$344,518	83,082	$28,643

The assumptions on the age and gender distribution for FYs 2017-2023 new books are based on the distribution of the HECM loans observed from FY 2015 Q4 through FY 2016 Q3. Since the sample doesn't include eligible younger co-borrowers and non-borrowing spouses, the distribution of the newly allowed spouses who are younger than 62 is based on research by FHA. The overall distribution is shown in Exhibit B-7.

Exhibit B-7. Future Endorsement Age and Gender Distribution

Current Program FYs 2017-2023 (Adjusted for Non-Borrowing Spouse)				
Age Group	Male	Female	Couple	Row Totals
< 62	0.00%	0.00%	3.89%	3.89%
62 to 65	5.25%	6.06%	9.21%	20.53%
66 to 70	5.29%	7.93%	11.81%	25.03%
71 to 75	3.97%	7.26%	9.63%	20.86%
76 to 85	4.89%	10.40%	8.14%	23.43%
85+	1.40%	4.19%	0.67%	6.26%
All Ages	20.80%	35.84%	43.36%	100.00%

Assumptions about future market share of loan interest rate types are consistent with the distribution observed from the recent HECM loans from FY 2015 Q4 through FY 2016 Q3, and are shown in Exhibit B-8.

Exhibit B-8. Future Distribution of Loan Amortization Types

FYs	Fixed Rate Loan	Variable Rate Loan
2017-2023	11.53%	88.47%

Assumptions for the projected cash draw distribution for each future cohort are based on the FY 2015 Q4 through FY 2016 Q3 endorsements as shown in Exhibit B-9. The cash draw behavior observed from the recent HECM loans from FY 2015 Q4 through FY 2016 Q3 best reflect the impact of the recent policy changes, which mandates that 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"[47] in the first policy year. The buckets below represent the cash draw preferences of future borrowers. Also, we assume that the first-month cash draw equals the first-year cash draw for future cohorts, for their termination and T&I default projections.

Exhibit B-9. Future Distribution of Projected Cash Draws for FYs 2017 - 2023

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	3.2%	3.4%	4.1%	4.8%	5.8%	32.1%	3.8%	5.9%	7.2%	26.8%	2.7%
66 to 70	4.3%	3.9%	4.2%	4.8%	5.0%	27.8%	4.4%	6.4%	7.8%	28.2%	3.2%
71 to 75	4.8%	4.5%	4.3%	5.6%	5.3%	27.2%	4.8%	7.0%	8.4%	25.5%	2.6%
76 to 85	6.5%	6.5%	6.0%	5.7%	5.2%	28.3%	4.7%	6.5%	8.0%	20.5%	2.0%
85+	10.3%	10.3%	8.0%	6.4%	5.4%	29.8%	3.8%	5.2%	6.4%	12.8%	1.5%
Weighted Column Totals	**5.1%**	**5.0%**	**4.9%**	**5.3%**	**5.3%**	**28.8%**	**4.4%**	**6.4%**	**7.8%**	**24.4%**	**2.6%**

The above assumptions form the basis for generating projected future HECM endorsements for FY 2017 through FY 2023.

[47] 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 purchase price of the property, and the national HECM FHA loan limit ($625,500 for FY 2016).

- **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 MCAs.

- **Conditional Claim Type I Rate (CC1R):** Among loans that terminated without note assignment, the number of such loans that had a shortfall divided by the total number of loans active as of the beginning of the same policy year. The shortfalls are labeled as Claim Type I. 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 II (Assignment):** If certain conditions are met, a lender can (but is not required to) assign the promissory note to FHA. FHA pays the UPB at the time of assignment to take the ownership of the note. Such assignment events are labeled as Claim Type II. One of the conditions for the promissory note to be eligible for assignment is that the outstanding UPB of a HECM reaches 98 percent of the MCA. FHA also imposes other conditions as noted in Section II.C.i. About 60 percent of the HECM loans that meet the 98% condition are not eligible for assignment.

- **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 (through assigned private servicers) 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 always the loan balance.

C2. Cash Flow Components

HECM cash flows are comprised of premiums, claims, note expenses and recoveries. Premiums consist of upfront and annual mortgage insurance premiums, which are inflows to the HECM program. Recovery after assignment, a cash inflow, represents cash recovered from the sale of the underlying property once the loan terminates. Claim Type I payments are cash outflows paid to the lender when the net proceed of a property sale 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 I Payments		X
Claim Type II (Assignment) Payments		X
Note Holding Expenses		X
Recoveries	X	

In this year's review, FHA provided additional data on other expenses that was not provided for previous Reviews. The sources of this additional data are the FHA Single Family Acquired Asset Management System for Claim Type I and FHA Home Equity Reverse Mortgage Information Technology (HERMIT) for Claim Type II. The total expenses of property sales differ depending on whether it is a Claim Type I or Type II, so we continue to model them separately. The details are described in Section 2.3. 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. In general, the UPB at a given time *t* is calculated as follows[48]:

$$UPB_t = UPB_{t-1} + Cash\ Draw_t + Accruals_t \quad (17)$$

The UPB for each period *t* consists of the previous loan balance plus any new borrower cash draws and accruals. The accruals include interest, annual mortgage insurance premiums, and servicing fees. Future borrower draws are estimated by assigning draw patterns to loans based on the cash draws during the first two years. As noted in Appendix D, we assume that tax and insurance default terminations before assignments will accrue additional UPB with tax and insurance payment for the assumed one year between the default date and the property disposition date. And 25 percent of the loans without available cash draws after assignments are assumed to fail to pay taxes and insurance, thus these loans will accrue additional UPB at annual property tax rates on the estimated property value until their termination. For the tax and insurance payment accrual amounts, we use state-level average property tax rates to estimate the tax accrual amounts, and assume 0.4% of property value as insurance accrual amounts.

C2.2. Premiums

Upfront and annual mortgage insurance premiums, along with recoveries, are the 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 FYs 2011 through 2013 endorsements, the upfront premium rate for the Saver program was 0.01 percent (1 basis point) of the MCA. For the new program introduced in FY 2014, the upfront premium rate is 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. The upfront premium is paid in full to FHA at the loan closing, and is a positive cash flow.

[48] 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.

C2.2.2. Annual Premiums

The annual premium is calculated as a percentage of the current loan balance. For the FY 2009 and FY 2010 books of business, the annual premium is 0.5 percent of the UPB. From FY 2011 onward, the annual premium is 1.25 percent of the UPB for all Standard, Saver, and the new program introduced in FY 2014. Before a loan is assigned, the annual premium is assumed to be advanced by the lender, paid to FHA, and added to the accruing loan balance.

C2.3. Claims

Claims made by lenders consist of Claim Type I and Claim Type II.

C2.3.1. Claim Type I (Pre-assignment)

Claim Type I enters the HECM cash flows as payments to the lender when a property is sold and the net proceeds from the sale are not sufficient to cover the balance of the loan at termination. This year's review assumes 40% of loans with UPB reaching 98% of MCA get assigned, and thus the remaining 60% of loans that are not assigned could become Claim Type I. The Claim Type I payment, for a loan that terminates without assignment, can be expressed as:

Claim Type I Payment = maximum (0, UPB - Net Property Sales Price) (18)

The net sales price of the property is:

Net Property Sales Price = Estimated Property Sales Price × *(*1 – *% sales expenses – % other expenses)* (19)

The estimated property sale price is derived from formulas for House Price Discount Factors described in Appendix B.B3. Sales expenses are those required to conduct the actual sale, and other expenses are those to manage the property until the sale.

Sales expenses remain at 7 percent of the sales price, varied by state, for this year's Review, but FHA provided additional data on other expenses that was not provided for previous Reviews. The source of this additional data is the HERMIT. The new dataset revealed the following information. There were 31,355 Claim Type Is that were endorsed between FYs 2002 to 2013 and terminated between FYs 2013 and 2015. On average, Claim Type Is had an average total expense of $20,000, which is approximately 25 percent of the sale price. Thus, the sales expense is still 7 percent but other expenses are now 18 percent. Other expenses were not taken into account in last year's Review. Thus, total expenses increased in this year's Review from 7 percent to 25 percent for Claim Type Is.

C2.3.2. Claim Type II (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, which is the loan balance (up to the MCA). The net losses from Claim Type II depend on two components, the note holding expenses after assignment and recoveries from assigned notes.

FHA imposes a set of requirements[49] that, if any of them are not met, makes the HECM loan ineligible for an assignment even when UPB reaches 98 percent of the MCA. Approximately 40 percent of the loans reached 98% MCA during FY 2007 through FY 2016 period were assigned to HUD. The remaining 60 percent of these loans were determined to be ineligible for assignment. In this FY 2016 review, we assume that only 40% of loans that reached the 98 percent UPB/MCA ratio will be assigned. This is a major change from the assumption made in the prior Reviews, where 100% loans assignment was assumed once they reached the 98 percent criteria.

C2.4. Note Holding Expenses after Assignment

The note holding cash outflows include the additional cash draws by the borrower and property taxes FHA paid for those borrowers who default on their tax & insurance payments during their assignment period.

Additional cash draws by the borrowers can occur under the contract after FHA takes ownership of the note only if the total cash drawn by the borrower has not reached the maximum principal limit upon the assignment date.

For loans without additional cash draws available after assignment, starting from the FY 2015 Review, we assume that 25 percent of the borrowers of the assigned loans will fail to pay taxes (and insurance). As discussed in Appendix D, the T&I default after assignment will not result in loan terminations. Instead, FHA will pay the taxes for the borrowers and accrue the payments on the loan UPB. Thus, the note holding expenses will also include the tax payments of those 25 percent of loans. The tax payments made by FHA are assumed to equal annual tax rates by state multiplied by the estimated property values, until the loan terminates.

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) is projected with the termination model in Appendix A. The amount of recovery of assigned loans at termination, can be expressed as:

[49] Assignment eligibilities are for reasons like due and payable, loss mitigation, foreclosure, etc.

Recovery Amount =

$$\begin{cases} minimum\ (UPB, Net\ Property\ Sales\ Price) & if\ terminated\ with\ Death\ or\ Move-out \\ UPB & if\ terminated\ with\ refinance \end{cases}$$

(20)

where the net sales price of the property is:

Net Property Sales Price = Estimated Property Sales Price × *(*1 – *% sales expenses – % other expenses)* (21)

Sales expenses are those required to conduct the actual sale, and other expenses are those to manage the property until the sale. Sales expenses remain at 7 percent of the sales price, varied by state, for this year's Review, but FHA provided additional data on other expenses that was not provided for previous Reviews. The sources of this additional data are the FHA Single Family Acquired Asset Management System (SAMS) and FHA Home Equity Mortgage Information Technology (HERMIT) System.

For Claim Type II terminated with conveyance, the dataset contained 5,003 conveyed REO cases that were endorsed between FYs 2001 and 2016 and terminated from FY 2001 to FY 2016. In prior years' Reviews, the known other expenses amounted to 12 percent of the sales price, for a total expense rate of 19 percent. However, according to the SAMS dataset, there are additional other expenses related to REO-conveyed properties, mostly in the Management & Operations account, which includes disaster repairs, mold treatment, property management fees, homeowners' association fees, demolition, clean-up, debris removal, yard maintenance and winterizing and snow removal fees These adjusted other expenses amount to 19 percent of the property sales price. Consequently, for Claim Type II terminated with conveyance, we increased other expenses from 12 percent to 19 percent of the sales price, to reflect the updated expenses observed by FHA upon disposition, and total expenses increased from 19 percent to 26 percent.

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 occur over time:

$$\begin{aligned} Net\ Cash\ Flow_t = \ & Upfront\ Premiums_t + Annual\ Premiums_t + Recoveries_t \\ & - Claim\ Type\ Is_t - Claim\ Type\ IIs_t - Note\ Holding\ Expenses_t \end{aligned} \quad (22)$$

C4. Present Value Discounting

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 2016 President's Budget reflect the recent Treasury yield curve, which captures the Federal government's cost of capital in raising funds. 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 2017 is multiplied by 0.9847 to convert it into a present value as of year-end FY 2016. Overall, the discount factors used in this Review are similar to but slightly higher than the corresponding discount factors in last year's Review.

Exhibit C-2. OMB Discount Factors

Fiscal Year	Discount Factor	Fiscal Year	Discount Factor
2017	0.9847	2036	0.5021
2018	0.9616	2037	0.4821
2019	0.9342	2038	0.4628
2020	0.9052	2039	0.4441
2021	0.8756	2040	0.4261
2022	0.8460	2041	0.4086
2023	0.8165	2042	0.3917
2024	0.7880	2043	0.3754
2025	0.7608	2044	0.3597
2026	0.7346	2045	0.3446
2027	0.7089	2046	0.3300
2028	0.6837	2047	0.3160
2029	0.6590	2048	0.3026
2030	0.6348	2049	0.2898
2031	0.6111	2050	0.2775
2032	0.5881	2051	0.2657
2033	0.5657	2052	0.2545
2034	0.5438	2053	0.2437
2035	0.5226	2054	0.2334

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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. Section D1 provides 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 a HECM loan with tax or insurance (T&I) delinquencies is considered due and payable, and therefore subject to foreclosure if the borrower does not comply with the repayment plan. Through impacts on termination speeds and recovery rates, this ruling was intended to positively impact the economic value of the HECM program by providing an intervention that could reduce potential losses.

There were several major policy changes in FY 2015 that may affect the T&I default experience. In Mortgagee Letter (ML) 2015-09, HUD introduced the requirement and calculation of Life Expectancy Set-Aside (LESA), which is used for the payment of property taxes and hazard and flood insurance premiums. The LESA guidelines became effective on 4/27/2015. With this set-aside, HECM loans with LESA will have fewer funds available for withdrawal, but there will be no T&I default before the life expectancy of the borrowers. Since this program has only a 1-year history and there is no origination data showing information related to LESA, we assume zero effect of this LESA guideline due to limited information about how this may be implemented. Once origination data with LESAs become available, the potential performance impact of this policy needs to be reviewed and re-evaluated.

For HECM loans before assignment, HUD provided additional guidance on due and payable policies and the timing requirements in Mortgagee Letter 2015-10 and Mortgagee Letter 2015-11. For HECM loans after assignment, HUD currently does not foreclose on assigned loans that are in tax and/or insurance default. In order to secure and maintain HUD's position on the lien of an assigned loan, HUD advances T&I payments on behalf of the borrower. HUD first advances funds from the borrower's available HECM funds. If no funds are available, HUD advances the tax payment and adds the payment amount to the loan balance. These policies affect all existing books and future books.

For unassigned loans, based on the same methodology as in prior years, the T&I model is used to project their default behavior. If a loan goes to default, we assume the foreclosure will be enforced within one year, and the costs of T&I default in that year will be accrued to the loan UPB. The T&I model does not affect loans after assignment. We assume a constant percentage of 25% of

assigned loans go to T&I default immediately after assignment. We use the property tax rates by state[50] to calculate the taxes HUD will pay annually until the termination of those loans. We also assume that the property insurance premium is 0.4 percent of the fair market value of the house. The T&I payments are treated as note holding expenses, a component of cash outflows as discussed in Appendix C, and added to the loan balance.

The remainder of this Appendix discusses the T&I default model. Notice that the T&I default model is only applicable to the performance of HECM loans before assignment.

D2. Data

FHA's databases identify which HECM loans have had episodes of T&I delinquency. Some of these loans may terminate through foreclosure pursuant to Mortgagee Letter 2011-01 or for other reasons, and some may have cured. For purposes of this analysis, "default" is defined as a T&I delinquent loan not making any T&I repayments over a consecutive 12-month period. Correspondingly, a loan stays in delinquency (but not default) as long as a partial repayment is made in any 12-month window. However, 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 borrower who 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 T&I payments. T&I default is defined as a terminal status, whereupon foreclosure proceedings are initiated. 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/policy-year combination. In order to build the predictive model, we obtained the following static and dynamic loan attributes for the entire active and terminated HECM loan universe as of March 31, 2016: 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 the highest HECM concentration (California and Texas), an indicator of whether the home value at origination was above or below the local area median value, loan age and current LTV.

The historical T&I default behavior varied throughout the years. In recent years, HECM loans are less likely to experience a T&I default due to the more effective enforcement of the foreclosure process. In this year's review, we use only the loan performances starting from FY 2011 to estimate our model, in order to base our predictions consistent with the recent policy change. In contrast to

[50] Source: Median Property Tax Rate by State, *The US Census Bureau, The Tax Foundation, and Tax-Rates.org.* http://www.tax-rates.org/taxtables/property-tax-by-state

previous reviews, we also included the terminated loans in the estimation process, to capture the T&I performance from the whole HECM universe.

D2.1. Variable Definitions

We used the following variable specifications in our regression analysis:

Currently in Default: this variable is 1 when the loan reaches a 12 months' delinquency status during the year with no partial repayments, and is 0 if not delinquent or fully cured, partially repaid delinquent, or delinquent less than 12 months during the year. (Dependent variable)

Percent Cash Draw Down: 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 knot point at 90%.

Original Age: borrower age at origination.

LOC : value is 1 if product type is line of credit; 0 otherwise.

Gender_Female : value is 1 if single female borrower; 0 otherwise.

Gender_Male: value is 1 if single male borrower; 0 otherwise.

Gender_Missing: value is 1 if borrower's gender is missing; 0 otherwise.

State CA: value is 1 if collateral property is in California; 0 otherwise.

State TX: value is 1 if collateral property is in Texas; 0 otherwise.

Relative house price to median: ratio of home value to the local area median home value at origination.

Policy Year: current loan age in years. A spline function is applied on this variable.

LTV Current: current UPB divided by the estimated current property value, with a knot point at 1.

D2.2. Descriptive Statistics

Exhibit D-1 shows selected statistics for the estimation sample dataset. 17.5 percent of HECM loans have had a T&I delinquency history, among which 46.5 percent are currently in default.

Exhibit D-1. Descriptive Statistics of Active and Terminated Loans

Variable	Number of Observations	Mean	Standard Deviation
Currently in Default	758,421	0.031	0.172
Default Policy Year	758,421	1.935	2.550
Percent Cash Drawdown	758,421	0.692	0.303
Original Age	758,421	71.972	7.239
LOC	758,421	0.907	0.291
Gender_Male	758,421	0.186	0.389
Gender_Female	758,421	0.399	0.490
Gender Missing	758,421	0.007	0.084
State CA	758,421	0.172	0.377
State TX	758,421	0.069	0.254
Relative house price to median	758,421	1.100	0.578

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 2016. All active and terminated loans endorsed in FY 2001 and later were included in the estimation sample. Endorsements prior to FY 2001 are excluded because of the new enforcement policy announced in Mortgagee Letter 2011-01. The sample loan performance period begins in FY 2010. Regression results are presented below in Exhibits D-2.

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		-8.4516	0.0722	13694.2256	<.0001
pct_cashdd1	**(0, 0.9]**	0.7820	0.0266	862.8302	<.0001
pct_cashdd2	**(0.9,1]**	-7.1617	0.1778	1621.5698	<.0001
Orig_Age		-0.0158	0.000636	619.5463	<.0001
LOC		1.0210	0.0325	986.2367	<.0001
Gender_Female		0.4359	0.00977	1990.9689	<.0001
Gender_Male		0.4626	0.0114	1645.6693	<.0001
gender_missing		0.3521	0.0496	50.3497	<.0001
stateCA		-0.1032	0.0129	64.3927	<.0001

Analysis of Maximum Likelihood Estimates					
Parameter	**Boundary Values**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
stateTX		0.5197	0.0146	1264.0866	<.0001
rel_hp		-0.1279	0.00832	236.2472	<.0001
pol_yr1	**[1,2]**	1.1106	0.0240	2138.9935	<.0001
pol_yr2	**(2,3]**	-0.2153	0.0142	228.9350	<.0001
pol_yr3	**(3,+∞)**	-0.2543	0.00277	8408.4913	<.0001
CLTV1	**(0,1]**	4.0988	0.0353	13475.3258	<.0001
CLTV2	**(1, +∞)**	0	.	.	.

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	72.4	**Somers' D**	0.469
Percent Discordant	25.5	**Gamma**	0.480
Percent Tied	2.2	**Tau-a**	0.024
Pairs	147996681740	**c**	0.735

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 the elapsed time from origination. Default propensity is lower among those with origination 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 and was not assigned during that year. Thus, the base termination model described in Appendix A takes sequential precedence over the T&I default termination model. We assume that T&I default will accrue UPB with tax and insurance amounts until termination. We also assume a fixed one-year period will elapse between the T&I default event and the subsequent property disposition. After assignment, T&I default model is not applicable, and we assume a 25 percent T&I default rate.

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 T&I default definition, *i.e.*, at the current time a loan has 12 or more months of delinquency history without any repayment, will be resolved through involuntary termination. There were 89,064 such loans as of March 31, 2016. In view of the one-year disposition time assumption, these defaulted loans were treated as if defaults occurred in FY 2016 and the dispositions are assumed to occur in FY 2017. 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 to occur one year 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 as of June 30, 2016 for all remaining years until the borrower reaches 110 years old. The resultant simulated cumulative lifetime T&I default rates of loans active as of June 30, 2016 by endorsement years appear in the Exhibit D-3 below. The results include loans meeting the default definition as of June 30, 2016, and the assumed 25% of tax default loans after assignment. This assumed 25% T&I default rate indicates a higher default rate than observed before the assignment, owing in part to the lack of an incentive for borrowers to pay property tax after their HECM is assigned to HUD, assuming they receive advice that they will not be foreclosed for not paying taxes and insurance.

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
2009	79,466	12.82%
2010	56,892	15.96%
2011	55,226	16.06%
2012	42,833	17.59%
2013	49,998	20.59%
2014	43,413	19.46%
2015	54,615	24.29%
2016*	36,879	22.96%
Total	**419,322**	**18.16%**

*2016 endorsements through 6/30/2016

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Appendix E
HECM Volume Model

Appendix E. HECM Volume Model

E1. Background

The Actuarial Review requires forecasting future volume of HECM loans for the FYs 2017 - 2023 in order to project future economic values of the MMI HECM portfolio. The HECM volume 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 volume model predicts volume by loan counts, not dollar amounts. Quarterly forecasts of the FHFA purchase-only repeat-sales home price indices were based on Moody's Analytics July 2016 forecasts.

HECM volume depends on the number of eligible senior homeowners who may choose to borrow from the program. To proxy this demographic volume 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.[51]

The most recent year for which this data is available is 2016. The census forecast of the future senior population had an annual instead of quarterly frequency. We applied linear interpolation to fill in quarterly observations. Although the HECM model is on an annual basis, we used quarterly data here in order to retain enough observation points to support the estimation of a time series model.

There were 53 (FY 2003 Q2 through FY 2016 Q2) quarterly observations used in the regression, reflecting data availability and taking into account the lags used in connection with the explanatory variables. The forecasted volume covers FYs 2016 Q3 through 2023 Q4. Forecasts for FYs 2016 Q3 and 2016 Q4 are needed to update the HECM insurance portfolio to the end of FY 2016. Exhibit E-1 summarizes the input data for the volume model.

Since the FY 2014 Review, the newly eligible younger co-borrowers and non-borrowing spouses may introduce additional modeling issues. However, from the historical data referred to in Section IV, we have not observed a significant increase of couple borrowers over the past two vintage years from this new policy, and thus the volume model is not modified as a result of this policy.

[51] http://www.census.gov/population/projections/data/national/2014.html

This 2016 Review assumes that younger co-borrowers and non-borrowing spouses account for 3.89% of the total population of future books (Appendix B).

Exhibit E-1. Input Data for the Volume Model

Period	HECM Loan Count	Couples	US. Pop>= 62 Years Old	HPI Index
2003 Q1	3,704	1,356	42,543,076	168
2003 Q2	5,043	1,935	42,828,724	171
2003 Q3	5,881	2,225	43,006,256	175
2003 Q4	7,145	2,639	43,184,524	179
2004 Q1	9,917	3,558	43,338,700	183
2004 Q2	9,844	3,524	43,444,736	187
2004 Q3	10,979	4,000	43,599,840	192
2004 Q4	9,430	3,477	43,755,500	197
2005 Q1	11,784	4,439	43,923,080	202
2005 Q2	9,130	3,553	44,115,412	207
2005 Q3	12,707	4,862	44,284,368	212
2005 Q4	14,731	5,803	44,453,972	217
2006 Q1	18,335	7,215	44,628,464	220
2006 Q2	22,435	8,749	44,813,524	222
2006 Q3	20,598	7,841	44,989,424	222
2006 Q4	23,968	9,002	45,166,016	223
2007 Q1	29,006	10,614	45,491,776	225
2007 Q2	27,328	10,382	46,125,232	224
2007 Q3	27,111	9,974	46,457,912	222
2007 Q4	24,647	9,087	46,792,992	218
2008 Q1	30,480	11,084	47,113,548	213
2008 Q2	28,663	10,188	47,406,636	207
2008 Q3	28,256	9,530	47,731,396	202
2008 Q4	27,557	9,566	48,058,380	196
2009 Q1	30,073	13,005	48,355,036	195
2009 Q2	28,617	10,880	48,591,744	192
2009 Q3	28,161	10,408	48,891,692	191
2009 Q4	24,773	8,995	49,193,492	191
2010 Q1	20,437	6,955	49,480,656	189
2010 Q2	15,347	5,445	49,739,692	189
2010 Q3	18,497	6,826	50,030,044	185
2010 Q4	18,384	7,234	50,322,088	184

Period	HECM Loan Count	Couples	US. Pop>= 62 Years Old	HPI Index
2011 Q1	20,659	7,808	50,669,320	179
2011 Q2	17,161	6,371	51,016,551	178
2011 Q3	16,904	6,166	51,363,783	179
2011 Q4	13,929	5,363	51,918,678	179
2012 Q1	14,978	5,710	52,473,573	180
2012 Q2	14,216	5,355	53,028,467	184
2012 Q3	11,695	4,515	53,583,362	186
2012 Q4	12,084	4,733	53,994,051	189
2013 Q1	15,832	6,297	54,404,740	193
2013 Q2	16,371	6,683	54,815,429	197
2013 Q3	15,636	6,372	55,226,118	201
2013 Q4	13,093	5,387	55,670,462	203
2014 Q1	14,827	5,899	56,114,805	206
2014 Q2	12,590	4,950	56,559,149	208
2014 Q3	11,106	4,240	57,003,492	210
2014 Q4	14,196	5,589	57,461,524	213
2015 Q1	14,285	5,479	57,919,556	216
2015 Q2	14,055	5,573	58,377,587	219
2015 Q3	15,440	6,101	58,835,619	222
2015 Q4	12,576	5,125	59,314,321	225
2016 Q1	12,990	5,362	59,793,023	228

E3. Quarterly Time Series Model of HECM Volume

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	0.81508	0.14133	5.77	<.0001
2-quarter lag of log of loan count	0.06918	0.13792	0.50	0.6182
Log (HPI at t / HPI at t - 4)	0.06319	0.52837	0.12	0.9053
Log (Pop >= 62 yr at t)	0.06426	0.03419	1.88	0.0662
Adj R-Sq = 0.9998 Durbin-Watson = 1.994 Number of Observations = 53				

E4. Forecasts of HECM Loan Counts based on HECM Volume Model

The HECM volume model uses the following variables: forecasts of home prices and the senior population, as well as lagged values of the dependent variable. A calibration factor is derived by dividing FHA's projected FY 2016 HECM volume by the model's projected volume. This calibration factor (0.9159) was applied to all future years among simulated future economic scenarios.

Exhibit E-3 presents the forecasts of future HECM endorsement counts based on alternative scenarios used in Section V.

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	Low Rate Scenario
2017	60,175	60,147	60,176	60,166	60,011	60,096	60,174	58,993	60,174
2018	66,719	66,795	66,719	66,851	66,520	66,233	66,726	63,856	66,726
2019	71,467	71,681	71,501	71,741	71,388	70,225	71,492	69,099	71,492
2020	75,178	75,413	75,303	75,457	75,104	72,980	75,204	73,614	75,204
2021	78,227	78,342	78,417	78,498	78,168	75,202	78,245	77,312	78,245
2022	80,824	80,695	80,990	81,083	80,591	78,244	80,838	80,391	80,838
2023	83,082	82,635	83,243	83,170	82,667	80,956	83,074	82,965	83,074

Appendix F

Stochastic Processes of Economic Variables

Appendix F. Stochastic Processes of Economic Variables

This Appendix describes the stochastic models used to generate the economic variables used in the Monte Carlo simulations of the FHA HECM Actuarial Review 2016. Starting from the 2012 Review, we computed the present value of expected cash flows among 100 possible paths of house price appreciation rates (HPAs) and unemployment and interest rates.

The concept of Monte Carlo simulation approach is to project a number of equally likely future paths of HPA and unemployment and interest rates; and compute the net present value (NPV) of the projected cash flows for each path. Since each path is equally likely to occur, the mean of the NPV among all simulated paths is the estimate of the expected value of the Fund NPV. By increasing the number of simulations, the average NPV among the paths will gradually converge to a constant level, which is the unbiased estimate of the expected present value of the MMI Forward Fund.

The economic variables modeled herein as stochastic for computing expected present 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 were modeled to project the "actuarial" or "real-world" distributions and hence were estimated using historical data.[52] This approach is appropriate for the Actuarial Review because the simulated rates are designed to approximate the actual future values. Since all status transition probability models were estimated using the historically observed interest and unemployment rates and house price appreciation rates, using the interest rates and other economic variables in the actuarial measure, versus risk-neutral measures typically used for security trading purposes, makes the entire model internally consistent.

[52] For valuing options, so-called "risk-neutral" future paths of the endogenous rates are 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 have any resemblance to historical movements in interest and house price appreciation rates and are not suitable for the purpose of the actuarial review.

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 a historically high level in early 1980's. Then the Federal Reserve shifted its monetary policy from managing interest rates to managing the money supply, at least until inflation, and consequently interest rates, receded. Exhibit F-1 shows historical interest rates since 1970. The 1-year Treasury rate (cmt01) was around 5% in 1970 and increased steadily to its peak of 16.31% in CY 1981 Q3. After that, it followed a decreasing trend and reached an all-time low of 0.10% in CY 2014 Q2. Also shown are the 10-year Treasury rate (cmt10) and the 1-year LIBOR rate (LIBOR_1y).

Exhibit F-1. Historical Interest Rates (%)

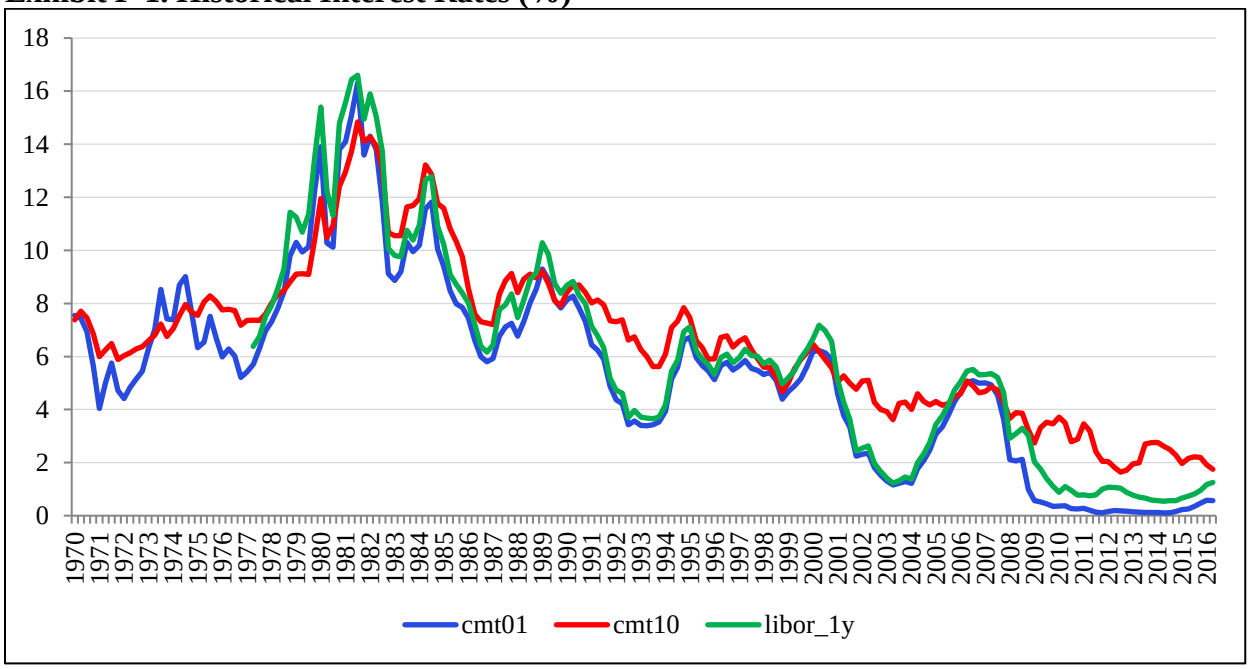
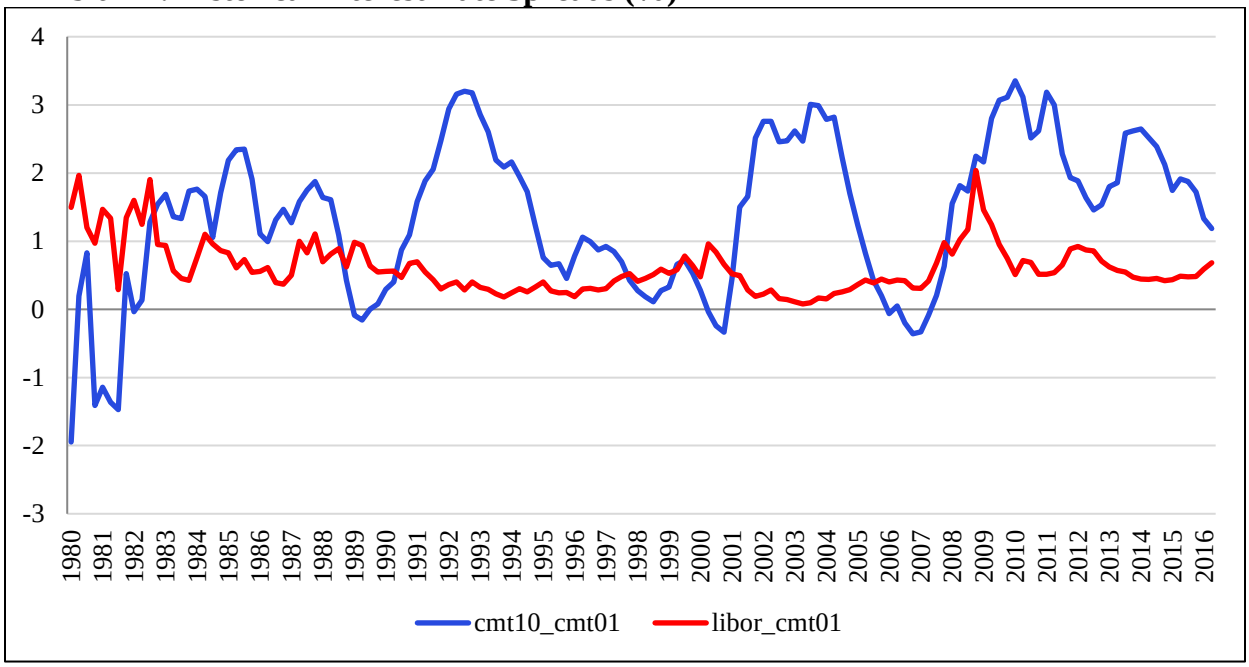


Exhibit F-2 shows historical interest rate spreads, including the spread between the 10-year and the 1-year Treasury rates and the spread between the 1-year LIBOR and the 1-year Treasury rate. The spread between the 10-year and 1-year Treasury rates appears to have long cycles and the spread is not always positive. However, the spread of LIBOR over the 1-year Treasury rate is always positive, reflecting the premium for credit risk.

Exhibit F-2. Historical Interest Rate Spreads (%)



F1.2. House Price Appreciation Rates

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

Exhibit F-3 shows the quarterly national HPI and HPA from CY 1991 Q1 to CY 2016 Q2. The long-term average quarterly HPA is around 0.83% (3.30% annual rate).

The HPI increased steadily before 2004 with quarterly appreciation rate of about 1.14%. Then house prices rose sharply starting in 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 CY 2005 Q2. After 2006, the average growth rate of house price became negative. Exhibit F-4 shows the average quarterly HPA by selected historical time periods.

Exhibit F-3. Historical National HPI and Quarterly HPA

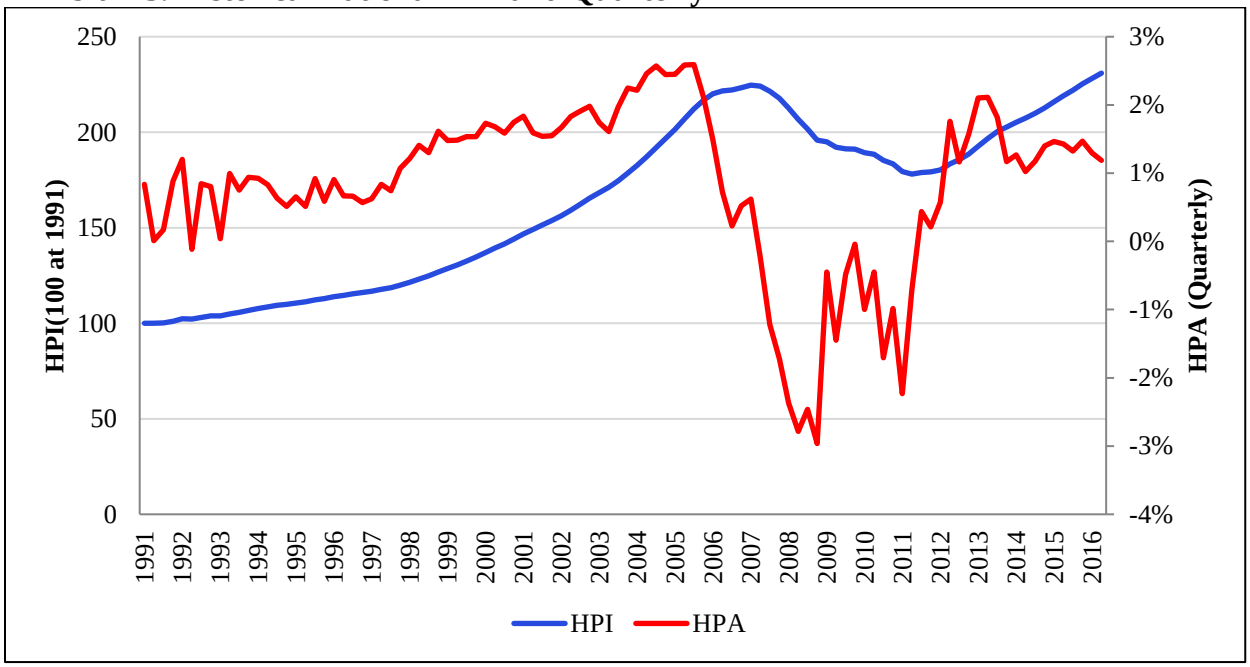


Exhibit F-4. Average Quarterly HPA by Time Span

Period	Average Quarterly HPA
1991 – 2003	1.13%
2004 – 2006	1.87%
2007 – 2010	-1.23%
2011 – 2015	1.03%

F2. 1-Year Treasury Rate

In this section, we present some historical statistics on the 1-year Treasury rate, and then describe the estimation model for the stochastic process, and finally report the parameter estimates and their standard errors. Exhibit F-5 shows the summary statistics of the historical 1-year Treasury rates for two periods, one from 1962 and the other from 1980.

Exhibit F-5. Statistics for the 1-Year Treasury Rates

Statistics	Since 1980	Since 1962
Mean	5.00%	5.32%
Standard Deviation	3.85%	3.37%
Max	16.31%	16.31%
95- Percentile	13.15%	11.60%
90- Percentile	10.14%	9.52%
50- Percentile	5.39%	5.41%
10- Percentile	0.21%	0.36%
5- Percentile	0.14%	0.17%
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 CY 1980 Q1 to CY 2016 Q2.[53] The process takes the following form:

$$r_{1,t} = A + B * r_{1,t-1} + \sigma_t dZ_1 \quad (23)$$

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

The variance (σ^2) of the residual term follows a generalized GARCH (1,1) process:

$$\sigma_t{}^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 + \beta_2 \sigma_{t-1}^2 + \gamma_1 r_{1,t-1} \quad (24)$$

where ε is the error term, which equals $\sigma_t dZ_1$ from equation (23)

The Full Information Maximum Likelihood (FIML) method was used to estimate the parameters in equations (23) and (24). The estimated results are presented in Exhibit F-6.

Exhibit F-6. Estimation Results for 1-Year Treasury Rate Model

Parameter	Estimate	Std Dev	t-value	prob>t
A	1.60E-04	0.000119	1.34	0.1816
B	0.971893	0.0113	85.87	<.0001
β_0	-2.71E-07	9.42E-08	-2.88	0.0046
β_1	0.362551	0.1632	2.22	0.0279
β_2	0.346784	0.1007	3.44	0.0008
γ_1	0.000259	0.000084	3.08	0.0025
Adj. R^2	0.962			

[53] An example of using a GARCH model for fixed income analysis includes Heston and Nandi (2003).

The model based on these parameters is used to simulate the 1-year Treasury rates for the forecast period starting in FY 2016 Q3. When the simulation is implemented, the "constant" term A is further calibrated to different time-dependent values to match Moody's baseline forecast in each forecasted quarter. The values were chosen so that the median value among 100 simulations used to compute the values of the endogenous variables in our models matches Moody's July 2016 baseline forecast of the 1-year Treasury rate quarter by quarter. We applied the same procedure for the "constant" terms in the interest rate, unemployment rate and HPA equations below.

Note that Moody's July forecast only covers the period until CY 2046 Q4. After 2046, we repeated Moody's last quarter forecasts for all remaining quarters. All the other interest and unemployment 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 1-year rate, the lagged value of the spread term and a random component. The model for the spread is

$$s_{10,t} = \alpha_{10,t} + \beta_{10} r_{1,t} + \gamma_{10} s_{10,t-1} + \varepsilon_{10,t} \quad (25)$$

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 is assumed to follow an ARCH (1) process:

$${\sigma_t}^2 = \beta_0 + \beta_1 \varepsilon_{t-1}^2 \quad (26)$$

FIML was used to estimate the parameters. The estimated parameters are shown in the following Exhibit F-7.

Exhibit F-7. Estimation Results for 10-Year Treasury Rate Spread Model

Parameter	Estimate	Std Dev	t-value	prob>t
α_{10}[54]	0.003	0.001	2.51	0.013
β_{10}	-0.017	0.013	-1.34	0.181
γ_{10}	0.845	0.043	19.45	<.0001
β_0	1.20E-05	2.56E-06	4.80	<.0001
β_1	0.580	0.267	2.17	0.031
Adj. R^2	0.835			

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 2016 base forecast of the 10-year Treasury rates quarter by quarter. 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:

$$r_{L,t} = \alpha_{L,t} + \beta_L r_{1,t} + \varepsilon_{L,t} \quad (27)$$

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 α_L and β_L. The estimated parameters are shown in Exhibit F-8.

Exhibit F-8. Estimation Results for the LIBOR Rate Model

Parameter	Estimate	Std Dev	t-Value	Prob>t
α_L[55]	0.005	0.000	11.17	<.0001
β_L	0.999	0.011	94.63	<.0001
Adjusted R^2	0.987			

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

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

July 2016 base forecast of the LIBOR rates quarter by 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. The model takes the following form:

$$HPA_t = \mu_t + \beta_1 HPA_{t-1} + \beta_2 HPA_{t-2} + \beta_3 r_{1,t} + \beta_4 r_{1,t-1} + \beta_5 s_{10,t} + \beta_6 s_{10,t-1} + \beta_7 s_{m,t} + \beta_8 s_{m,t-1} + \sigma_{h,t} dZ_h \quad (28)$$

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:

$$\sigma_{h,t}{}^2 = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 \sigma_{h,t-1}{}^2 \quad (29)$$

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 (28) and (29). The results are shown in Exhibit F-9.

Exhibit F-9. Estimation Results for the National HPA Model

Parameter	Estimate	Std Dev	t-value	prob>t
μ	0.001	0.002	0.73	0.4642
β_1	0.632	0.084	7.50	<.0001
β_2	0.244	0.082	2.96	0.004
β_3	-0.092	0.067	-1.37	0.174
β_4	0.077	0.067	1.16	0.249
β_5	-0.145	0.088	-1.65	0.101
β_6	0.133	0.087	1.53	0.129
β_7	-0.069	0.136	-0.51	0.610
β_8	0.152	0.125	1.22	0.224
γ_0	3.56E-07	3.57E-07	1.00	0.321
γ_1	0.406	0.113	3.61	0.000
γ_2	0.630	0.073	8.68	<.0001
Adj. R^2	0.686			

We used these parameters to simulate future HPAs from FY 2016 Q3. Also, we calibrated the mean of HPA (μ_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 CY 2046 Q4, so we repeat the last four quarters for the remaining terms.

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:

$$Disp_{i,t}^{Base} = (HPA_{i,t}^{Base} - HPA_{national,t}^{Base}) \quad (30)$$

This dispersion forecast under Moody's base case was 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:

$$HPA_{i,t}^{j} = (HPA_{national,t}^{j} + DISP_{i,t}^{Base}) \quad (31)$$

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.[56] We understand this approach is equivalent to assuming perfect correlation of dispersions among different locations across simulated national HPA paths, which creates systematic house price

[56] The dispersion of each MSA remains constant among all alternative Moody's forecast scenarios.

decreases during economic downturns and vice versa during booms. Due to Jensen's Inequality, this tends to generate a more conservative estimate of claim losses.

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 2016 Q1 to estimate the national unemployment rate. The model we adopted was:

$$ue_t = \mu_t + \beta_1 ue_{t-1} + \beta_2 ue_{t-2} + \beta_3 r_{1,t} + \beta_4 r_{m,t} + \beta_5 HPA_t + \varepsilon_t \quad (32)$$

where, $r_{1,t}$ is the 1-year Treasury rate,
$r_{m,t}$ 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-10: Estimation Results for the National Unemployment Rate Model

Parameter	Estimate	Std Dev	t-value	prob>t
μ	0.182	0.092	1.98	0.050
β_1	1.496	0.063	23.78	<.0001
β_2	-0.568	0.059	-9.58	<.0001
β_3	-0.048	0.019	-2.45	0.016
β_4	0.072	0.023	3.14	0.002
β_5	-1.570	0.454	-3.46	0.001
Adj. R^2	0.981			

From the simulated interest rates and house prices, we applied the parameters shown in Exhibit F-10 to calculate the corresponding national unemployment rate. Based on historical statistics, the national unemployment rate was capped at 20% with a floor at 2%.

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