Annual Actuarial Review of

The FHA Mutual Mortgage Insurance Fund

HECM Loans

Fiscal Year 2023

Submitted to:

**United States Department of Housing
and Urban Development**

Submitted by:

IT Data Consulting, LLC

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Contract Number: 86615723C00002
Base Year Deliverables: A005 – Actuarial Studies

November 12, 2023

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The Honorable Julia R. Gordon
Assistant Secretary for Housing and Federal Housing Commissioner
U.S. Department of Housing and Urban Development (HUD)
451 Seventh Street, S.W., Room 9100
Washington, D.C. 20410

Dear Ms. Gordon,

IT Data Consulting, LLC (ITDC) has finalized and is now submitting the Fiscal Year 2023 Independent Actuarial Review of the Home Equity Conversion Mortgages (HECM) under the Mutual Mortgage Insurance Fund, under contract number 86615723C00002.

This report is based on data as of September 30, 2023, providing an overview of the Economic Net Worth and details regarding the Cash Flow Net Present Value (NPV) for the Mutual Mortgage Insurance (MMI) HECM Loan portfolio as of the conclusion of Fiscal Year 2023. We've included a comparison with the corresponding estimate from the end of Fiscal Year 2022, evaluation under various scenarios, and offered detailed insights into the models employed for developing this estimate.

ITDC is here to answer any questions or address any comments you may have about the report and its conclusions.

Respectfully,

Benny Asnake
President and CEO
IT Data Consulting, LLC

November 12, 2023

The Honorable Julia R. Gordon
Assistant Secretary for Housing and Federal Housing Commissioner
U.S. Department of Housing and Urban Development (HUD)
451 Seventh Street, S.W., Room 9100
Washington, D.C. 20410

Dear Ms. Gordon,

I, Min Ji, am a Professor in Actuarial Science and Risk Management at Towson University. I am a member of the American Academy of Actuaries (MAAA), fellow of the Society of Actuaries (FSA), and fellow of the Institute and Faculty of Actuaries (FIA) and I meet the Qualification Standards for Actuaries Issuing Statements of Actuarial Opinion in the United States of the American Academy of Actuaries to render the actuarial opinion contained herein.

I have reviewed the "Annual Actuarial Review of The FHA Mutual Mortgage Insurance Fund, HECM Loans, for Fiscal Year 2023". 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 provided by the Federal Housing Administration (FHA). I have relied on 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 from the 2024 Mid-Session Review for the President's Economic Assumptions (PEA).

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 may not unfold as projected.

Respectfully,

Min Ji, Ph.D., MAAA, FSA, FIA
Professor, Actuarial Science and Risk Management, Towson University

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Summary of Deliverables

Below we summarize the findings associated with each of the required deliverables:

Deliverable 1: Produce a written Actuarial Study for HECM that provides actuarial central estimates of MMI Economic Net Worth as of the end of Fiscal Year 2023 and assesses HUD's estimates of Economic Net Worth.

The Economic Net Worth is defined as cash available to the MMI plus the Net Present Value (NPV) of all future cash outflows and inflows that are expected to result from the mortgages currently insured by the MMI. As of the end of Fiscal Year 2023 ITDC's Actuarial Central Estimate (ACE) of the MMI HECM Cash Flow NPV is positive $6.742 billion.

The total capital resource as reported in the Annual Report to Congress Regarding the Status of the Federal Housing Administration (FHA) Mutual Mortgage Insurance Fund is positive $8.627 billion as of the end of Fiscal Year 2023. Thus, the estimated Economic Net Worth of the MMI is positive $15.368 billion*.

Cash Flow NPV and Total Capital Resources do not sum to the Economic Net Worth due to rounding.

Deliverable 2: Include a review of the risk characteristics of existing MMI loans including commentary on how such characteristics have changed in recent years.

A review of the risk characteristics of existing MMI HECM loans and commentary of how these risk characteristics have changed is included in Section III.

Deliverable 3: Apply the final HECM actuarial model to the existing portfolio to produce conditional (and cumulative) claim, prepayment, and loss-given-default rates at various levels of aggregation across loans, and for individual policy years and policy year-quarter. Cash-flow summaries should also be provided for major categories (e.g., premium revenues, claim expenses and recoveries or net loss due to claims, with affected loan counts and balances).

Models for projecting loan terminations and performance are described in Appendix B and C. Cash flow summaries by major category are displayed in the table below and discussed in more detail in Sections II and IV along with a detailed analysis of the cash flow calculations in Appendix D.

Exhibit SD-1. Cash Flow Summary for FY 2009 – FY 2023 ($ Million)

Cash Flow Category	Net Present Value of Cash Flow
Mortgage Insurance Premium	$ 4,769,186,062
Claim Type 1 Loss Incurred	$ (140,720,322)
Claim Type 2 Loss Incurred	$ (50,230,157,697)
Recovery (Claim Type 2c and 2p)	$ 57,390,021,374
Note Holding Expense	$ (5,046,593,342)
Total	$ 6,741,736,075

Deliverable 4: To promote transparency of the Studies' assessments, the Studies should identify methodological vulnerabilities that may occur in its actuarial models or in HUD's analyses of Economic Net Worth. This discussion should evaluate the scope and scale of such vulnerabilities in creating possible forecast risk and suggest possible lines of research in these areas. The Studies should assess and comment upon HUD's own models that estimate Economic Net Worth for methodological vulnerabilities and compare HUD's methodologies with those in the Studies.

The assumptions and judgments on which the estimates are based are summarized in Section V, Summary of Methodology, and the listed appendices in that section. Various NPVs based on simulated economic scenarios and sensitivity testing are summarized in Section IV. The economic conditions that could result in materially adverse changes to the Cash Flow NPV are discussed.

Appendix B summarizes the specifications and assumptions related to the base termination models. The loan performance and cash draw models for HECMs are summarized in Appendix C and D, respectively. Lastly, Appendix E describes the stochastic models and the simulated percentile paths of economic variables.

We have examined the vulnerabilities of our studies and compared the results under various scenarios. We will continue our investigation by comparing results and methodologies with HUD's methodologies in future research.

Deliverable 5: The Studies should include historical data on changes in program terms as well as relevant loan and borrower characteristics (e.g., credit scores, loan-to-value ratios) by cohort and other sub-populations. Loan performance data (claim rates, prepayment rates, severity, and recovery rates) both historical and projected shall be presented in the "finger-table" formats (arrayed by cohort and policy years for different loan products).

Section I provides historical information on changes in the HECM programs. A review of the risk characteristics of existing MMI loans and commentary of how these risk characteristics have changed are included in Section III.

Appendix B shows the interim and final termination rates by cohort and policy year. Historical and projected termination rates are calculated for cohorts 2009 and 2023.

Deliverable 6: The Contractor should use the President's Economic Assumptions, provided by Office of Risk Management and Regulatory Affairs (ORMRA), for the actuarial central estimates of the Studies. However, in addition to the central single path economic forecast, the Studies shall test alternative economic forecasts for stress-testing and sensitivity analysis to estimate ranges of reasonableness.

ITDC has conducted a comprehensive analysis, based on the President's Economic Assumptions for Fiscal Year 2024 Budget provided by the Office of Management and Budget (OMB). Based on our assessment, the Cash Flow Net Present Value (NPV) by the conclusion of the 2023 fiscal year for cohort years from 2009 to 2023 is a positive $6.742 billion.

In the table below, we estimate that the range of Cash Flow NPV based on the optimistic upside and pessimistic downside stochastic simulation scenarios is between negative $9.559 billion to positive $15.820 billion. These two values from the optimistic upside and pessimistic downside are two extreme scenarios that are highly unlikely to occur. Our Baseline PEA economic net worth of $6.742 billion stays in the middle of $12.607 billion from the moderate upside scenario and $0.609 billion from the moderate downside scenario.

Exhibit SD-2. Net Present Value of the HECM Fund under Different Economic Scenarios ($ Million)

Economic Scenario	Fiscal Year 2023*	
Baseline PEA	$	6,742
Alternative 1 – Optimistic Upside	$	15,820
Alternative 2 - Moderate Upside	$	12,607
Alternative 3 – Moderate Downside	$	609
Alternative 4 – Pessimistic Downside	$	(9,559)

The Cash Flow NPV estimate provided by FHA to be used in the FHA Annual Report to Congress is positive $2.399 billion. Based on ITDC's actuarial central estimate utilizing the Baseline PEA and range of results from the stochastic simulation scenarios, we conclude that the FHA estimate of Cash Flow NPV is reasonable.

Deliverable 7: To provide comparability to HUD estimates of Economic Net Worth, the Contractor shall use Federal Credit Reform Act discounting assumptions and procedures.

ITDC has developed estimates of Economic Net Worth using the Federal Credit Reform Act discounting assumptions which include using the cohort specific single effective rates (SERs) supplied by FHA.

Deliverable 8: This Study should use stochastic or Monte Carlo simulations of future economic conditions including for interest rates and house price appreciation. The objective of these requirements is to illustrate the sensitivity of forecasts to economic uncertainty and other forms of forecast error.

As described in Section V, Summary of Methodology and detailed in Appendix E: Stochastic Simulation Models, we generated different percentile economic scenarios using stochastic simulations.

Deliverable 9: Provide econometric appendices to the Study that include variable specifications and statistical output from all regressions in the Studies.

Appendix B shows the predictive model parameters and goodness of fit measures for the Termination model. Appendix C shows the parameters and goodness of fit measures for the conveyance model.

Executive Summary

The Federal Housing Administration (FHA) administers the Home Equity Conversion Mortgage (HECM) program, facilitating senior homeowners' access to cash based on the value of their homes. Initially launched as a pilot program in 1989 and solidified in 1998, the program underwent substantial expansion between 2003 and 2008. This expansion was attributed to increased product awareness, favorable interest rates, rising home values, and augmented FHA mortgage limits. Preceding Fiscal Year 2009, the HECM program was integrated into the General Insurance (GI) Fund. The Housing and Economic Recovery Act of 2008 (HERA)[1] effectively transferred all new HECM program endorsements into the Mutual Mortgage Insurance (MMI) fund, commencing on October 1, 2008.

The Cranston-Gonzalez National Affordable Housing Act (NAHA) 1990 introduced capitalization requisites for the MMI fund.[2] Specifically, it mandated a minimum capital ratio of 1.25% by 1992, increasing to 2.0% by 2000. The capital ratio is the ratio of the capital to unamortized insurance-in-force (IIF). The term 'capital' means the economic net worth of the MMI Fund, which is defined by NAHA as 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. NAHA stipulated the necessity of an annual independent actuarial study concerning the MMI. Subsequently, HERA expanded these obligations to encompass HECM mortgages within the MMI. Consequently, an actuarial review is now customarily conducted on HECM mortgages within the MMI. This report analyzes the HECM portion of the MMI, explicitly focusing on mortgages endorsed in Fiscal Year 2009 and onward.

A.   Status of the MMI HECM Portfolio

To assess the adequacy of the current and future capital resources to meet estimated future liabilities, we analyzed all HECM historical terminations and associated recoveries using loan-level HECM data reported by FHA through September 30, 2023. Based on historical experience, we developed loan level termination and cash flow models to estimate the future loan performance of the FY 2009 to FY 2023 books-of-business using various assumptions, including macroeconomic forecasts from the Office of Management and Budget (OMB), Moody's Analytics (Moody), and the expected HECM portfolio characteristics provided by FHA.

Using the President's Economic Assumptions (PEA) and Moody's forecast of Secured Overnight Finance Rate (SOFR) in place of LIBOR, ITDC estimated the performance of the FY 2009 to 2023 books of HECM loans and projects the HECM Cash Flow Net Present Value (NPV) as of the end of FY 2023 is positive $6.742 billion. The HECM portion of total capital resource as reported in the Annual Report to Congress Regarding the Status of the FHA Mutual Mortgage Insurance Fund is

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[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] Public Law 101-625, 101st Congress, November 28, 1990, Section 332

positive $8.627 billion at the end of Fiscal Year 2023. Thus, the estimated Economic Net Worth of the HECM MMI is positive $15.368 billion.

We also estimate that the range of Cash Flow NPV based on randomly generated economic scenarios is between negative $9.559 billion to positive $15.820 billion. These two values from the optimistic upside and pessimistic downside are two extreme scenarios that are highly unlikely to occur. Our Baseline PEA economic net worth of $6.742 billion stays in the middle of $12.607 billion from the moderate upside scenario and $0.609 billion from the moderate downside scenario.

The Cash Flow NPV estimate provided by FHA to be used in the FHA Annual Report to Congress is positive $2.399 billion. Based on ITDC's actuarial central estimate utilizing the Baseline PEA and range of results from the stochastic simulation scenarios, we conclude that the FHA estimate of Cash Flow NPV is reasonable.

The insurance-in-force (IIF) is calculated as the total Unpaid Principal Balance (UPB) of all HECMs remaining in the insurance portfolio as of September 30, 2023. New endorsements in 2023 are added to the portfolio and the HECM IIF as of the end of FY 2023 is $65.432 billion. Exhibit ES-1 provides endorsements, IIF, maximum claim amount (MCA), the Actuarial Central Estimate (ACE) of the HECM NPV for FY 2009 through FY 2023. The MCA of all active insured loans represents FHA's maximum risk exposure of the portfolio and serves as the cap on the amount of insurance claims that FHA will pay the lender for unassigned loans.

Exhibit ES-1. Baseline NPV, Insurance-in-Force, and Endorsement for FY 2009 – FY 2023

Cohort Year*	Endorsement*	Insurance-in-Force**	MCA***	Net Present Value
2009-2023, N	863,102	307,482	307,482	
2009-2023, $ million	$ 272,153	$ 65,432	$ 115,073	$ 6,742

*Endorsement is the number of outstanding loans endorsed from FY 2009 – FY 2023.
**Insurance-in-force is estimated as the sum of the UPBs of the remaining loans endorsed from FY 2009 - FY 2023 in the insurance portfolio.
***The MCAs of the remaining loans endorsed from FY 2009 – FY 2023 in the insurance portfolio.

B.   Sources of Change in the Status of the HECM Portfolio

The FY 2022 HECM Review reports that the economic net worth of the HECM portfolio was positive $3.646 billion at the conclusion of FY 2022, contrasting with this year's Review, which estimates a positive value of $6.742 billion at the end of FY 2023. Exhibit ES-2 compares our Cash Flow NPV and IIF estimate for Fiscal Year 2023 to the estimates in the 2022 Review.

Exhibit ES-2. Estimate of Cash Flow Changes as of the End of the FY 2023 ($ Million)

Item	Cash Flow NPV	Capital Resources	Insurance-In-Force
2022	$ 3,646	$ 8,929	$ 66,276
2023	$ 6,742	$ 8,627	$ 65,432
Difference	$ 3,096	$ (302)	$ (844)
Percent Change	84.91%	-3.39%	-1.27%

As seen in Exhibit ES-2, the HECM portion of the MMI's estimated Fiscal Year 2023 Cash Flow NPV has increased by $3.096 billion from the level estimated in Fiscal Year 2022, from positive $3.646 billion to positive $6.742 billion. The capital resources available to the HECM portion of the MMI have decreased by 3.39%, from $8.929 billion to positive $8.627 billion. The unamortized IIF measured by UPB decreased slightly by 1.27% from $66.276 billion to $65.432 billion.

The actuarial estimates for each of the two years are based on different models and assumptions, we cannot quantify the change to different sources. The change was driven by many factors, such as differences in the actual performance of the economy versus what was projected and differences in the actual composition of the portfolio.

C. Impact of Economic Forecasts

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

House Price Appreciation: House Price Index (HPI) reflects the relative change in housing prices from period to period. House price appreciation (HPA) impacts the recovery FHA receives upon mortgage terminations and the termination rate at which borrowers will refinance or move out of their property. The baseline scenario for the HPA is from the President's Economic Assumptions (PEA) for FY 2024, which was published by the Office of Management and Budget in compliance with the requirements of Federal Credit Reform Act. Alternative scenarios are from stochastic simulation.

Expected Interest Rate: Interest rates impact the growth of mortgage balances. All the interest rate projections used in this review are based on the PEA baseline estimates, except the one-year Secured Overnight Financing Rate (SOFR) forecast, which is from Moody since the PEA assumption of future SOFR rates is not available. Expected interest rates also determine the unused HECM line of credit growth and how much homeowners can get access to upon refinance, which indirectly impacts voluntary termination of a HECM loan.

Termination Rates: Net present value of the HECM cash flow depends on how long borrowers hold onto their HECM loan before selling their home, moving out, refinancing

their loan, or passing away. Refer to Appendix B for the details of the calculation of termination rates.

Cash Drawdown Rates: These rates represent the speed at which borrowers draw on their available HECM fund over time, which impacts the growth of the mortgage unpaid balance (UPB). We estimate borrowers' cash draw rates based on past HECM program experience and borrower characteristics and summarize actual borrower draw patterns into ten buckets based on the first month cash draw.

House Price Sale Discount: The sale price of the houses underlying HECM loans tends to be lower than the market price of otherwise identical houses, due to borrowers' failure to maintain their home adequately and expedited sale of the house after borrowers' death or relocation. A deeper discount in the sale price would negatively impact the economic net worth of the Fund.

The realized economic variables will be different from the estimates in this analysis if the actual drivers of mortgage performance deviate from the projections based on the baseline assumptions.

Exhibit ES-3. presents the HECM cash flow NPV from the projections based on the PEAs and four alternative scenarios, which represent different percentile paths of economic variables from our stochastic simulation. Each scenario estimates the NPV under a specific future path of interest rates and the HPI.

Exhibit ES-3. Net Present Value of the HECM Fund under Different Economic Scenarios ($ Million)

Scenarios	Fiscal Year 2023*
Baseline**	$ 6,742
Alternative 1 – Optimistic Upside***	$ 15,820
Alternative 2 - Moderate Upside	$ 12,607
Alternative 3 – Moderate Downside	$ 609
Alternative 4 – Pessimistic Downside	$ (9,559)

*All values are expressed as of the end of the fiscal year
**Baseline is based on PEA
*** Description of these scenarios are in Section VI and Appendix E

Our Baseline PEA economic net worth of $6.742 billion stays in the middle of $12.607 billion from the moderate upside scenario and $0.609 billion from the moderate downside scenario. The range of NPV based on the alternative economic scenarios is negative $9.559 billion to positive $15.820 billion. These two values from the optimistic upside and pessimistic downside are two extreme scenarios that are highly unlikely to occur.

The numbers in Exhibit ES-3 from the actuarial central estimate of the NPV (baseline) and four alternative scenarios are projected with COVID-19 impact, which potentially causes slightly higher termination rate. We also investigate the COVID-19 by incorporating indicator dummy

variables in the termination model and therefore the future termination rates are projected with COVID-19 impact eliminated. The resulted baseline NPV is $6.667 billion, slightly lower than the ACE estimate of $6.742 billion.

The Cash Flow NPV estimate provided by FHA to be used in the FHA Annual Report to Congress is positive $2.399 billion. Based on ITDC's actuarial central estimate utilizing the Baseline PEA and range of results from the stochastic simulation scenarios, we conclude that the FHA estimate of Cash Flow NPV is reasonable.

Distribution and Use

ITDC provides this report to the FHA and policymakers for their assessment of the Economic Net Worth of the MMI. The distribution of this report is allowed on the condition that it is shared in its entirety, including all exhibits and appendices, without any excerpts. ITDC acknowledges that FHA will integrate this report into its Annual Report to Congress, and ITDC grants permission for this purpose. We are available to address any questions that may arise concerning this report.

Any third parties receiving this report should understand that its provision does not replace their responsibility to conduct due diligence. They should not place reliance on this report or its enclosed data to establish any explicit or implicit representations, warranties, duties, or liabilities from ITDC to the third party.

Our conclusions are based on various assumptions about future conditions and events, detailed in subsequent sections of this report. These assumptions must be comprehended to contextualize our conclusions properly. Furthermore, our work is subject to inherent limitations, also discussed in this report.

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.[3] ITDC was engaged by the Department of Housing and Urban Development (HUD) to conduct an independent actuarial review of the MMI Fund for FY 2023.

The FHA Modernization Act within the Housing and Economic Recovery Act of 2008 (HERA)[4] 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 HECM portion of the economic net worth and insurance-in-force (IIF) of the MMI portfolios in FY 2023 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 funds by borrowing against the equity in their homes. All the following conditions must be met to be eligible for a HECM:

- At least one of the homeowners must be 62 years of age or older.
- If there is an existing mortgage, the outstanding balance must be paid off with the HECM proceeds.
- The borrower(s) must have received FHA-approved reverse mortgage counseling to learn about the program.

HECM's are available from FHA-approved lending institutions. These approved institutions provide homeowners with cash payments or lines of credit secured by the collateral property. There is no required repayment if the borrower continues to live in the home and meets the HUD guidelines on property taxes, homeowners' insurance, and property maintenance. Borrowers use reverse mortgages to access cash for various reasons, including, home improvements, medical bills, paying off balances on existing traditional mortgages, or for everyday living. Borrowers also use a HECM to purchase a primary residence if they can use cash on hand to pay the difference between the HECM proceeds and the sales price plus closing costs for the property to be purchased. A HECM loan terminates for reasons including death, moving out of the home, and refinancing. The existence of negative equity does not require borrowers to pay off the mortgage

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[3] 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).

[4] HERA was passed by the United States Congress on July 24, 2008, and signed by President George W. Bush on July 30, 2008.

and does not prevent the borrowers from receiving additional cash draws, if available, based on their HECM contract.

The reverse mortgage insurance provided by FHA through the HECM program protects lenders from losses due to insufficient recovery on terminated mortgages and protects borrowers from lenders' failure to advance funds. When a mortgage terminates and the mortgage balance exceeds the net sale price of the home, the lender can file a claim for loss up to the maximum claim amount (MCA). A lender can assign the mortgage note to FHA if the mortgage meets the eligibility requirements when the mortgage balance reaches 98% of the MCA. On assignment, the lender is reimbursed for the balance of the mortgage (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 mortgage until termination. At mortgage termination (post-assignment), FHA attempts to recover the mortgage balance including any expenses, accrued interest, property taxes and insurance premiums. The following are definitions of common HECM terms.

i.   Maximum Claim Amount (MCA)

The MCA is the minimum of the appraised value or purchase price of the home and the FHA mortgage 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 (PLF) to calculate the maximum amount of initial credit available to the borrower. The MCA is determined at origination and does not change over the life of the mortgage. However, if the home value appreciates over time, borrowers may access additional credit by refinancing. In the event of termination, the entire net sales proceeds[5] can be used to pay off the outstanding mortgage balance, regardless of whether the size of the MCA was capped by the FHA mortgage limit at origination.

ii.   Principal Limits (PLs) and Principal Limit Factors (PLFs)

FHA manages its insurance risk by limiting the percentage of equity available to the borrower through a set of Principal Limit Factors (PLFs). Conceptually, the PLF is like the loan-to-value ratio applied to a traditional mortgage. It represents the ratio of the amount of initial available equity to the MCA at origination. Exhibit I-1 illustrates a selected number of PLFs as of August 2023. The PLF increases with the borrower's age at origination and decreases with the expected mortgage interest rate (with a floor of 5.5 percent).

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

Exhibit I-1. Selected Principal Limit Factors

Expected Mortgage	Borrower Age at Origination *		
Interest rate	65	75	85
5.5%	0.403	0.467	0.570
7.0%	0.333	0.400	0.511
8.5%	0.276	0.343	0.459

The age of the younger borrower or spouse

The amount of equity available at origination is known as the initial principal limit and is calculated as the product of the PLF and the MCA. Over the course of the loan, the principal limit grows with the mortgage interest, mortgage insurance premium, and service fee. Once the HECM unpaid loan balance reaches the principal limit, no more cash advances are available to the borrower.

iii. 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 mortgage if they have not exhausted their PL. The payment plans are:

Tenure plan: equal monthly payments as long as at least one borrower lives and continues to occupy the property as a principal residence.

Term plan: equal monthly payments for a fixed period of months selected.

Line of credit: unscheduled payments or in installments, at times and in an amount of borrower's choosing until the line of credit is exhausted.

Modified Tenure: combination of line of credit and scheduled monthly payments for as long as borrower remains in the home.

Modified Term: combination of line of credit plus monthly payments for a fixed period of months selected by the borrower.

Single Disbursement Lump Sum: all the available loan proceeds are accessed at closing. Generally, this occurs when the borrower uses the HECM for Purchase program or to pay off a large existing mortgage on the property.

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.

iv.   Unpaid Principal Balance (UPB) and Mortgage Costs

The Unpaid Principal Balance (UPB) is the mortgage balance and represents the amount drawn from the HECM. In general, after the initial cash draw, the mortgage balance continues to grow with additional borrower cash draws and accruals of interest, premiums, and servicing fees until the mortgage terminates.[6]

v.   Loan Terminations

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.

vi.   Assignments and Recoveries

The assignment option is a unique feature of the HECM program. When the balance of a HECM reaches 98% 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 mortgage assignment. FHA will pay an assignment claim in the full amount of the mortgage balance (up to the MCA) and will continue to hold the note until termination. During the note holding period, the mortgage balance will continue to grow by additional draws and unpaid taxes and insurance. Borrowers can continue to draw cash if the mortgage balance is below the current PL. The only exception is that borrowers on scheduled payments are not constrained by the current PL. At mortgage termination, the borrowers or their estates are required to repay FHA the minimum of the mortgage balance and the net sales proceeds of the home. These repayments are referred to as post-assignment recoveries.

C.   HECM Policy Changes

The Home Equity Conversion Mortgage (HECM) program has undergone several policy changes over the years, including changes in insurance premiums, principal limit factors, and loan limits. The goal of these changes has been to enhance the program's sustainability, protect borrowers, and reduce risks to the MMI fund. FHA publishes the policy changes in Mortgagee Letters (ML) with several examples listed in the references at the end of this report and in footnotes. These changes generally do not affect outstanding HECM contracts. In this section, we highlight some significant HECM policy changes.

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[6] 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.

i. Principal Limit Factors (PLFs) Reduction

PLFs determine the maximum amount a borrower can access from their home's equity over time, which depends on several factors, including the age of the youngest borrower (or non-borrowing spouse), expected mortgage interest rates, and regulatory changes aimed at ensuring the financial stability of the MMI fund. There have been multiple adjustments to the PLFs, as HUD sought to balance the program's attractiveness to potential borrowers with the need to maintain its financial stability. Exhibit I-2 below illustrates a selected set of PLFs for the standard HECM program.

Prior to 2013: PLFs were generally higher, allowing borrowers to access a larger portion of their home's equity.

2013 Adjustments: Due to increasing default rates and declining home values during the housing crisis, HUD significantly reduced PLFs to improve the health of the MMI fund.

2014 Adjustments: With the financial assessment requirements introduced, PLFs refined as part of the comprehensive effort to reduce tax and insurance defaults and ensure the long-term sustainability of the program.

2017 Adjustments: HUD implemented another significant reduction in PLFs together with adjusted Mortgage Insurance Premium (MIP) structure, in response to raised concerns about the financial health of the MMI fund.

Exhibit I-2. Selected Principal Limit Factors for Standard HECMs

Age*	Mortgage Rate	Principal Limit Factors					
		Prior to FY 2010	FY 2010	FY 2011 to FY 2013	9/30/2013 to 8/3/2014	8/4/2014 to 10/1/2017	On or after 10/1/2017
65	5.50%	0.649	0.584	0.569	0.483	0.478	0.403
	7.00%	0.489	0.440	0.428	0.363	0.332	0.333
	8.50%	0.369	0.332	0.326	0.277	0.227	0.276
75	5.50%	0.732	0.659	0.636	0.541	0.553	0.467
	7.00%	0.609	0.548	0.516	0.438	0.410	0.400
	8.50%	0.503	0.453	0.425	0.361	0.304	0.343
85	5.50%	0.819	0.737	0.703	0.597	0.644	0.570
	7.00%	0.738	0.664	0.606	0.515	0.513	0.511
	8.50%	0.660	0.594	0.531	0.451	0.414	0.459

* Age of the younger borrower or spouse at loan origination

ii. Loan Limit Increases

Maximum claim amount (MCA) serves as the loan limit, which is reviewed and potentially adjusted each year based on the housing market conditions. The Department of Housing and Urban

Development (HUD) typically reviews and announces any changes to the HECM loan limits towards the end of each calendar year, which then take effect the following year. Exhibit I-3 displays the loan limits from 2009 through 2023. The increasing maximum mortgage limits for HECMs align with the conforming loan limits established by the Federal Housing Finance Agency (FHFA) for Freddie Mac and Fannie Mae home mortgages and reflects national House Price Appreciation, Inflation, and Cost of Living Adjustments.

Exhibit I-3. Loan limits from FY 2009-2023

Effective Date	Maximum Mortgage Limit	Percent Change from Previous Limit
Jan-23	$1,089,300	12.21%
Jan-22	$970,800	18.05%
Jan-21	$822,375	7.42%
Jan-20	$765,600	5.38%
Jan-19	$726,525	6.90%
Jan-18	$679,650	6.84%
Dec-16	$636,150	1.70%
Feb-09	$625,500	

iii.   Mortgage Insurance Premium (MIP) Structure Change

The MIP structure for HECM loans has undergone several changes in response to the evolving needs of the program and its financial health. In 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 specified initial disbursement limitations. The annual rate was 1.25% of the outstanding loan balance, while the initial MIP depended on borrowers' initial disbursement limit in the first year, that is, the initial MIP is 0.5% of the maximum claim amount for borrowers taking 60% or less of the principal limit during the first 12 months and 2.5% of MCA otherwise.

Effective from October 2017, to simplify the MIP structure and improve the sustainability of the MMI fund, HUD standardized the upfront MIP to a flat 2% of the maximum claim amount, irrespective of how much the homeowner drew from the reverse mortgage in the first year. The annual MIP rate remained at 1.25% of the outstanding loan balance.

iv.   Protection for Non-Borrowing Spouses (NBS)

A non-borrowing spouse refers to a spouse who is not a borrower on the HECM loan but is married to a borrower at the time of loan origination. Given the potential hardships faced by non-borrowing

spouses, HUD implemented policy changes in 2014 to provide protections and rights of non-borrowing spouses. Lenders have the option, called Mortgagee Optional Election (MOE) Assignments, to assign the HECM loan to HUD if the borrowing spouse dies and the non-borrowing spouse wishes to remain in the home, if they meet certain requirements. ML 2021-11 expanded assignment criteria to all existing loans and eliminated the requirement for an eligible non-borrowing spouse to establish marketable title or other legal right to remain in the property.

v.   Financial Assessment for Borrowers

The main goal of the Financial Assessment is to evaluate a borrower's ability to meet their financial obligations, including property taxes, homeowner's insurance, homeowners' association (HOA) fees (if applicable), and basic home maintenance costs. By 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. If, based on financial assessment, there's concern about the borrower's ability to meet ongoing property-related expenses, the lender might establish LESA to cover property taxes and homeowner's insurance for the expected life of the borrower. LESA results in less loan proceeds available for withdrawal but will reduce Tax and Insurance (T&I) default rate.

vi.   Other Policy Changes

There are other HECM policy changes that will affect our estimation models. Our model parameters have been updated to accommodate these new changes happening this year as of FY2023.

> FHA expanded the assignment claim submission window to begin at 97% of MCA (ML 2023-10) from the previous 97.5% of MCA (ML 2017-05) to support timely payment of assignment claims and provide greater flexibility for mortgagees in managing their HECM portfolios.

> Phase out of LIBOR: Mortgagee Letter (ML) 2023-9 requires that the Secured Overnight Financing Rate (SOFR) replace LIBOR for both new and existing HECM loans indexed to LIBOR.

D.   Current and Future Market Environment

Apart from MMI policies, the economic backdrop significantly influences the default and claim rates, ultimately shaping the Cash Flow NPV of the MMI. A rise in interest rates tends to push up mortgage rates, contributing to increased default rates. Furthermore, the overall economic well-being directly affects home values, with higher home values typically leading to reduced losses for the MMI due to increased proceeds from home dispositions. Additionally, an upswing in the general economic health often correlates with heightened demand for mortgages, typically resulting in increased interest in mortgages endorsed by the MMI for insurance.

i.   House Price Growth Rates

The rate of home price growth exerts influence over several key factors: the volume of mortgages endorsed by FHA, the proportion of mortgage defaults, and the eventual cost of mortgage insurance claims. The yearly percentage shift in the historical Federal Housing Finance Agency (FHFA) Purchase Only House Price Index for each quarter is illustrated in Exhibit I-4.

Between 1992 and 2005, the annual rate of change experienced a notable increase, peaking at over 10%. However, during the housing crisis that commenced in 2006, this rate took a significant downturn, reaching a low point of -10% in 2008 and remaining in negative territory until 2011. Subsequently, the trend reversed, and this upward trajectory persisted through 2013, fluctuating between 5% and 7% until the second quarter of 2020. Then, starting in the third quarter of 2020, the rate embarked on an upward trajectory, driven by heightened housing demand, and reaching its zenith at 18.9% in the first quarter of 2022. House appreciation slowed down in 2022 dropping to an annual rate of change of 12.3% and continued to drop to annual rate of 2.3% as of the second quarter of 2023. The quarterly percentage variations in the nationwide FHFA Purchase Only House Price Index by quarter are displayed in Exhibit I-4

Exhibit I-4: Historical FHFA Purchase-Only House Price Index and Percent change[7]
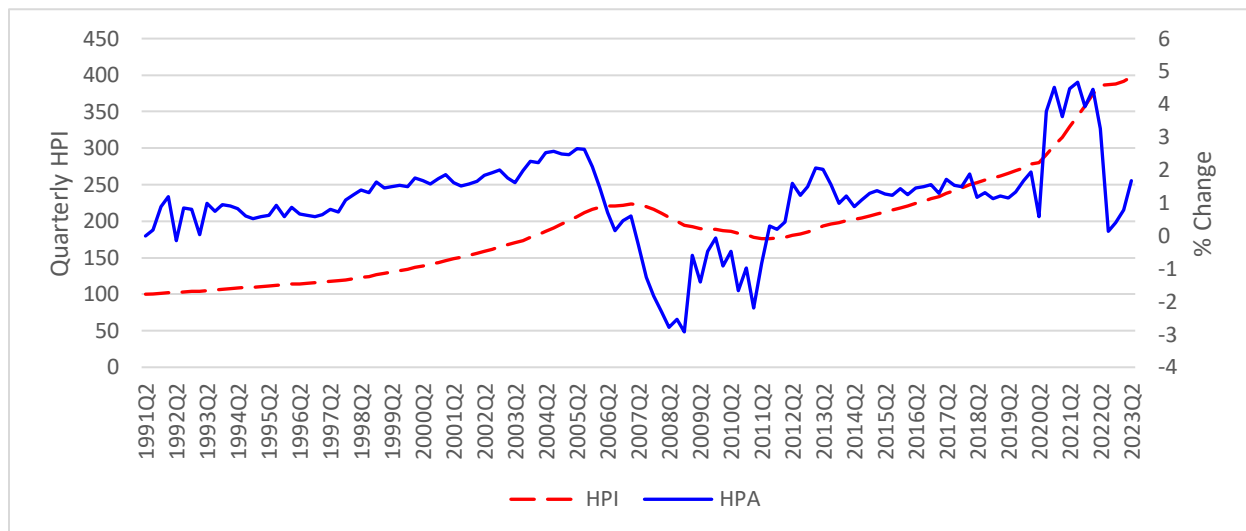
ii.   Interest Rates

In 2008, in response to the housing crisis and economic recession, the Federal Reserve began decreasing interest rates as part of an active monetary policy. At the beginning of 2007, the one-year Treasury rate was around 5%. Over the next seven years, the rate dropped steadily to a low of 0.1% in the second quarter of 2014. After 2014, the rate began increasing to 2.7% by December

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[7] U.S. Federal Housing Finance Agency, Purchase Only House Price Index for the United States [HPIPONM226S], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/HPIPONM226S, October 26, 2023.

2018. Since then, the rate has been decreasing, and as of the second quarter of 2021 reached 0.06%, the lowest level since the one-year CMT rate began in 1953. This drop was due to monetary policy in response to the economic impact of COVID-19. Following the peak of the COVID-19 pandemic, the Federal Reserve began increasing interest rates to curb inflationary pressures. As of the third quarter of 2023, the rate has risen to 4.86%. Exhibit I-5 shows the historical one-year and ten-year CMT rates.

Exhibit I-5: Historical 1-Year and 10-year Constant Maturity Treasury[8, 9]
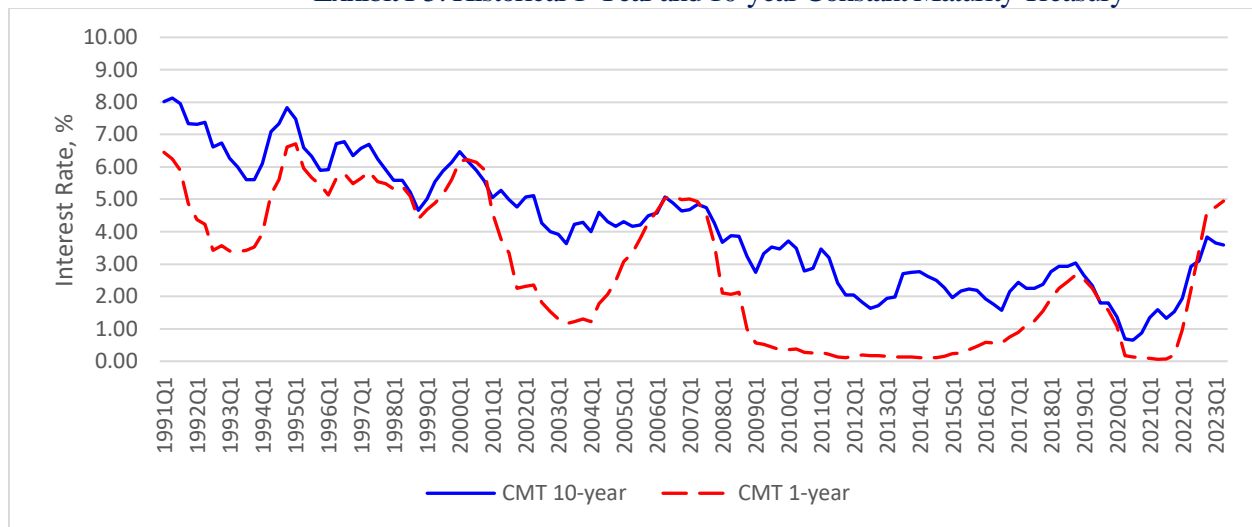
The 10-year CMT rate exhibits a similar trajectory, although the fluctuations are less pronounced. During 2007, the 10-year CMT rate stood at slightly over 5%. Subsequently, it gradually declined, falling below 2% by 2012. Post-2012, the rate increased, reaching just over 3.0% by December 2018. However, it began a descent once again and, due to the economic repercussions of COVID-19, dropped to 0.64% by the third quarter of 2020, marking the lowest level in the past three decades. In 2022, the rate rebounded to about 3.6% at the end of the year. As of the third quarter of 2023, the rate is about 3.76%.

Exhibit I-6 shows the statistics of the 10-year Constant Maturity Treasury (CMT) rate, 1-year CMT rate, 30-day CMT rate, 30-day London Interbank Offered Rate (LIBOR) and 1-year SOFR has risen for the last two years. All rates have increased during the past two years.

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[8] Board of Governors of the Federal Reserve System (US), Market Yield on U.S. Treasury Securities at 1-Year Constant Maturity, quoted on an Investment Basis [DGS1], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/DGS1, October 26, 2023.

Exhibit I-6 Selected Historical Interest Rates

Rate Type	Interest Rate		
	2021 Q3	2022 Q3	2023 Q3
PEA* - 10-year CMT	1.32%	3.11%	3.76%
PEA* - 1-year CMT	0.08%	3.40%	4.86%
1-year SOFR	0.06%	3.51%	5.39%
PEA* - 30-day CMT	0.05%	2.20%	4.97%
PEA* - 30-day LIBOR	0.09%	2.48%	5.58%

*President's Economic Assumptions (PEA) from 06/06/2023 - Midyear release

E.   Structure of this Report

The remainder of this report consists of the following sections:

Section II. Summary of Findings: Presents the economic net worth and insurance-in-force of the HECM Fund portfolios as of the end of FY 2023.

Section III. The Current Status of HECMs in the MMI Fund: Analyzes the estimated economic net worths in further detail.

Section IV. Characteristics of the MMI HECM Books of Business: Presents various characteristics of HECM endorsements for FYs 2009 through 2023.

Section V. HECM Performance under Alternative Scenarios and Sensitivity Testing: Presents the HECM portfolio economic net worths using alternative economic scenarios.

Section VI. Summary of Methodology: Provides a summary of the models utilized in the analysis.

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 Data Reconciliation: Provides data reconciliation results.

Appendix B. HECM Base Termination Model: Provides a technical description of the loan performance model for the causes of loan termination.

Appendix C. 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 D. 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 E. Stochastic Simulation of Economic Variables: Discusses the simulated economic scenarios that were generated by a Monte Carlo stochastic model to forecast the economic net worths of the MMI HECM portfolio.

II.   Summary of Findings

This section presents the projected economic net worths and insurance-in-force of the 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 net worth 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 net worth calculation does not include the effect of endorsements in future fiscal years. According to NAHA, the economic net worth 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 net worth for the HECM portfolio as the sum of the amount of capital resources and the net present value of all expected future cash flows of the active HECM loans as of the end of FY 2023.

A.   The FY 2023 Actuarial Review

The FY 2023 Actuarial Review estimates the economic net worth of the HECM Fund as of the end of FY 2023 (September 30, 2023). The objectives of our analysis include:

- Analyze all HECM historical termination experience and the associated recoveries using loan-level HECM data maintained by FHA through September 2023.

- Identify the tax and insurance default and estimate the impact of tax and insurance default or extra cash out flow burden of HECM loans. We also build the conveyance/payoff selection equation.

- Construct a model using the economic scenarios of interest rates and house price appreciation rates. These economic paths were calibrated to center around the baseline macroeconomic forecasts from the PEA assumptions and Moody's Analytics in June 2023.

- Provide detailed descriptions of the termination model, cash flow model, and economic assumptions used (presented in Appendices A to E). The following is a summary of the major findings in this review, which are also illustrated in Exhibit II-1.

This Review is carried out by examining historical loan performance data supplied by FHA, creating econometric models with the estimation of their parameters, and generating economic scenarios consistent with the President's Economic Assumptions (PEA) for the FY 2024 Federal Budget. Econometric models are employed to forecast the Fund's future cash flows, and their present value is compared to the Fund's financial resources to determine the economic worth of the Fund.

Estimation of the loan status transition models utilized loan-level data on the Fund's historical loan performance from the early 1990s through to the end of FY 2023. The performance of FHA loans through the 2007-2010 mortgage crisis, the period of recovery and declining interest rates that followed the crisis, and the recent COVID-19 emergency have all provided real-world "stress tests" upon which to train our econometric models and develop forecasts of future performance. Further discussion and in-depth descriptions of the individual models, their underlying assumptions, and comprehensive econometric outputs are provided in a series of appendixes to the report.

B.   Economic Net Worth

Exhibit II-1 presents the components of the economic net worth for FY 2023. ITDC projects the Actuarial Central Estimate (ACE) of the HECM portion of the MMI Fund at an estimated economic net worth of positive $15.368 billion at the end of FY 2023.

Exhibit II-1: Estimated Economic Net Worth of the HECM Portfolio for FY 2009-FY 2023 in the MMI Fund at the End of FY 2023 ($ Million)

Item	End of FY 2023*
Total Capital Resources as of EOY	$ 8,627
+ NPV of Future Cash Flows on Outstanding Business	$ 6,742
Economic Net Worth	$ 15,368
Insurance-In-Force	$ 65,432
MCA	$ 115,073

*Source: FHA Financial Statements for September 2023

Data through September 2023 was used for the total capital resources. The total economic net worth 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 $8.627 billion at the end of FY 2023.

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 annual cash inflows and outflows using economic forecasts and loan performance projections. The net present value of future cash flows is estimated to **be *positive* $6.742 billion** as of the end of FY 2023.

C.   Changes in the Economic Net Worth

The FY 2022 HECM Review reports that the economic net worth of the HECM portfolio was positive $3.646 billion at the conclusion of FY 2022, contrasting with this year's Review, which estimates a positive value of $6.742 billion at the end of FY 2023.

For two years' actuarial central estimates are based on different models and assumptions, we cannot quantify the change to different sources. Here are the main factors that might explain the change.

Exhibit II-2. Estimate of Cash Flow Changes as of the End of the FY 2023 ($ Million)

Item	Cash Flow NPV	Capital Resources	Insurance-In-Force
2022	3,646	8,929	66,276
2023	6,742	8,627	65,432
Difference	3,096	(302)	(844)
Percent Change	84.91%	-3.39%	-1.27%

The change was driven by many factors, such as differences in the actual performance of the economy versus what was projected and differences in the actual composition of the portfolio versus what was projected. Here are some possible factors that might explain the change.

- Higher death termination caused by the COVID-19 pandemic was in the data and led to different age composition of the active loan. We leave this to future research to identify the impact of the COVID-19 pandemic on the composition of surviving loans.

  Excluding the impact of COVID-19 pandemic on termination rates, the forecasted NPV is $6.667 billion, which reduces the actuarial central estimate of $6.742 billion with COVID impact by $0.074 billion.

- The June 2023 release of PEA assumptions have higher house appreciation rate than the June 2022 PEA assumptions.

- New endorsements in 2023 contribute to a positive NPV according to our model.

D.   Current Insurance-in-Force of HECM in the MMI Fund

According to NAHA, the insurance-in-force (IIF) is defined as the "obligation on outstanding mortgages", which is generally understood to describe amortized insurance-in-force. We estimate the IIF as the total UPB of all outstanding HECM loans in the insurance portfolio as of the end of FY 2023.

Another possible IIF measure is the MCA, which represents FHA's maximum risk exposure of the portfolio and serves as the cap on the amount of insurance claims that FHA will pay the lender for unassigned loans. UPB tends to increase over time from interest accruals, premiums, service fees and borrower cash draws. The current UPB would under-represent FHA's long-term insurance exposure depending on the distribution of loan ages in the HECM portfolio. The aggregate MCA for the portfolio will only depend on insurance termination and will be more stable over time, as the highest claim amount FHA may be required to pay out at insurance termination, although it may not cap the possible exposure.

Therefore, in Exhibit II-3 we also list the aggregate MCA to indicate the insurance risk exposure of the HECM MMI fund. Exhibit II-3presents the estimated net present value, survival loan count and insurance-in-force and MCA for FY 2009 to FY 2023 active endorsements at the end of FY 2023.

Exhibit II-3. Estimated Survival Loan Count and Insurance-in-Force

Endorsement Fiscal Year	Net Present Value of Future Cash Flows ($ Million)	Survival Loan Count	Insurance-in-Force* ($ Million)	MCA ($ Million)
2009	187	11,228	3,000	2,927
2010	365	6,338	1,850	1,782
2011	181	6,263	1,638	1,706
2012	152	4,537	1,193	1,221
2013	144	6,137	1,482	1,605
2014	380	14,379	2,829	3,558
2015	811	21,282	4,307	5,529
2016	1,168	19,793	4,068	5,589
2017	1,078	25,322	5,268	7,630
2018	520	22,642	4,121	7,125
2019	351	14,924	2,349	4,910
2020	791	24,242	4,695	9,176
2021	683	37,343	8,577	16,166
2022	(483)	60,632	14,857	30,257
2023	413	32,420	5,196	15,892

- The MMI insurance-in-force (IIF) is expressed as the sum of the UPBs of all HECM loans remaining in the insurance portfolio. The estimated IIF reflects the combined, cumulative impacts of loan terminations and new endorsements. The total IIF for 2009 to 2023 cohorts was estimated to be $65.432 billion at the end of FY 2023.

- The total MMI MCA for 2009 to 2023 cohorts is estimated to be $115.073 billion at the end of FY 2023.

III.   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 2023. HECM loans were first included in the MMI Fund in FY 2009. The loans from these books of business that have not been terminated constitute the HECM portfolio as of the end of FY 2023. A review of the characteristics of these cohorts helps define the current risk profile of the HECM Fund. Some of the characteristics of previous books are shown as well to demonstrate trends.

A.   Volume and Share of Mortgage Originations

FHA endorsed 32,932 HECM loans in Fiscal Year 2023, with a total MCA of $15.892 billion. The total number of endorsements for Fiscal Years 2009 to 2023 is 863,102. The corresponding MCA is $115.073 billion. Since the inception of the HECM program, this program has been the largest reverse mortgage product in the U.S. market, representing most reverse mortgages. Exhibit III-1 presents the count of HECM endorsements by origination Fiscal Year.

Exhibit III-1: Number of HECM Endorsements per Fiscal Year
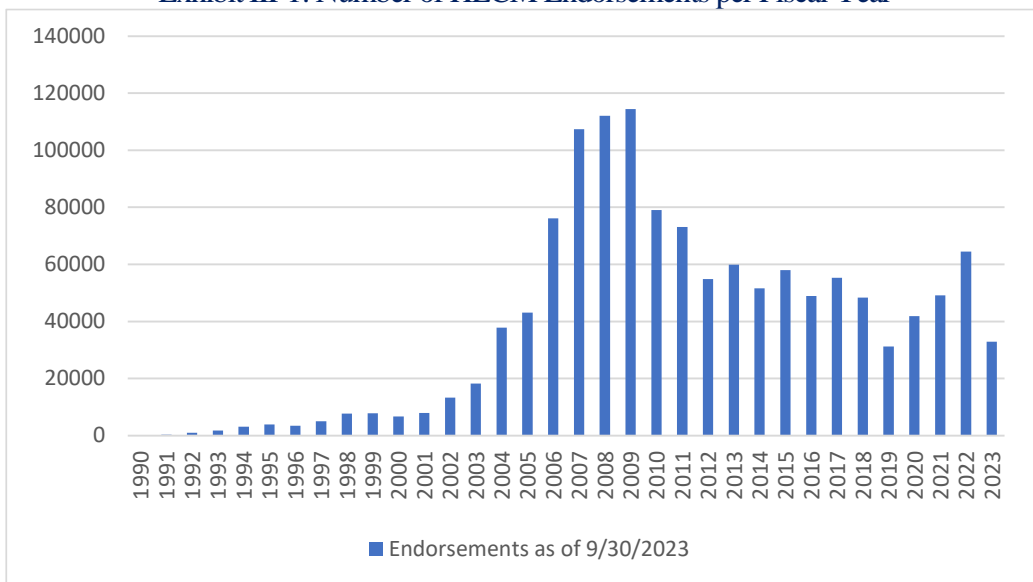
B.   Payment Types

HECM borrowers receive loan proceeds by selecting from term, line of credit, tenure payment, and lump sum plans. Borrowers can also choose a combination of payment plan types. Exhibit III-2 presents the distribution of HECM loans by payment plan. The majority of HECM borrowers select the line of credit option. This option has accounted for over 87% of the endorsements since Fiscal Year 2009 and has been increasing since 2017.

Exhibit III-2: Distribution of FY 2009-FY 2023 HECM Loans by Payment Type

Fiscal Year	Payment Type						
	Term	Line of Credit	Tenure	Term+ Line of Credit	Tenure+ Line of Credit	Lump Sum	Total, N
2009	0.8%	91.9%	1.4%	3.8%	2.0%	0.0%	114,421
2010	0.5%	94.3%	0.9%	2.8%	1.5%	0.0%	79,052
2011	0.4%	94.5%	0.8%	2.8%	1.4%	0.0%	73,109
2012	0.3%	94.9%	0.8%	2.6%	1.4%	0.0%	54,812
2013	0.4%	95.1%	0.8%	2.4%	1.2%	0.0%	59,924
2014	0.7%	93.5%	1.3%	3.0%	1.5%	0.0%	51,616
2015	0.6%	93.6%	1.0%	2.8%	1.6%	0.5%	57,990
2016	0.6%	89.4%	0.9%	2.8%	1.6%	4.6%	48,868
2017	0.5%	87.1%	0.9%	2.8%	1.7%	7.1%	55,290
2018	0.5%	87.6%	0.7%	2.6%	1.5%	7.0%	48,329
2019	0.5%	90.0%	0.7%	2.4%	1.3%	5.1%	31,272
2020	0.5%	94.5%	0.4%	2.2%	1.0%	1.5%	41,835
2021	0.4%	90.6%	0.3%	2.0%	0.8%	5.8%	49,195
2022	0.4%	93.3%	0.6%	2.0%	0.9%	2.8%	64,457
2023	0.6%	94.3%	0.8%	2.3%	1.3%	0.7%	32,932

C. Interest Rate Type

HECM borrowers can select fixed or adjustable-rate mortgages. Exhibit III-3 shows the distribution of HECM loans by interest rate type.

The majority of HECM borrowers selected monthly adjustable-rate mortgages in Fiscal Year 2009. The next year, however, the percentage of fixed-rate endorsements increased sharply to 69%. This was due, in part, to a significant drop in interest rates beginning in the last half of 2008. This percentage persisted in Fiscal Years 2011 - 2013. Subsequently, the share of fixed-rate HECM loans dropped sharply. In Fiscal Year 2014, the percentage of fixed rate loans dropped to 19%, and as of the end of Fiscal Year 2020 it had dropped to less than 2% of the HECM loans originated. However, in 2021 the percentage of fixed rate loans increased to over 7% and is at 4.4% of the loans in 2022. This is due in part to the low interest rates that persisted into 2022. High interest rates led to a significant drop in fixed rate loans in 2023.

Beginning in 2021, the LIBOR rate was discontinued. As a result, the SOFR replaced the LIBOR as an option for an index for adjustable mortgages. The data does not include a different variable for LIBOR and SOFR, and we use LIBOR to represent both.

Exhibit III-3: Distribution of FY 2009-FY 2023 HECM Loans by Interest Rate Type

Fiscal Year	Libor Indexed		Treasury Indexed		Fixed	Total
	Annually Adjusted	Monthly Adjusted	Annually Adjusted	Monthly Adjusted		
2009	0.0%	34.6%	0.7%	53.1%	11.6%	114,421
2010	0.0%	30.6%	0.0%	0.5%	68.9%	79,052
2011	0.0%	31.9%	0.0%	0.1%	68.0%	73,109
2012	0.0%	30.5%	0.0%	0.1%	69.4%	54,812
2013	0.0%	39.3%	0.0%	0.0%	60.6%	59,924
2014	2.4%	78.9%	0.0%	0.0%	18.7%	51,616
2015	40.0%	44.3%	0.0%	0.0%	15.7%	57,990
2016	75.4%	13.9%	0.0%	0.0%	10.6%	48,868
2017	86.1%	3.5%	0.0%	0.0%	10.3%	55,290
2018	88.4%	1.4%	0.0%	0.0%	10.1%	48,329
2019	93.7%	0.2%	0.0%	0.0%	6.0%	31,272
2020	98.0%	0.1%	0.0%	0.0%	1.9%	41,835
2021	30.1%	0.1%	2.1%	60.4%	7.2%	49,195
2022	0.0%	0.0%	0.8%	94.8%	4.4%	64,457
2023	0.0%	0.0%	0.1%	99.0%	0.9%	32,932

D.   Product Type

There are three types of HECM loans: traditional HECM, HECM refinance, and HECM for purchase. Almost all loans endorsed in Fiscal Years 2009 through 2023 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 have been a small percentage of HECM endorsements each year as seen in Exhibit III-4. In our analysis, the traditional and for-purchase HECMs are treated the same, as the volume of for-purchase HECMs is small.

Exhibit III-4: Distribution of FY 2009-FY 2023 HECM Loans by Product Type

Fiscal Year	Product Type				
	Traditional HECMS	Refinance HECMS	HECMs for Purchase		Total, N
			First Month Cash Draw >= 90% of Initial Principal Limit	First Month Cash Draw < 90% of Initial Principal Limit	
2009	91.7%	7.8%	0.4%	0.1%	114,421
2010	92.1%	6.1%	1.6%	0.1%	79,052
2011	94.2%	3.7%	2.1%	0.0%	73,109
2012	94.4%	2.6%	2.9%	0.1%	54,812
2013	93.4%	3.1%	3.4%	0.0%	59,924
2014	91.8%	4.7%	3.5%	0.1%	51,616
2015	86.2%	9.6%	4.0%	0.1%	57,990
2016	84.1%	11.0%	4.5%	0.3%	48,868
2017	80.7%	14.5%	4.4%	0.4%	55,290
2018	82.5%	12.1%	5.0%	0.4%	48,329
2019	87.3%	5.4%	6.8%	0.5%	31,272
2020	73.5%	20.6%	5.5%	0.4%	41,835
2021	53.5%	42.0%	4.2%	0.3%	49,195
2022	51.6%	45.0%	3.2%	0.2%	64,457
2023	81.7%	12.2%	5.6%	0.5%	32,932

E.   Endorsement Loan Counts by State

Among all endorsements in Fiscal Years 2015 through 2023, over half of all loans originated in the top 10 states. California had the highest endorsement volume every year over this period, while Florida has had the second highest endorsement volume since 2015. The endorsement volume in Arizona has increased from 1.7% in Fiscal Year 2012 to 6.3% in Fiscal Year 2023 and is the fourth largest state in 2023. The endorsement breakdown of the top 10 states is shown in Exhibit III-5.

Exhibit III-5: Percentage of Endorsements by State for FY 2009 - FY 2023 HECM Loans

Top 10 states*	California	Florida	Texas	Arizona	Colorado	Washington	Utah	North Carolina	Georgia	Oregon	Total
2009	13.7%	13.2%	6.6%	3.1%	1.8%	2.8%	1.5%	1.8%	2.1%	2.7%	49.3%
2010	14.0%	9.0%	8.0%	2.1%	1.8%	3.0%	1.3%	2.0%	2.5%	2.3%	45.9%
2011	13.5%	6.8%	9.1%	2.0%	1.9%	2.5%	1.4%	2.6%	2.4%	1.8%	43.9%
2012	12.7%	6.1%	8.9%	1.7%	2.0%	2.3%	1.8%	2.8%	2.0%	1.7%	42.1%

Top 10 states*	California	Florida	Texas	Arizona	Colorado	Washington	Utah	North Carolina	Georgia	Oregon	Total
2013	14.1%	6.5%	8.6%	2.4%	2.1%	2.3%	2.0%	3.1%	2.0%	1.4%	44.3%
2014	17.5%	6.9%	7.4%	2.9%	2.3%	2.1%	1.7%	2.6%	2.0%	1.4%	46.9%
2015	20.3%	8.3%	7.0%	3.2%	2.4%	2.3%	1.7%	2.4%	2.1%	1.4%	51.2%
2016	21.8%	8.8%	7.6%	3.6%	3.7%	2.7%	1.8%	2.5%	2.1%	1.9%	56.5%
2017	23.7%	8.7%	7.6%	3.7%	5.4%	3.2%	1.9%	2.3%	2.0%	2.4%	61.2%
2018	22.7%	8.4%	7.4%	4.0%	5.9%	4.3%	2.4%	2.5%	2.0%	2.6%	62.1%
2019	21.1%	8.6%	7.4%	4.8%	6.0%	4.0%	2.8%	2.5%	2.0%	2.4%	61.6%
2020	24.7%	8.4%	6.4%	5.6%	7.1%	4.8%	3.2%	2.4%	1.9%	2.8%	67.4%
2021	26.0%	8.2%	6.0%	7.0%	7.0%	5.7%	4.2%	2.1%	1.9%	2.9%	71.0%
2022	23.7%	9.1%	6.6%	8.5%	6.9%	5.2%	5.4%	2.3%	2.0%	3.2%	72.8%
2023	18.5%	10.7%	8.4%	6.3%	5.2%	4.2%	3.5%	3.1%	3.1%	2.6%	65.4%

*Top 10 states by 2023 count of endorsements.

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 the cap on the potential insurance claim amount. Exhibit III-6 shows the distribution of HECM endorsements by the MCA. Approximately 65% of loans endorsed in Fiscal Year 2009 had an MCA of less than or equal to $300,000, and this percentage increased to approximately 72% by Fiscal Year 2012. Since then, the percentage of endorsements less than $300,000 has decreased steadily to approximately 23% for Fiscal Year 2023.

The percentage of endorsements with an MCA between $300,000 and $417,000 decreased from 17.6% in 2009 to about 12-14% during Fiscal Years 2010 through 2014. In 2023, it has increased to 23.6%. As the principal limit has been increasing, the percentage of endorsements with an MCA over $417,000 has increased steadily since 2012.

Exhibit III-6: Distribution of FY 2009-FY 2023 HECM Loans by MCA Level

FY	Less Than $100K	$100K to Less Than $200K	$200K to $300K	$300K to $417k	$417k to $600K	$600 to $726.2K	Greater Than $726.2K
2009	9.5%	31.9%	22.9%	17.6%	13.2%	4.9%	0.0%
2010	12.1%	33.9%	20.0%	13.8%	11.5%	8.6%	0.0%
2011	14.9%	35.7%	19.4%	12.9%	9.9%	7.2%	0.0%
2012	16.1%	37.0%	18.7%	12.6%	9.2%	6.3%	0.0%
2013	15.6%	36.3%	18.8%	13.1%	9.3%	6.9%	0.0%

FY	Less Than $100K	$100K to Less Than $200K	$200K to $300K	$300K to $417k	$417k to $600K	$600 to $726.2K	Greater Than $726.2K
2014	13.0%	34.2%	19.7%	14.0%	11.0%	8.1%	0.0%
2015	11.0%	31.4%	20.7%	15.2%	12.5%	9.1%	0.0%
2016	7.8%	28.3%	21.8%	16.8%	14.6%	10.7%	0.0%
2017	5.5%	24.8%	22.7%	18.7%	16.6%	11.8%	0.0%
2018	4.1%	22.8%	23.0%	19.8%	17.0%	13.4%	0.0%
2019	3.1%	21.3%	24.1%	20.3%	17.0%	10.2%	4.0%
2020	1.7%	15.7%	22.7%	21.6%	19.3%	8.9%	10.1%
2021	0.8%	11.0%	19.2%	22.7%	22.0%	10.4%	13.9%
2022	0.3%	5.7%	14.0%	22.0%	26.5%	12.6%	18.8%
2023	0.4%	6.9%	16.7%	23.6%	23.7%	10.5%	18.1%

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 III-7 shows the percentage of HECM loans with an appraised house value greater than the area median value.

Exhibit III-7: Percentage of Borrowers with Appraised House Value Greater than Area Median Value
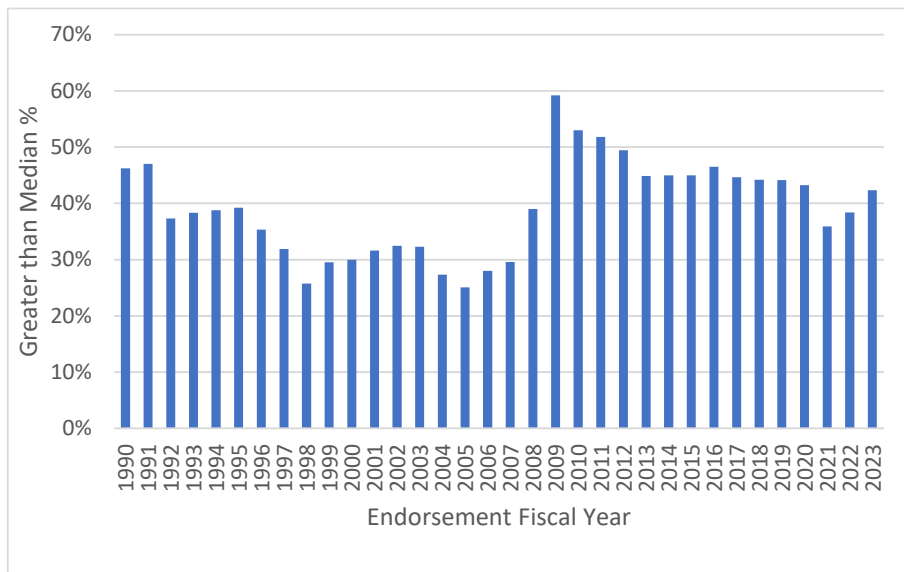
H.   Borrower Age Distribution

The borrower age profile of an endorsement year affects loan termination rates and the PL available to the borrower. Exhibit III-8 shows the average borrower age at origination for Fiscal Years 1990 through 2023. The average borrower age had been declining through 2013 but has been increasing since then. Younger borrowers represent a higher financial risk exposure for FHA as they have a longer life expectancy. The PLFs, which limit the percentage of initial equity available to the borrower, were lowered for younger borrowers in September 2013, limiting their cash draws to a smaller portion of the equity in the house. This has caused the average borrower age to increase since 2013, and it is now over 74 years old in Fiscal Year 2023.

Exhibit III-8: Average Borrower Age at Origination by Fiscal Year
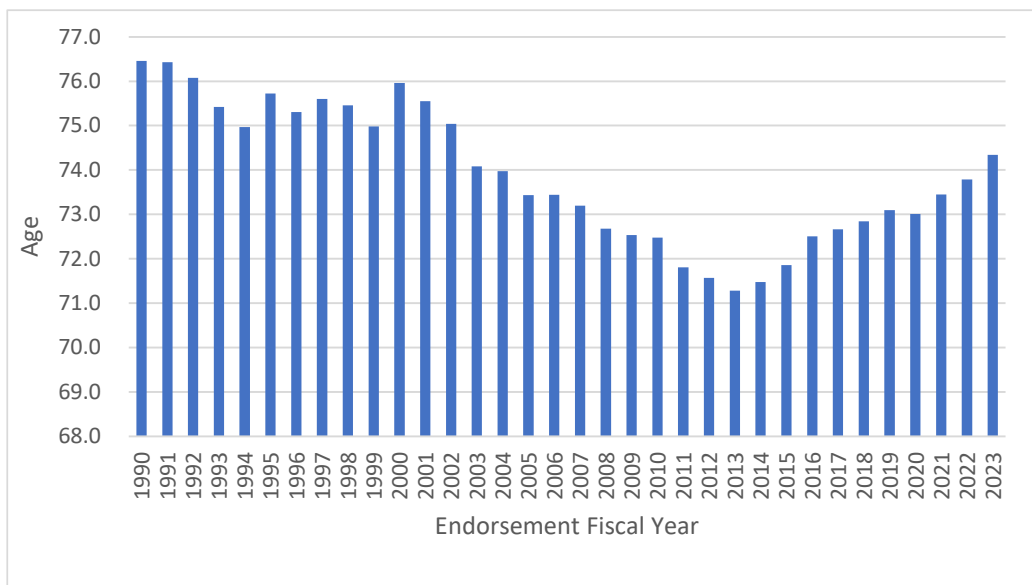
I.   Borrower Gender Distribution

Gender also affects termination behavior due to differences in mortality rates. HECM loan behavior indicates that single males tend to terminate their loans the quickest, followed by single females, with couples terminating the slowest. Exhibit III-9 shows the gender distribution of HECM endorsements.

Exhibit III-9: Distribution of FY 2009-FY 2023 HECM Endorsements by Gender

Endorsement Fiscal Year	Male	Female	Couple	Missing
2009	21.7%	40.9%	36.8%	0.6%
2010	21.5%	41.9%	35.3%	1.4%
2011	20.9%	40.3%	37.1%	1.8%
2012	21.2%	39.2%	37.4%	2.3%
2013	21.1%	37.6%	39.0%	2.3%

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Endorsement Fiscal Year	Male	Female	Couple	Missing
2014	20.6%	38.7%	38.7%	2.0%
2015	21.9%	38.5%	38.9%	0.7%
2016	21.7%	36.8%	41.1%	0.5%
2017	20.9%	37.1%	40.9%	1.0%
2018	20.7%	36.7%	40.2%	2.4%
2019	21.2%	38.1%	38.8%	1.9%
2020	20.2%	35.3%	39.7%	4.8%
2021	20.9%	35.9%	38.6%	4.6%
2022	19.9%	35.4%	40.3%	4.4%
2023	21.3%	39.6%	32.8%	6.3%

J. Cash Draw Distribution

Cash draw is an important factor in understanding the risk of the HECM portfolio. Over the years, FHA has done a tremendous job managing the competing risk of maximum borrower equity and MMI solvency. FHA has sought to manage this risk through careful and deliberate adjustments to the principal limit factor (PLF) table, which is published by FHA. These PLFs dictate the amount of equity the borrower is allowed to consume based on the borrower's age and the interest rate environment. Over the years, borrowers have become more savvy using HECM proceeds. We see on average; all historic cohorts have drawn 80%+ of their initial principal limit. To identify future HECM cash draws, we have proposed using historical experience, which includes scheduled and unscheduled borrower cash draws.

The table below, Exhibit III-10, looks at historical cash drawn by cohort to understand how much equity is available for borrower withdrawals.

Exhibit III-10: Total Cash Draw by Cohort for FY 2009-2023

MMI Cohort	Total Cash Draw (as a % of initial principal limit)
2009	96%
2010	95%
2011	98%
2012	96%
2013	98%
2014	94%
2015	92%
2016	87%

MMI Cohort	Total Cash Draw (as a % of initial principal limit)
2017	85%
2018	82%
2019	80%
2020	80%
2021	81%
2022	79%
2023	64%

Data shows that loans which have drawn a higher percentage of the initial amount of equity available tend to have a higher likelihood of refinancing. Exhibit III-11 shows the distribution of the cash draw in the first month as a percentage of the initial PL by age group for HECM endorsements.

Exhibit III-11: First-Month Borrower Cash Draw of FY 2009-FY 2023 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	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	23,707	11.9%	9.9%	64.6%	0.2%	13.3%
	66-70	28,213	14.5%	10.7%	61.7%	0.1%	13.0%
	71-75	24,935	18.9%	11.4%	58.3%	0.0%	11.4%
	76-85	30,664	25.0%	11.9%	53.1%	0.1%	9.9%
	85+	6,902	36.5%	10.2%	45.8%	0.1%	7.5%
	Total	114,421	19.1%	11.0%	58.3%	0.1%	11.5%
2010	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	17,647	7.3%	4.3%	8.1%	0.2%	80.1%
	66-70	18,819	9.2%	5.3%	9.6%	0.2%	75.7%
	71-75	16,651	13.5%	6.4%	10.8%	0.1%	69.2%
	76-85	20,625	20.2%	7.7%	13.1%	0.1%	58.8%
	85+	5,310	32.7%	8.8%	14.5%	0.3%	43.7%
	Total	79,052	14.1%	6.2%	10.8%	0.2%	68.7%
2011	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	18,801	8.4%	5.0%	9.9%	0.3%	76.4%
	66-70	18,009	10.8%	5.9%	9.5%	0.2%	73.7%
	71-75	14,799	15.4%	6.5%	10.0%	0.1%	68.0%
	76-85	17,014	22.8%	8.0%	10.8%	0.1%	58.4%
	85+	4,486	36.9%	8.1%	10.7%	0.1%	44.3%
	Total	73,109	15.5%	6.4%	10.1%	0.2%	67.9%

Endorsement Fiscal Year	Age Group	Number of Loans	Variable Rate Loans			Fixed Rate Loans	
			0-40%	40-60%	60%-100%	0-60%	60-100%
2012	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	15,267	8.5%	5.4%	10.4%	0.2%	75.5%
	66-70	13,488	10.9%	5.7%	9.2%	0.1%	74.0%
	71-75	10,529	14.4%	6.5%	9.4%	0.1%	69.7%
	76-85	12,136	20.9%	7.2%	9.9%	0.1%	61.9%
	85+	3,392	34.5%	7.7%	10.1%	0.2%	47.5%
	Total	54,812	14.6%	6.2%	9.8%	0.1%	69.3%
2013	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	16,876	8.0%	5.8%	20.7%	0.2%	65.4%
	66-70	15,414	9.9%	5.8%	20.5%	0.2%	63.6%
	71-75	11,624	13.8%	6.3%	19.2%	0.2%	60.6%
	76-85	12,728	19.6%	7.0%	19.1%	0.2%	54.1%
	85+	3,282	32.3%	7.1%	15.9%	0.3%	44.4%
	Total	59,924	13.4%	6.2%	19.7%	0.2%	60.4%
2014	<62	1	0.0%	0.0%	100.0%	0.0%	0.0%
	62-65	13,602	12.2%	26.5%	38.4%	1.8%	21.1%
	66-70	13,608	15.4%	24.7%	39.2%	1.7%	19.1%
	71-75	10,290	19.1%	25.4%	37.4%	1.7%	16.4%
	76-85	11,035	24.9%	26.0%	35.0%	1.9%	12.2%
	85+	3,080	37.5%	26.7%	26.5%	2.3%	7.1%
	Total	51,616	18.6%	25.7%	37.0%	1.8%	16.9%
2015	<62	2	0.0%	0.0%	100.0%	0.0%	0.0%
	62-65	14,215	12.8%	35.4%	33.0%	0.6%	18.2%
	66-70	14,773	14.9%	32.9%	33.8%	0.6%	17.8%
	71-75	12,052	18.4%	31.6%	33.9%	0.5%	15.6%
	76-85	13,377	24.0%	32.5%	31.8%	0.6%	11.0%
	85+	3,571	34.8%	33.6%	25.0%	1.0%	5.5%
	Total	57,990	18.4%	33.2%	32.6%	0.6%	15.1%
2016	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	9,970	16.9%	34.9%	34.2%	0.8%	13.3%
	66-70	12,708	18.2%	31.4%	37.2%	0.5%	12.7%
	71-75	10,772	19.3%	31.1%	38.5%	0.2%	10.8%
	76-85	12,004	24.4%	31.8%	36.9%	0.4%	6.6%
	85+	3,414	35.6%	32.9%	28.2%	0.6%	2.7%
	Total	48,868	20.9%	32.3%	36.2%	0.5%	10.2%
2017	<62	1	0.0%	0.0%	100.0%	0.0%	0.0%
	62-65	10,663	18.1%	32.2%	36.1%	1.0%	12.6%
	66-70	14,524	17.1%	28.7%	41.6%	0.5%	12.2%

Endorsement Fiscal Year	Age Group	Number of Loans	Variable Rate Loans			Fixed Rate Loans	
			0-40%	40-60%	60%-100%	0-60%	60-100%
	71-75	12,495	19.3%	27.3%	42.7%	0.4%	10.3%
	76-85	13,804	22.2%	29.3%	41.4%	0.4%	6.7%
	85+	3,803	32.8%	32.2%	32.0%	0.3%	2.7%
	Total	55,290	20.2%	29.5%	40.1%	0.5%	9.8%
2018	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	8,990	18.6%	32.1%	36.8%	0.7%	11.7%
	66-70	12,451	17.4%	28.1%	41.6%	0.5%	12.4%
	71-75	11,167	20.1%	27.6%	41.9%	0.3%	10.1%
	76-85	12,295	22.2%	30.2%	40.3%	0.4%	6.9%
	85+	3,426	33.3%	31.7%	31.6%	0.3%	3.0%
	Total	48,329	20.6%	29.5%	39.7%	0.5%	9.7%
2019	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	5,470	17.7%	29.5%	45.4%	0.4%	6.9%
	66-70	7,912	17.6%	27.3%	48.2%	0.2%	6.7%
	71-75	7,267	20.0%	27.0%	46.3%	0.2%	6.5%
	76-85	8,191	24.2%	30.4%	40.7%	0.3%	4.5%
	85+	2,432	33.9%	32.4%	31.0%	0.6%	2.1%
	Total	31,272	21.2%	28.8%	44.0%	0.3%	5.8%
2020	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	6,850	16.3%	25.4%	56.2%	0.1%	2.0%
	66-70	10,614	14.2%	23.8%	59.4%	0.1%	2.5%
	71-75	10,376	15.2%	23.5%	59.6%	0.1%	1.6%
	76-85	11,209	18.7%	26.2%	53.6%	0.2%	1.4%
	85+	2,786	30.8%	29.8%	38.2%	0.4%	0.8%
	Total	41,835	17.1%	25.0%	56.0%	0.1%	1.8%
2021	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	6,745	12.9%	26.1%	53.2%	0.4%	7.5%
	66-70	12,150	11.2%	20.6%	59.9%	0.3%	7.9%
	71-75	12,977	11.0%	18.7%	62.4%	0.3%	7.7%
	76-85	14,107	12.7%	19.5%	61.6%	0.3%	6.0%
	85+	3,216	23.3%	22.9%	50.2%	0.2%	3.4%
	Total	49,195	12.6%	20.7%	59.5%	0.3%	6.9%
2022	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	7,814	13.7%	25.8%	55.3%	0.2%	5.0%
	66-70	15,549	11.5%	20.6%	62.9%	0.2%	4.7%
	71-75	17,225	11.1%	18.1%	66.0%	0.2%	4.7%
	76-85	19,647	11.3%	18.1%	66.9%	0.2%	3.5%
	85+	4,222	19.5%	18.9%	59.0%	0.4%	2.2%

Endorsement Fiscal Year	Age Group	Number of Loans	Variable Rate Loans			Fixed Rate Loans	
			0-40%	40-60%	60%-100%	0-60%	60-100%
	Total	64,457	12.1%	19.7%	63.8%	0.2%	4.2%
2023	<62	-	0.0%	0.0%	0.0%	0.0%	0.0%
	62-65	4,427	20.6%	33.7%	44.8%	0.1%	0.8%
	66-70	7,272	19.4%	30.7%	48.8%	0.2%	1.0%
	71-75	7,874	19.8%	30.4%	48.8%	0.2%	0.7%
	76-85	10,260	22.0%	28.3%	48.9%	0.2%	0.6%
	85+	3,099	30.8%	24.8%	43.5%	0.2%	0.5%
	Total	32,932	21.6%	29.7%	47.8%	0.2%	0.7%

IV. HECM Performance under Alternative Scenarios

The HECMs' economic net worth for FY 2023 will depend on the economic conditions expected to prevail over the next 75 years and, most critically, during the next 10 years. The baseline scenario for the primary economic drivers was developed consistent with the President's Economic Assumptions (PEA) for FY 2023. The PEA is published by the Office of Management and Budget in compliance with the requirements of the Federal Credit Reform Act. The realized economic net worth will vary from the baseline estimate if the economic conditions deviate from the baseline projections.

We have captured the most significant factors in the U.S. economy affecting the performance of the HECM loans insured by the MMI Fund using the following variables in our models:

- One-year constant maturity Treasury rates
- 10-year constant maturity Treasury rates
- One-year SOFR rate
- National and local house price indexes

The PEA forecast developed by OMB does not cover all the economic drivers that are included in our models. Additional economic variables that must be forecasted, such as one-year SOFR, are developed using the PEA and additional forecast data from Moody's.

A. FHFA House Price Indexes

The actuarial central estimates are based on PEA assumptions for the quarterly future performance of the FHFA Purchase Only (PO) seasonally adjusted HPI for the period FY 2023 FQ3 to FY 2033 FQ4 and 3% annualized HPA for years after FY 2033.

Consistent with the PEA, house price indexes (HPIs) produced and published by FHFA were applied in loan status transition model estimation. FHFA publishes both purchase-only (PO) and all-transactions (AT) versions of their HPIs. We have applied the AT version of the FHFA HPIs in model estimation, due to the significantly broader regional coverage provided by the AT version of the HPI, including more than 300 additional MSA-level HPIs.

Prior reviews have expressed the view that the HPI PO version is necessarily more accurate than the HPI AT version due to the reliance of the latter on appraisal valuations in addition to observed sale prices. The actual evidence is limited, mixed, and sometimes points to the opposite conclusion as it regards HPI availability and accuracy. One must keep in mind that the choice between PO and AT versions of the HPI is not an either-or proposition, as the AT version still uses a blended sample of sale and refinance transactions.

Calhoun (1991) first noted the benefits of having appraisal based HPIs during periods when sales transactions are limited or in locations where they are non-existent. Calhoun (1991) also examined

the potential for greater sample-selection bias when only sales transaction data are used. Simply stated, mortgage borrowers may be willing to refinance at appraised values well below their reservation prices for selling, so that relying solely on sales prices draws from the higher end of the house price distribution at any point in time. In our view, geographic aggregation bias far outweighs concerns about appraisal bias, particularly given the overall consistency between AT and PO versions of the HPI at the same level of geography. Later research by Calhoun, Harter-Dreiman, VanderGoot (1998) and Leventis (2006) indicate that the actual evidence for systematic appraisal bias is mixed or inconclusive. On the other hand, geographic bias is large, immediate, and certain if the HPI PO version must be applied at the state level when no MSA-level HPI is available, Therefore, we opted for broader geographic coverage at the MSA level.

Nevertheless, we were required to apply the PEA for the national FHFA PO HPI in developing our baseline forecast of portfolio economic net worth. To meet this requirement, we applied the following two-step procedure to obtain regional HPI forecasts from the PEA national forecasts: (1) compute the period-by-period differentials between national forecast HPI appreciation rates and the corresponding appreciation rates for each regional HPI from the same forecast; and then (2) apply these differential appreciation rates to the PEA national HPI forecast to obtain regional HPIs forecasts consistent with the PEA. So as the PEA national forecast varies period-by-period, our regional HPIs vary in a consistent manner, and will maintain the regional dispersion based on historical patterns.

To implement step (1), we use appreciation rates for the Moody's baseline forecasts of the FHFA AT version HPIs at the national and regional levels. This enables us to retain the broader geographic coverage of the AT version of the FHFA HPIs that we applied in estimation. We note that using the Moody's regional forecasts of the FHFA PO version HPI for step (1) would result in loss of the regional coverage we seek to preserve. Step (2) is implemented by adding the respective appreciation rate differentials from step (1) to the appreciation rates of the mandated PEA national forecast of the FHFA PO version HPI.

To be clear, we are not applying Moody's forecasts in place of the mandated PEA national HPI forecast. Changes in the local forecasts will still represent the pattern of house price appreciation for the PEA national forecast, plus regional differentials in appreciation rates based on observed historical patterns. The Moody's AT and PO version national forecasts are quite consistent in terms of projected appreciation rates at both the national and regional levels, and the Moody's baseline national forecasts are quite like the PEA. As described in Appendix F, alternative scenarios for sensitivity analysis based on our stochastic simulation models use a similar approach to go from the simulated national PEA forecasts to the corresponding simulated regional forecasts. The same procedure for developing regional forecasts from PEA national HPI forecasts was applied for both Single Family and MMI fund performance.

B. Secured Overnight Financing Rate (OFR)

Mortgagee Letter (ML) 2023-9 required that the Secured Overnight Financing Rate (SOFR) replace LIBOR for both new and existing adjustable rate HECM loans indexed to the LIBOR.

The Alternative Reference Rates Committee (ARRC) noted that regardless of what rate was chosen as a LIBOR alternative, there would need to be an adjustment for the difference between LIBOR and the fallback rate. Market participants preferred the 'historical mean/median approach,' which is based on the 5-year historical median difference between USD LIBOR and SOFR for the spread adjustment. Bloomberg published the following values shown in Exhibit IV-1 as the long-term spread adjustments, based on historical 5-year median spreads between USD LIBOR and compounded averages of SOFR:

Exhibit IV-1. Historical median difference between USD LIBOR and SOFR

LIBOR tenor being replaced	Spread applied to SOFR based rate (bps)
1-week USD LIBOR	3.839
1-month USD LIBOR	11.448
2-month USD LIBOR	18.456
3-month USD LIBOR	26.161
6-month USD LIBOR	42.826
1-year USD LIBOR	71.513

The ARRC's initial consultation demonstrated that a static spread could produce results that are as, or more, accurate than a potentially dynamic spread, and showed a static spread of 0.08% based on 5-Year median spread to SOFR for spread-adjusted loans Loan with 5-years remaining maturity. In this review, we assume one-year SOFR plus a fixed 0.08% spread adjustment that measures the average difference between USD LIBOR and SOFR to be substantially equivalent to one-year LIBOR.

Four alternative stochastic scenarios are based on the best GARCH models calibrated to the historical data.

C. Stochastic Scenarios

Our primary source of historical data on these economic factors is Moody. Moody has developed data from original sources, including the Federal Reserve, Bureau of Labor Statistics, Bureau of the Census, Bureau of Economic Analysis, Federal Housing Finance Agency, The Conference Board, Dow Jones, National Association of Realtors, and Freddie Mac. Depending on the data series, information is provided at the national, state, county, metropolitan area, and ZIP Code level.

The Moody's data are combined with historical loan-level data from HUD's Single-Family Data Warehouse (SFDW) to build out loan-level panel data and event histories (defaults, cures, claims, prepayments) for use in estimating statistical models of loan performance. The estimated loan

performance models are then combined. Four scenarios for which we report economic net worth estimates are:

- Optimistic Upside Scenario in Simulation, the path that is most favorable to the HECM MMI fund.
- Moderate Upside Scenario in Simulation, the path that is moderately favorable to the HECM MMI fund.
- Moderate Downside Scenario in Simulation, the path that is moderately unfavorable to the HECM MMI fund.
- Pessimistic Downside Scenario in Simulation, the path that is most unfavorable to the HECM MMI fund.

Each of the simulated scenarios is based on combinations of simulated "percentile" paths for the economic drivers that correspond to favorable or unfavorable outcomes regarding the prospects of the HECM loan portfolio. Low interest rates with rising housing values are favorable outcomes because they lead to lower UPB growth and lower crossover risk (UPB is higher than the collateralized house property). Conversely, increasing interest rates with falling house prices are unfavorable outcomes, because they lead to higher UPB and higher crossover risk. The specific combinations of paths associated with each of the overall simulated scenarios listed above are as follows:

Scenario 1 – Optimistic Upside Scenario

CMT 1-Year Rate:	10th percentile path
CMT 10-Year Rate:	10th percentile path
SOFR Rate:	10th percentile path
HPA Rate:	90th percentile path

Scenario 2 – Moderate Upside Scenario

CMT 1-Year Rate:	25th percentile path
CMT 10-Year Rate:	25th percentile path
SOFR Rate:	25th percentile path
HPA Rate:	75th percentile path

Scenario 3 – Moderate Downside Scenario

CMT 1-Year Rate:	75th percentile path
CMT 10-Year Rate:	75th percentile path
SOFR Rate:	75th percentile path

HPA Rate: 25th percentile path

Scenario 4 – Pessimistic Downside Scenario

CMT 1-Year Rate: 90th percentile path

CMT 10-Year Rate: 90th percentile path

SOFR Rate: 90th percentile path

HPA Rate: 10th percentile path

D.   NPV Values

The estimated ACE economic net worth of the Fund as of the end of FY 2023 is positive $6.742 billion. These projections constitute the baseline against which the projections from the alternative scenarios are compared. The Fund's economic net worth for FY 2023 under the alternative scenarios are presented in Exhibits IV-2. Each alternative scenario is based on a single specified path of HPA, 10-year CMT rate, One-year CMT rate, and one-year SOFR.

Exhibit IV-2. Net Present Value of the HECM Fund under Different Economic Scenarios ($ Millions)

Scenarios	Fiscal Year 2023*	
Baseline **	$	6,742
Alternative 1 – Optimistic Upside***	$	15,820
Alternative 2 - Moderate Upside	$	12,607
Alternative 3 – Moderate Downside	$	609
Alternative 4 – Pessimistic Downside	$	(9,559)

*All values are expressed as of the end of the fiscal year
**Baseline is based on PEA
*** Description of these scenarios are in Section V and Appendix E.

The ACE economic net worth stays in the middle of $12.607 billion from the moderate upside scenario and $0.609 billion from the moderate downside scenario. The range of NPV based on the alternative economic scenarios is negative $9.559 billion to positive $15.820 billion. These two values from the Optimistic Upside Scenario and the Pessimistic Downside Scenario are two extreme scenarios that are highly unlikely to occur.

Exhibit IV-3 shows the breakdown of the estimated NPV by cohort year for each scenario.

Exhibit IV-3: Cash Flow NPV Summaries from Alternative Scenarios by Cohort ($ Millions)

Endorsement Fiscal Year	Baseline PEA	Alternative - 1 Optimistic Upside	Alternative 2 - Moderate Upside	Alternative 3 - Moderate Downside	Alternative 4 - Pessimistic Downside
2009	$ 187	$ 331	$ 281	$ 81	$ (133)
2010	$ 365	$ 478	$ 435	$ 286	$ 130
2011	$ 181	$ 298	$ 251	$ 107	$ (33)
2012	$ 152	$ 268	$ 218	$ 88	$ (25)
2013	$ 144	$ 314	$ 242	$ 48	$ (112)
2014	$ 380	$ 589	$ 542	$ 189	$ (154)
2015	$ 811	$ 1,235	$ 1,125	$ 463	$ (139)
2016	$ 1,168	$ 1,775	$ 1,578	$ 745	$ 33
2017	$ 1,078	$ 1,984	$ 1,641	$ 528	$ (368)
2018	$ 520	$ 990	$ 840	$ 167	$ (436)
2019	$ 351	$ 440	$ 464	$ 172	$ (170)
2020	$ 791	$ 1,468	$ 1,277	$ 259	$ (645)
2021	$ 683	$ 2,204	$ 1,630	$ (274)	$ (1,819)
2022	$ (483)	$ 2,458	$ 1,214	$ (2,106)	$ (4,579)
2023	$ 413	$ 989	$ 868	$ (145)	$ (1,111)

V. 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-E. The following briefly summarizes how we process the data and develop the component models in appendices.

Data Reconciliation (Appendix A)

To reconcile the data processed in this review with the data provided by FHA, we compare summaries of key data elements with the summaries provided by FHA. Most of the data processed matches the FHA data totals within 1%. The summaries for the IIF, number of active assignments and the number of claims to date are shown in Appendix A.

HECM Base Termination Model (Appendix B)

No repayment of principal is required on a HECM loan when the loan is active. Termination of a HECM loan typically occurs due to death, relocation, or voluntary termination via refinance or payoff. The termination model estimates the probabilities of three mutually exclusive HECM termination events: mobility, refinance, and mortality. Multinominal logit regression modeling is adopted to capture the competing-risk structure of the different termination events. This is consistent with literature, HECM experience, and the FHA Single Family forward mortgage actuarial review.

Following Szymanoski, DiVenti, and Chow (2000) and Yuen-Reed and Szymanoski (2007), and previous years' Actuarial Review of HECM loans, a competing risk logistic regression or logit model approach is used to estimate the probability of HECM loan termination events. We test the significance of parameters to achieve a parsimonious model that provides goodness-of-fit.

The multinominal logit approach has several benefits. First, logit models eliminate the likelihood of a negative probability for any estimated event. Second, the multinomial approach ensures the event probabilities sum to 100 percent. In other words, a HECM loan can experience only one of the four possible outcomes in any period: relocation, refinance, death, or survival. Third, it captures the zero-sum nature of the different termination events, whereby the increased probability of one risk decreases the probabilities of the other risks.

The termination model adopts four main categories of explanatory variables:

Fixed initial borrower characteristics: borrower age at origination and gender.

Fixed initial loan characteristics: expected mortgage interest rate, origination year and quarter, the first month cash draw percentage and the estimated ratio of property value to the local area's median home values at time of origination.

Dynamic variables based entirely on loan/borrower characteristics: mortgage age (i.e., policy year, mortality rate.)

Dynamic variables derived by combining loan characteristics with extraneous economic data: interest rates, house price indices (determines the cumulative house price growth), the amount of additional equity available to the borrower through refinancing, and the probability of negative equity.

For each termination event, a separate logit model is estimated based on economic indicators and loan level historical HECM data. The three logit models are then aggregated to estimate the overall termination probabilities for the HECM program, following the approach suggested in Begg and Gray (1984). The logit model for each termination event is unique, including only the variables that impact the occurrence of that event.

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 June 2023. Death dates were aligned with a one-year shift before and two-year shift after termination dates to determine which loans terminated due to death; this accounts for possible time lags between the dates of the recorded termination and the actual death.

Cash Draw-Down Model

For estimating future borrower expected cash draws, the HECM model captures each borrower's initial cash draw-down (cash draws within the first month of endorsement) as a proxy for future cash draw patterns. Since cash draw patterns can vary due to an individual borrower's need and payment plan, the entire HECM history (to date) is used to summarize actual borrower draw patterns based on the first month cash draw. The first-month cash draw percentage is divided into 10 buckets with equal width (in an increment of 10%), and the draw patterns by policy year are summarized for each of the ten (10) buckets. The ten-bucket methodology represents how HECM borrowers are drawing the HECM proceeds over policy years. Borrowers who draw a large percentage of their principal limit in their first year tend to draw less in future years. On the other hand, borrowers who draw a small percentage of their principal limit in their first year tend to draw more in future years. When the current UPB reaches the current principal limit, the borrower not on a scheduled payment plan is no longer eligible to draw cash, and cash draw down equal zero (0). The HECM program started to ramp up in 2004, so there is limited empirical data for actual borrow cash draws and payment plan changes in out years. To estimate borrower's future cash draws, in addition to the cash draw table, we assume when a borrower is past policy year 20 that all drawable equity is taken or drawn in policy year 20. For future analysis, we will include additional analysis to investigate different cash draw patterns.

Loan Performance Projections (Appendix C)

The multinominal logit termination model is fitted to the historical data from all endorsed HECM loans from FY 1990 to FY 2023 books-of-business and the historical economic experience through June 30, 2023. Loan-level historical experience obtained from FHA is used to align with key economic predictors of HECM terminations such as changes in house prices and interest rates. The PEA baseline estimates are used for the actuarial central estimate. The Federal Housing Finance Agency (FHFA) Metropolitan Statistical Area (MSA)-level house price appreciation rates and volatility parameters are used when available; otherwise, state-level FHFA data is used.

Using the estimated multinominal logit termination model, we forecast future termination rates for all the loans currently in force, based on all characteristics of the surviving portfolio and forecasts of economic variables. Actual data is used between the time of origination and FY 2023 and forecasted data is used beginning in FY 2024. For future house price appreciation, MSA level forecasts are used for house price appreciation with state level forecasts being used if the MSA level data is not available.

HECM Cash Flow Analysis (Appendix D)

The cash flow model estimates the HECM economic net worth for the FY 2009 to FY 2023 books of business. It projects the net present value of future cash flows for these books-of-business in the FHA insurance portfolio. For existing books-of-business, it estimates cash flows for all surviving loans at the time of this review.

The HECM cash flow model consists of four components: premiums, claims, note holding expenses, and recoveries on projected notes in inventory. Cash flows are discounted according to the cohort specific single effect rates (SERs) supplied by the FHA.

Stochastic Economic Scenarios (Appendix E)

The assumption of these future interest and house price growth rates are the fundamental economic factors that drive future termination rates and HECM loan. To forecast the economic net worths of the MMI HECM portfolio, we use the OMB economic assumptions released in September 2023 as the baseline economic scenario.

To illustrate the sensitivity of forecasts to economic uncertainty and other forms of forecast error, stochastic models are conducted to provide the range of the projected economic net worths due to the variations in the economic assumptions.

VI. Qualifications and Limitations

The estimates provided in this review are based on models that are constructed according to certain assumptions, forecasts, and theoretical frameworks. The two models are the econometric model and the cash flow model. In this section, we discuss the limitations and potential constraints of the model estimates.

The econometric model relates the rates of loan termination to several parameters, including borrower characteristics, loan characteristics, and key macroeconomic variables such as house prices and interest rates. It captures the three major competing risks of loan terminations to date: mortality, mobility, and refinance. The impact of these parameters on loan terminations is calibrated using FHA's actual historical experience through a statistical optimization technique known as maximum likelihood estimation. Future termination estimates are determined based on the calibrated model using future loan portfolio characteristics and certain economic assumptions.

The cash flow model estimates the present value of all future cash flows for each book of business. The key inputs to the model are the estimated termination rates from the econometric model, loan characteristics, macroeconomic forecasts, and the cohort specific single effective rates (SERs). The cash flow model also draws on assumptions based on past FHA experience, including lenders' behavior regarding their option to assign as well as borrowers' behavior in drawing cash over the life of the loan.

A. Fundamental 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.

HECM has a relatively short program history. The pilot program began in 1989 and became permanent in 1998 after endorsing only 20,000 loans. The endorsements exceeded 10,000 loans per year in 2002 and reached 100,000 per year in 2007. Unlike the MMI Single Family forward mortgage program, HECM has a limited number of loans that have remained in FHA's portfolio for more than 16 years. The lack of long-run performance data potentially limits the robustness of the models' predictive capacity for later.

B. Model Sensitivity to Economic Projections

The financial estimates presented in this review require economic forecasts 75 years into the future. The economic forecasts, including house price appreciation and interest rate trends are from PEA.

The extent to which the realized experience differs from these model assumptions will affect how close our current estimates will be to the realized results in the future.

Due to the long-term nature of HECM cash flows, the estimates of economic net worth are very sensitive to future economic projection assumptions. Unlike the MMI Single Family forward mortgages, whose claim and recovery cash flows typically occur within the first seven years following loan origination, the majority of HECM cash flows occur in later policy years. Hence, the present value of HECM cash flows is particularly sensitive to long-term assumptions. As the interest rate environment changes, the uncertainty in the future economic environment will have a dramatic impact on the future cash flows.

C.   Changing Reverse Mortgage Market Landscape

Regulatory updates, evolving demographics, economic conditions, and consumer preferences, unclear interest rate and house market will contribute to the changing landscape of the HECM market. Changes in financial markets, retirement needs, and long-term care needs will affect borrowers' participation in the HECM program, how they use HECM loans, and the innovation in product design. This will affect the loan termination and performance of current loans.

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. LESA, announced in 2015, introduced additional guidelines and assumptions for handling T&I defaults. In 2017, the MIP structure was simplified to have an annual MIP rate of 1.25 percent regardless of the amount of the mortgagor's initial draw at loan closing.

Lastly, Congress has constantly increased the loan limit every year since 2018, and the current loan limit has been raised to $1,089,300 in 2023. The continuation of the higher loan limit might attract current borrowers to refinance their current HECM to get access to home equity. As a result, the actual loan termination rates might be different from the estimate presented in this review.

Acknowledgement

References

1. Begg, C. B. and Gray, R. (1984). Calculation Of Polychotomous Logistic Regression Parameters Using Individualized Regressions. *Biometrika* (71)

2. Bera, A. K., and Higgins, M. L. (1993). ARCH Models: Properties, Estimation and Testing, *Journal of Economic Surveys,* 7, 305-366.Bollerslev, T. (1986).

3. Generalized Autoregressive Conditional Heteroskedasticity, *Journal of Econometrics*, 31, 307-327.

4. Mortality Tables for Determining Present Value Under Defined Benefit Pension Plans, A Proposed Rule by the Internal Revenue Service on 04/28/2022, available at https://www.soa.org/globalassets/assets/files/resources/experience-studies/2019/pri-2012-mortality-tables-report.pdf.

5. Nugroho, D. B., Priyono, A., & Susanto, B. (2021). Skew normal and skew student-t distributions on GARCH (1, 1) model. *Media Statistika*, 14(1), 21-32.

6. Glasserman, P. (2004), *Monte Carlo Methods in Financial Engineering*, Springer.

7. FHA Actuarial Review of the Mutual Mortgage Insurance Fund, available at https://www.hud.gov/program_offices/housing/rmra/oe/rpts/actr/actrmenu

8. HECM Homepage, available at https://www.hud.gov/program_offices/housing/sfh/hecm/hecmhome

9. Mortgagee Letters, available at https://www.hud.gov/program_offices/administration/hudclips/letters/mortgagee

10. Mayer, C., & Moulton, S. (2022). The market for reverse mortgages among older Americans. *New Models for Managing Longevity Risk: Public-Private Partnerships*, 258-300.

11. Selecting and Documenting Mortality Assumptions for Pensions American Academy of Actuaries Pension Committee, available at https://www.actuary.org/sites/default/files/files/Mortality_PN_060515_0.pdf

12. Summary of the ARRC's Fallback Recommendations October 6, 2021, available at https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2021/spread-adjustments-narrative-oct-6-2021

13. TITLE II of the Cranston-Gonzalez National Affordable Housing Act, available at https://www.hud.gov/sites/documents/19576_HOMELAWS.PDF

14. Zivot, E. (2009). Practical issues in the analysis of univariate GARCH models. In Handbook of financial time series (pp. 113-155). Berlin, Heidelberg: Springer Berlin Heidelberg.

Appendix A. HECM Data Reconciliation

Data reconciliation is a very important step to ensure the accuracy of the model and the estimation results. To reconcile the data processed with the data provided by FHA, we compared summaries of key data elements with the summaries provided by FHA. The number of active loans, summaries for the IIF (based on UPB), number of active assignments, and the number of claims to date are shown in the following tables. Most of the data processed matches the FHA data totals, with differences centered on early years. The exceptions are the number of claims to date for the 2009 and 2010 cohorts. The reconciliation tables are based on data as of October 19, 2023.

Exhibit A-1: Data Reconciliation for Number of Active Loans

Credit Subsidy Cohort	Federal Housing Administration	Data Reconciliation: Independent Actuary	Difference (Actuary - FHA)	Percent Difference (Actuary - FHA) / FHA
2009	37,598	38,678	1,080	3%
2010	28,553	29,890	1,337	5%
2011	28,239	29,335	1,096	4%
2012	22,490	23,200	710	3%
2013	25,978	26,565	587	2%
2014	19,850	19,892	42	0%
2015	23,711	23,723	12	0%
2016	21,259	21,270	11	0%
2017	26,267	26,271	4	0%
2018	22,774	22,774	-	0%
2019	14,924	14,924	-	0%
2020	24,240	24,242	2	0%
2021	37,343	37,344	1	0%
2022	60,632	60,632	-	0%
2023	32,420	32,420	-	0%
Total	426,278	431,160	4,882	1%

Exhibit A-2: Data Reconciliation for Insurance-in-Force (based on UPB) (million)

Credit Subsidy Cohort	Federal Housing Administration	Independent Actuary	Difference (Actuary - FHA)	Percent Difference (Actuary - FHA) / FHA
2009	$3,000	$3,000	0	0%
2010	$1,847	$1,850	3	0%
2011	$1,637	$1,638	0	0%
2012	$1,191	$1,193	2	0%
2013	$1,482	$1,482	0	0%
2014	$2,829	$2,829	0	0%
2015	$4,311	$4,307	(4)	0%
2016	$4,142	$4,068	(74)	-2%
2017	$5,367	$5,268	(98)	-2%
2018	$4,195	$4,121	(75)	-2%
2019	$2,389	$2,349	(40)	-2%
2020	$4,746	$4,695	(51)	-1%
2021	$8,631	$8,577	(53)	-1%
2022	$14,915	$14,857	(57)	0%
2023	$5,211	$5,196	(15)	0%
Total	**$65,893**	**$65,432**	**(462)**	**-1%**

Exhibit A-3: Data Reconciliation for Number of Active Assignments

Credit Subsidy Cohort	Federal Housing Administration	Independent Actuary	Difference (Actuary - FHA)	Percent Difference (Actuary - FHA) / FHA
2009	26,373	27,450	1,077	4%
2010	22,233	23,552	1,319	6%
2011	21,978	23,072	1,094	5%
2012	17,963	18,663	700	4%
2013	19,843	20,428	585	3%
2014	5,473	5,513	40	1%
2015	2,429	2,441	12	0%
2016	1,471	1,477	6	0%
2017	946	949	3	0%
2018	132	132	-	0%
2019	-	-	-	0%
2020	-	-	-	0%
2021	1	1	-	0%
2022	-	-	-	0%
2023	-	-	-	0%
Total	26,373	27,450	1,077	4%

Exhibit A-4: Data Reconciliation for Claims to Date

Credit Subsidy Cohort	Federal Housing Administration	Independent Actuary	Difference (Actuary - FHA)	Percent Difference (Actuary - FHA) / FHA
2009	65,098	65,098	-	0%
2010	48,238	48,238	-	0%
2011	41,634	41,634	-	0%
2012	30,988	30,988	-	0%
2013	31,199	31,199	-	0%
2014	8,189	8,189	-	0%
2015	4,301	4,301	-	0%
2016	2,444	2,443	(1)	0%
2017	1,495	1,495	-	0%
2018	271	271	-	0%
2019	17	17	-	0%
2020	4	4	-	0%
2021	10	10	-	0%
2022	2	2	-	0%
2023	-	-	-	0%
Total	233,890	233,889	(1)	0%

Appendix B. HECM Base Termination Model

This appendix describes the base termination model used to estimate the historical and future performance of HECM loans. Each loan can terminate for one of three reasons: mobility, refinance, and mortality. A multinomial logit model was created for these competing risks. Each type of termination is modeled by a separate logit model. The probability of termination from each model was then aggregated to estimate the probability a particular loan would terminate in any policy year.

The base termination model is estimated based on all the historical HECM termination and survivorship data, which includes HECM mortgages that were endorsed under the General Insurance (GI) Fund between Fiscal Years 1990 and 2008, and mortgages endorsed under the MMI from Fiscal Year 2009 through September 30, 2023. The change from the GI fund to MMI fund has been a transparent process to the lenders and borrowers and we assume it has no impact on loan termination behavior.

B1. The Multinomial Logistic Model

Begg and Gray (1984) showed that it is statistically equivalent to model a multinomial logit regression model as an aggregation of individually estimated binomial logit regression models. Specifically, the parameters are first determined in individual multinomial logit regression model per risk. The models are then aggregated to estimate the total likelihood of termination. This methodology requires that all risk outcomes are compared to each other in separate logit models. For HECM termination modeling, this means that active loans are compared to mobility terminations, refinance terminations, and mortality terminations to create three individual model specifications. These risks are then combined to create a single competing risk model. This approach allowed us to effectively account for the censoring effect of one termination outcome on the other two potential outcomes. For example, when a loan was terminated due to a relocation, we can account for its censoring effect of the other two termination outcomes, which are refinance and death.

Each individual termination model specification estimates the conditional probability that a loan will terminate due to one of three reasons: mortality ($P_D(t)$), refinance ($P_R(t)$), and mobility (($P_M(t)$). The mathematical expressions that correspond to each of these three risks are given by:

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

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

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

The constant terms α_D, α_R, and α_M as well as the coefficient vectors β_D, β_R, and β_M are the unknown parameters that are estimated by the multinomial logit model. The subscripts "D", "R" and "M" denote mortality, refinance, and mobility, respectively. The vectors of dependent variables for predicting the conditional probability of termination due to mortality, refinance, and mobility are represented by $X_D(t)$, $X_R(t)$ and $X_M(t)$, respectively. There are several economic, loan, and borrower characteristics used in each vector to predict HECM terminations. Some of these components are held constant over the life of the loan while others may vary over time *(t)*.

To classify historic terminations between the three possible outcomes, we first identified the terminations that resulted in refinances based on FHA's endorsement records. The remaining terminations are cross referenced with the Social Security Administration's mortality data provided by FHA. If a loan terminated within one year prior and two years after the borrower's recorded death date, the loan is considered to terminate due to death. The remaining terminations are considered as mobility terminations.

B1.1. Death Termination Model

The death termination 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 and co-borrowers. We obtained the most updated mortality data up to June 2023 from the Social Security Administration data provided by FHA to determine the date of death for HECM borrowers. Death dates were aligned with termination dates to determine which loans terminated due to death.

In contrast to the mobility and refinance model, the mortality model does not include economic or loan characteristics. The three major factors in forecasting death terminations are mortality rates, gender, and policy year. Among these three independent variables, the mortality rate plays a role as the base mortality.

The *GenderSpecificMortality* variable is used as the base mortality. It is based on the Pri-2012 Life Table, the most recent available gender-specific private retirement plan mortality tables published in 2019. IRS in government publication Federal Register suggest the usage of Pri-2012 Life Table for defined benefit pension plans. HECM borrowers' mortality is lower than the general population and HECM loan is close to products of post-retirement benefit.

Since Pri-2012 mortality table has base year of 2012, so we use the most recently released mortality improvement scale table published by SOA to project it to FY 2023 to consider mortality improvement and longevity risk. This application follows Actuarial Standard of Practice (ASOP)

No. 35. The projected mortality rates in 2023 are lower than the Decennial Life Table 1999-2001 used in previous annual review reports.

Gender and age specific mortality rate in the projected mortality table for a single borrower is used. In the case of a couple, the gender and age specific mortality rate for the younger borrower or non-borrowing spouse is used as a base mortality rate for simplicity.

The last survivor mortality rate for a couple is slightly lower in early policy years and higher in later years than the younger borrower's mortality. Two additional variables specific to couples are included to capture the unique characteristics for loans with more than one borrower. The dummy variable *Gender(Couples)* and the interaction term $Couple_{Dummy}$ x $GenderSpecificMortality$ are designed to account for this experience.

Prior HECM experience also indicates that the likelihood of death terminations increases with policy year while the death termination in the first policy year is suppressed. The time dependent variable *PolicyYear* and the dummy variable $1stYear_{Dummy}$ are in place to capture this experience. The variable *PolicyYear* has a value equal to the number of years the loan has been active. These two independent variables can capture the possible anti-selection effect and the discrepancy between last survivor mortality rate and the younger borrower or non-borrower spouse's mortality rate that we use as the base mortality rate for a couple. HECM loans have been endorsed over the past 33 years, but most of the loans were endorsed in the last 19 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 19.

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 effect.

B1.2. Refinance Model

Prior HECM experience shows that most refinances occur after the first few years of the loan. The variable *PolicyYear* is designed to account for this experience. The series of piece-wise linear spline functions for loan age are defined as follows.

B1.2.1. Loan Age Variables for the Refinance Model

Prior HECM experience shows that most refinances occur after the first few years of the loan. The variables *PolicyYear*, $1stYear_{Dummy}$, $2ndYear_{Dummy}$, and $3rdYear_{Dummy}$ are designed to account for this experience. The series of piece-wise linear spline functions for loan age are defined as follows.

$$Pol\_yr1 = \begin{cases} Loan\ age, & if\ Loan\ age\ \leq K_1 \\ K_1, & if\ Loan\ age\ > K_1 \end{cases},$$

$$Pol\_yr2 = \begin{cases} 0, & if\ Loan\ age\ \leq K_1 \\ Loan\ age\ - K_1, & if\ K_1 < Loan\ age\ \leq K_2, \\ K_2 - K_1, & if\ Loan\ age\ > K_2 \end{cases}$$

$$Pol\_yr3 = \begin{cases} 0, & if\ Loan\ age\ \leq K_2 \\ Loan\ age\ - K_2, & if\ K_2 < Loan\ age\ \leq K_3, \\ K_3 - K_2, & if\ Loan\ age\ > K_3 \end{cases}$$

$$Pol\_yr4 = \begin{cases} 0, & if\ Loan\ age\ \leq K_3 \\ Loan\ age\ - K_3, & if\ K_3 < Loan\ age\ \leq K_4, \\ K_4 - K_3, & if\ Loan\ age\ > K_4 \end{cases}$$

$$Pol\_yr4 = \begin{cases} 0, & if\ Loan\ age\ \leq K_4 \\ Loan\ age\ - K_4, & if\ Loan\ age\ > K_4 \end{cases},$$

where $K_1 = 3$, $K_2 = 7$, $K_3 = 11$, and $K_4 = 14$

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:

$$PolicyYear = \beta_1 \times Pol\_yr1 + \beta_2 \times Pol\_yr2 + \beta_3 \times Pol\_yr3 + \beta_4 \times Pol\_yr4$$

B1.2.2. Borrower-Related Variables for the Refinance Model

The variables *OriginationAge* and Gender are the two borrower characteristics in the refinance model. *OriginationAge* is the borrower's age at endorsement and is held constant for the life of the loan, because historical experience suggests that older borrowers are less likely to refinance. We use the following piece-wise linear spline functions for piece-wise linear spline functions *OriginationAge*.

$$Orig\_Age_1 = \begin{cases} 0, & if\ OriginationAge\ \leq 64 \\ OriginationAge\ - 64, & if\ 64 < OriginationAge\ \leq 71, \\ 71 - 64, & if\ OriginationAge\ > 71 \end{cases}$$

$$Orig\_Age_2 = \begin{cases} 0, & if\ OriginationAge\ \leq 71 \\ OriginationAge\ - 71, & if\ 71 < OriginationAge\ \leq 87, \\ 87 - 71, & if\ OriginationAge\ > 87 \end{cases}$$

$$Orig\_Age_3 = \begin{cases} 0, & if\ OriginationAge\ \leq 87 \\ OriginationAge\ - 87, & if\ OriginationAge\ > 87 \end{cases}$$

Similarly, borrowers with different genders also refinance at differing rates. Gender is a categorical variable with possible values of female, male, and couple, with female as the baseline. Historical experience suggests that couples are less likely to refinance than females, and males are more likely to refinance than females.

Current loan to value $CLTV$ is also affects refinance decision. The following spline functions are used.

$$CLTV_1 = \begin{cases} CLTV, & if\ CLTV\ \leq 0.5 \\ 0.5\ , & if\ CLTV\ > 0.5 \end{cases},$$

$$CLTV_2 = \begin{cases} 0 & , & if\ CLTV\ \leq 0.5 \\ CLTV\ - 0.5\ , & if\ 0.5 < CLTV\ \leq 0.8, \\ 0.3 & , & if\ CLTV\ > 0.8 \end{cases}$$

$$CLTV_3 = \begin{cases} 0 & , & if\ CLTV\ \leq 0.8 \\ CLTV - 0.8\ , & if\ CLTV\ > 0.8 \end{cases}$$

The likelihood of refinances is also driven by the cash draw pattern of the borrower. We found that the first-month cash draw ($1^{st}\ month\ cash\ draw$) is a representative indicator of the likelihood of future refinances. Borrowers who draw large amounts of cash initially are more likely to refinance than borrowers who do not.

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 chooses 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.

B1.2.3. Economic Variables for the Refinance Model

To further explain the behavior of HECM borrowers' willingness and ability to refinance a loan, the refinance incentive measure was created. The refinance incentive measure represents the net increase in principal limit for a borrower given the costs associated with refinancing. Equation 5 depicts the refinance incentive measure calculation.

$$rft_t = MAX \left[\frac{\min(MCA_0 * \Delta H, LoanLimit_t) * PFL_t - C - PL_t}{C}, 0 \right]$$

Where MCA_0 = Original maximum claim amount for loan at time 0

$\Delta H = \frac{HPI_t}{HPI_O}$, if HPI is the FHFA house price index per MSA (or state if loans are 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

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

B1.3. Mobility Model

The mobility model was constructed to estimate the probability that a HECM loan terminates due to the borrower moving out and paying off the loan. Factors such as borrower characteristics, economic factors, and loan specific variables were examined to define the final model specification.

Loan Age Variables for the Mobility Model

Historical experience of mobility terminations shows the likelihood of a HECM borrower paying off their loan due to mobility. The $FirstYear_{Dummy}$ variable has a value of 1 if it is the first year of the loan and 0 for all other years of the loan. This variable was included in the model to reflect the limited number of loans terminating in the first policy year.

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.

Historical experience then shows that mobility begins to taper off starting in the tenth year. To model this experience, a duration variable for policy years greater than nine was used. The specification of the duration variable is shown in *Equation 6*.

$$Duration \ (year \ 9+) \begin{cases} 0, & if \ PolicyYear \leq 9 \\ PolicyYear - 9 & if \ PolicyYear > 9 \end{cases}$$

Borrower-Related Variables for the Mobility Model

Borrower specific characteristics are also key drivers of move-out likelihood. Historical experience suggests that gender-specific mortality rates and gender are two major determining factors.

The *Mortality* variable is used to capture 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.

The *Gender* categorical variable includes values of female, male, and couple. Female is used as the baseline since the majority of HECM borrowers are females. Results show that couples are less likely to move-out and males are more likely to move-out.

A loan-type dummy variable Term HECM is included. 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.

Economic Variables for the Mobility Model

Historical experience suggests that faster house price appreciation increases the likelihood of relocation. Moreover, move-out is more likely when the one-year Treasury rate increases, which accelerates the rate of loan balance growth. Quarterly house price appreciation data is from Moody's Analytics (Moody) house price Index (HPI) based on the MSA (or state if the loan is located outside of an MSA). Historical data on interest rates is obtained from Moody. The *CumulativeHPA* variable captures the expected resale value of the home. The *ChangeOneYearCMT* variable reflects the changes in the speed of interest accruals, which acts as a trigger event related to the perception of product cost.

The *HomeValueVsAreaMedian* variable, which estimates the ratio of appraised property value at origination to median value in the local area, is added to this year's review. The local median house price data is attained from Moody at the MSA and state level, with the most granular level available being used for each property. This variable intends to capture the implicit differences in relocation behavior of borrowers whose homes have higher relative values than that of borrowers whose homes have lower relative values.

The distributions of individual home values are estimated based on the house price drift and volatility parameters based on FHFA House Price Indexes (HPIs). The parameters α and β represent the variability of home values within a geographical area, which are specific to MSA and state. The parameter c represents the variability of home values over time, which is also specific to MSA and state. These parameter values are provided by FHA.

B1.4. Combining the Three Risks

The joint termination hazard rate can be defined as

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

Where $P_j(t)$ is defined in Equations 1, 2, and 3.

The majority of HECM loans have been endorsed in the past five years, so there are a limited number of loans that have remained in FHA's portfolio for a significant amount of time. As a result, the accuracy of the competing risk logit model to predict terminations for later policy years is limited. Experience with elderly homeowners has shown that as the borrower ages, the likelihood of voluntary move-outs (mobility) and refinances decrease and hence mortality would dominate the risk of termination. Therefore, to mitigate the risk of limited long-term surviving loans on model accuracy, the termination model integrates the hazard rate from Equation 11 with the borrower's mortality rate.

$$h_i(t) = \begin{cases} P(t), & if \ PolicyYeart \leq 0.10 \\ MAX\{P(t), m_i(t)\}, & if \ Pr\{nedEuity\} > 0.10 \end{cases}$$

The result of $h_i(t)$ is the conditional probability that a HECM loan will terminate due to one of the three competing risks. These probabilities are calculated at the loan level so that each loan has a conditional probability of termination to estimate the future cash flows. Appendix B discusses the technical approach to estimating future terminations at the cohort and policy year level.

B2. Model Estimation Results

Exhibits B-1, B-2, and B-3 present the coefficient estimates for the parameters and the goodness-of-fit statistics for the binomial logistic regression models.

Exhibit B-1: Refinance Termination Model Estimation

Analysis of Maximum Likelihood Estimates					
Description	Parameter	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	Intercept	-6.436	0.0204	99676.3475	<.0001
Policy Year	Pol_yr_r1	0.8873	0.00542	26789.6261	<.0001
	Pol_yr_r2	-0.2363	0.00236	9996.9623	<.0001
	Pol_yr_r3	-0.2174	0.00381	3250.4446	<.0001
	Pol_yr_r4	0.1197	0.00709	285.0991	<.0001
	Pol_yr_r5	0.2071	0.007	875.2971	<.0001

Description	Parameter	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
1-Year HPI Change	Marginal_HPI_Change	2.3891	0.0363	4320.5627	<.0001
Borrower's Gender	Gender_Couple	-0.1911	0.00704	736.7675	<.0001
	Gender_Female	-0.1167	0.00722	261.2433	<.0001
Cash Drawdown Percentage	cdd_bucket	0.619	0.00639	9378.5937	<.0001
Line of Credit	LOC_Loan	0.1318	0.00871	229.1569	<.0001
Current LTV	CLTVR1	1.3568	0.0282	2316.1974	<.0001
	CLTVR2	-8.0075	0.0426	35402.3277	<.0001
	CLTVR3	-3.4959	0.1499	543.6701	<.0001
Home Value Above Area Median	hp_above_med	-0.0358	0.00523	46.8696	<.0001
Age at Loan Origination	Orig_Age2	0.0299	0.00111	732.1341	<.0001
	Orig_Age3	0.013	0.00077	284.0518	<.0001
	Orig_Age4	0.02	0.00455	19.3277	<.0001
Refinance Incentives	RFI_1	0.0159	0.000663	578.3651	<.0001
	RFI_2	0.1814	0.0018	10201.6626	<.0001

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	78.5	Somers' D	0.592
Percent Discordant	19.2	Gamma	0.606
Percent Tied	2.3	Tau-a	0.022
Pairs	1378993600000	C	0.796

Exhibit B-2: Death Termination Model Estimation

Analysis of Maximum Likelihood Estimates					
Description	Parameter	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
	Intercept	-6.6219	0.0292	51456.926	<.0001
Policy Year	Pol_yr_d1	1.5302	0.0152	10113.2791	<.0001
	Pol_yr_d2	-0.021	0.00295	50.4411	<.0001
	Pol_yr_d3	-0.00739	0.00166	19.7435	<.0001
	Pol_yr_d4	0.0224	0.00405	30.6821	<.0001
	Pol_yr_d5	0.0152	0.00444	11.693	0.0006
1st Month Cash Draw	FM_pct_cashdd	-0.7611	0.00763	9962.1897	<.0001

Term Product with Line of Credit	TermLOC_Loan	0.1887	0.00991	362.2604	<.0001
Borrower Couple	gender_couple	-0.8673	0.00605	20517.962	<.0001
Transformed Mortality Rates	mortality_rate_speci	7.7886	0.0288	73006.6386	<.0001

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	75.4	Somers' D	0.541
Percent Discordant	21.2	Gamma	0.561
Percent Tied	3.4	Tau-a	0.021
Pairs	1491377700000	c	0.771

Exhibit B-3: Mobility Termination Model Estimation

Analysis of Maximum Likelihood Estimates					
Description	**Parameter**	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > ChiSq**
	Intercept	-9.9563	0.0464	46084.6336	<.0001
Policy Year	Pol_yr_nr1	1.5936	0.0124	16532.1712	<.0001
	Pol_yr_nr2	0.1002	0.000835	14391.3237	<.0001
	Pol_yr_nr3	-0.0564	0.00204	761.0775	<.0001
	Pol_yr_nr4	0.1498	0.00721	431.1587	<.0001
Age at Origination	Orig_Age	0.0463	0.000541	7324.0705	<.0001
Term Loan	Term_Loan	0.1702	0.0176	93.0553	<.0001
Borrower Gender	Gender_Couple	-0.0308	0.00565	29.7534	<.0001
	Gender_Female	-0.0398	0.00569	48.9292	<.0001
1-Year HPI Change	Marginal_HPI_Change	1.9574	0.0266	5396.5345	<.0001
Transformed Mortality	mortality_rate_speci	0.788	0.0571	190.46	<.0001
One Year CMT rate	OneYrCmt_bucket1	-0.1771	0.00866	418.3754	<.0001
	OneYrCmt_bucket3	-0.0346	0.0086	16.1749	<.0001
Current LTV	CLTVNR1	-0.9559	0.0217	1933.7169	<.0001
	CLTVNR2	-1.215	0.0153	6315.7	<.0001
	CLTVNR3	0.0187	0.00545	11.7576	0.0006
First Month Cash Draw Percentage	FM_pct_cashdd	0.3333	0.00793	1769.0221	<.0001
Appraised Value to Area Median House Price at Origination	hp_above_med	0.0573	0.00391	215.414	<.0001

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	68.3	Somers' D	0.39
Percent Discordant	29.3	Gamma	0.4
Percent Tied	2.5	Tau-a	0.025
Pairs	2522401100000	c	0.695

B3. Model Validation

We did in-sample estimate to verify the model using data from 2009-2023. We use the life table estimation to obtain empirical conditional termination rate (conditional on surviving to the beginning of the policy year) and use the obtained parameters for the logit model to estimate the historical termination rates. The following plots compare the empirical termination rate from the life table test with the estimated termination rates from the model. The overall estimated termination rates are close to the empirical rates.

Model validation is required to comply with Actuarial Standards of Practice 23 (Data Quality) and 56 (Modeling). ASOP 23 applies when an actuary is selecting, using, or relying on data provided by others, all of which are relevant to our review of MMI Fund performance. ASOP 56 provides guidance on designing, developing, selecting, modifying, and using models when performing actuarial services. We employ models that are used for actuarial review of HECM since 2010. As such, the models we use are the culmination of a multi-year process of model design, development, and application that we feel contributes meaningfully to the current validation process. This ongoing process has also provided us with considerable experience with the data required for estimation and forecasting the performance of FHA single-family mortgages. Nevertheless, we are not simply relying on prior models and experience. We have undertaken an expansive and fresh look at data and model development to support the FY 2023 review.

The primary data source for our analysis is the FHA Single-Family Data Warehouse (SFDW). We consider that the SFDW is compliant with ASOP 23 with regard to the appropriateness, availability of current information, internal consistency of the data, and comprehensive coverage of current and past FHA mortgages. The data are well documented by the SFDW Meta Data workbook that ITDC requested from HUD to better understand the available data. The SFDW is an appropriate and sufficient source of FHA loan data, including detailed information on over 60 million single-family mortgages.

ASOP 23 instructs us to consider known data limitations. Historically, data limitations specifically impacting HECM loan performance model development efforts include: (1) missing borrower gender; (2) not enough data for long-age loans; and (3) missing underwriting information on HECM refinance. We code missing gender as missing in the coding so that this issue must still be

addressed in modeling. The second issues will have faded as concerns over time, and we use the loan's first 15 policy years' information to calibrate the model for this review.

The primary ASOP 56 requirement for model output validation is that the model output reasonably represents that which is being modeled, which in our case is loan termination probabilities. The validation should include testing the model output against observed historical results and evaluating whether the model output applied to hold-out data is reasonably consistent with model output developed without using the hold-out data. ASOP 56 also raises the issue of potential model over-fitting, defined as a situation where the model fits the data used to develop the model so closely that prediction accuracy materially decreases when the model is applied to different data. For example, over-fitting may occur when an excessively flexible function form is applied to a relatively small number of data points, such that the model explains those data almost perfectly, while failing to conform to other data from the same process. The voluminous data available from the SFDW essentially eliminates any possibility of over-fitting, even for models with large numbers of explanatory variables.

The models used in this review are the standard models used in HECM termination analysis. For this reason, our focus is the goodness-of-fit, that is, whether our model outputs, which are estimated loan termination transition probability functions, can reasonably represent observed average loan transition frequencies. We use a series of in-sample comparisons based on all the loans with policy years less than or equal to 15 and demonstrate estimated loan termination probabilities and empirical loan termination probabilities from the same data.

We include the results of our comparisons for each termination type and the overall termination probabilities. The model fits indicated by these comparisons appear quite good, with little deviation in mobility termination around policy year 11. Since mobility termination is more vulnerable to borrowers' personal information and therefore more challenging to be fully explained by available variables. We thereby confirm that the model outputs reasonably represent what was being modeled as required by ASOP 56.

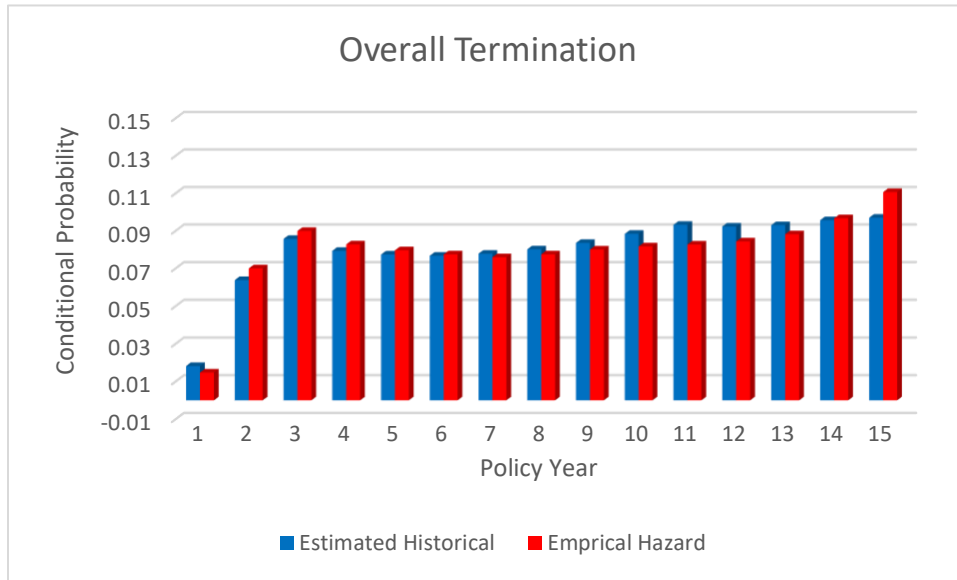Exhibit B-4: Termination Model Validation – Hazard Rate comparison for loans up to 15 years

Exhibit B-5: Refinance Termination Model Validation – Hazard Rate comparison for loans up to 15 years
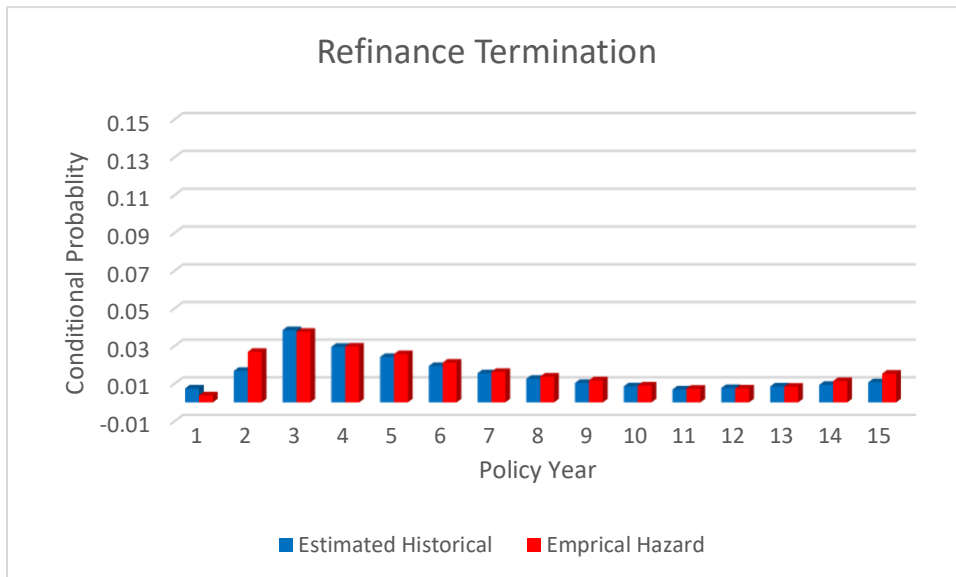
Exhibit B-6: Death Termination Model Validation – Hazard Rate comparison for loans up to 15 years
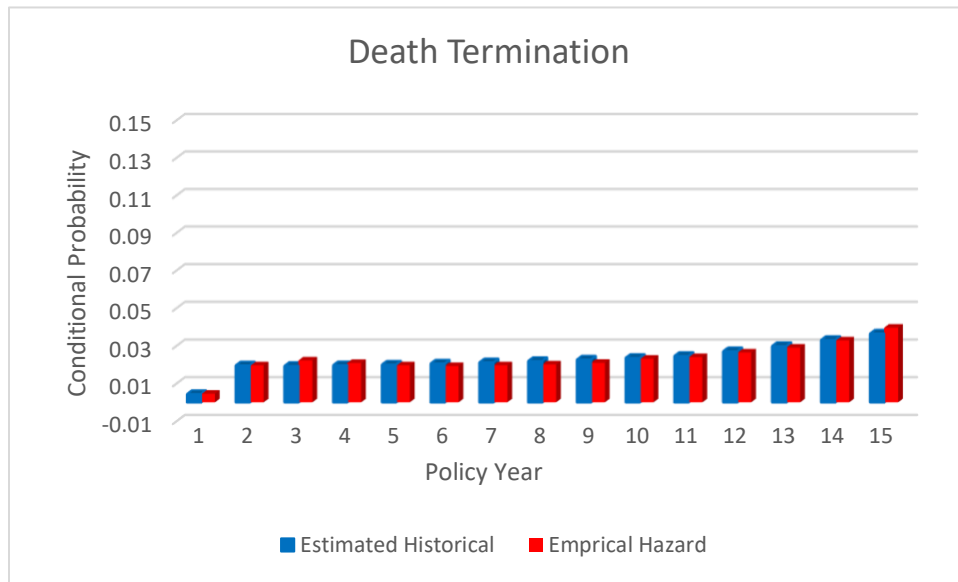
Exhibit B-7: Mobility Termination Model Validation – Hazard Rate comparison for loans up to 15 years
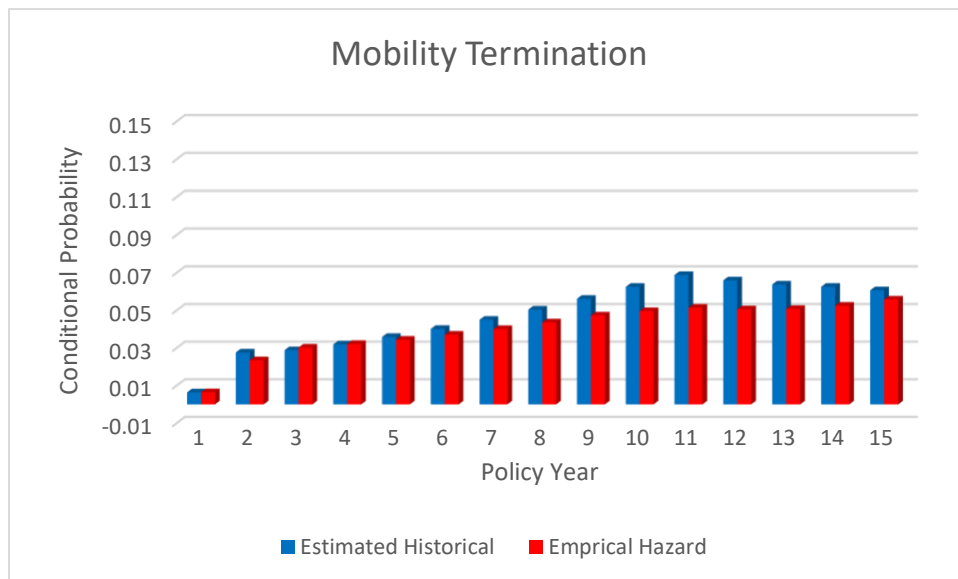
B4. Base Termination Model Implementation

Representing the combined hazard rate, Exhibit B-8 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 B-8 numbers above the shaded numbers are historically observed termination rates; the FY 2023 termination year (shaded) was estimated based on partial year actual data.

Exhibit B-8. HECM Termination Rates Conditional on Surviving to the Beginning of the Policy Year
Placeholder

Policy Year	Endorsement Fiscal Year														
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	2.09%	1.11%	1.06%	1.08%	1.29%	1.33%	1.92%	1.39%	1.30%	1.41%	1.29%	1.02%	1.65%	1.40%	7.20%
2	3.55%	4.05%	3.48%	4.95%	4.76%	9.59%	6.42%	7.04%	5.40%	5.81%	10.82%	16.50%	17.74%	8.10%	9.80%
3	3.28%	3.66%	5.28%	6.06%	7.08%	9.49%	12.13%	10.17%	7.31%	13.74%	26.00%	27.38%	8.30%	7.30%	9.20%
4	3.02%	4.61%	5.32%	6.98%	7.10%	9.91%	10.02%	8.29%	10.37%	21.56%	23.37%	8.60%	7.60%	7.00%	8.90%
5	4.06%	4.63%	6.48%	7.06%	7.82%	9.38%	8.47%	9.99%	18.54%	21.24%	8.80%	8.10%	7.40%	7.10%	8.80%
6	4.26%	6.57%	6.91%	7.54%	7.55%	8.02%	9.21%	15.94%	20.20%	8.40%	8.50%	8.00%	7.70%	7.30%	8.50%
7	6.80%	6.72%	7.46%	7.24%	6.55%	8.29%	12.73%	17.72%	7.90%	8.00%	8.60%	8.50%	7.90%	7.30%	8.40%
8	6.56%	7.38%	7.39%	6.56%	6.33%	11.65%	15.15%	7.90%	7.70%	8.20%	9.20%	8.80%	7.90%	7.40%	8.50%
9	7.40%	6.89%	6.56%	5.82%	8.43%	14.00%	7.90%	7.80%	7.90%	8.70%	9.70%	8.90%	8.10%	7.70%	8.70%
10	7.38%	6.54%	6.36%	7.68%	10.03%	8.20%	7.80%	8.10%	8.60%	9.40%	9.80%	9.10%	8.40%	8.00%	9.00%
11	7.10%	6.01%	7.27%	8.55%	7.30%	7.80%	7.80%	8.40%	8.60%	9.00%	9.60%	8.90%	8.20%	7.80%	8.80%
12	6.54%	6.78%	8.54%	7.50%	7.00%	7.90%	8.20%	8.50%	8.30%	8.80%	9.40%	8.60%	7.90%	7.70%	8.70%
13	7.70%	8.27%	7.70%	7.10%	7.00%	8.20%	8.30%	8.20%	8.10%	8.60%	9.30%	8.50%	7.80%	7.60%	8.60%
14	9.84%	7.80%	7.50%	7.20%	7.50%	8.60%	8.20%	8.10%	8.00%	8.60%	9.30%	8.40%	7.90%	7.60%	8.50%
15	8.40%	7.40%	7.70%	7.70%	7.60%	8.50%	8.10%	8.10%	8.00%	8.60%	9.50%	8.50%	7.90%	7.60%	8.60%
16	8.90%	8.20%	8.90%	8.60%	8.20%	9.30%	8.90%	8.80%	8.70%	9.50%	10.70%	9.40%	8.70%	8.40%	9.40%
17	9.8%	9.3%	9.9%	9.2%	8.9%	10.1%	9.7%	9.6%	9.5%	10.6%	11.9%	10.4%	9.6%	9.3%	10.3%
18	11.3%	10.4%	10.6%	9.9%	9.6%	11.0%	10.5%	10.5%	10.6%	11.7%	13.2%	11.5%	10.6%	10.3%	11.2%
19	12.6%	11.1%	11.4%	10.7%	10.4%	11.9%	11.5%	11.6%	11.6%	12.9%	14.7%	12.7%	11.6%	11.3%	12.3%
20	13.5%	11.9%	12.3%	11.6%	11.3%	12.9%	12.7%	12.7%	12.7%	14.1%	16.3%	14.0%	12.8%	12.4%	13.4%
21	14.5%	12.9%	13.3%	12.5%	12.4%	14.3%	13.8%	13.9%	13.8%	15.5%	18.0%	15.3%	14.0%	13.7%	14.7%
22	15.7%	13.9%	14.3%	13.7%	13.7%	15.5%	15.1%	15.1%	15.1%	16.9%	19.8%	16.8%	15.4%	15.0%	16.0%
23	16.9%	15.1%	15.6%	15.1%	15.0%	16.9%	16.4%	16.5%	16.5%	18.5%	21.8%	18.3%	16.8%	16.4%	17.4%
24	18.2%	16.4%	17.1%	16.5%	16.4%	18.3%	17.8%	17.9%	17.9%	20.0%	23.8%	20.0%	18.4%	18.0%	18.8%
25	19.8%	18.1%	18.7%	18.0%	17.9%	19.8%	19.2%	19.4%	19.4%	21.7%	25.8%	21.7%	20.0%	19.6%	20.4%
26	21.6%	19.8%	20.3%	19.7%	19.6%	21.4%	20.8%	21.0%	21.1%	23.3%	28.0%	23.5%	21.8%	21.4%	22.2%
27	23.5%	21.6%	22.2%	21.5%	21.5%	23.0%	22.5%	22.7%	22.8%	25.0%	30.1%	25.3%	23.6%	23.3%	24.0%
28	25.5%	23.7%	24.2%	23.5%	23.5%	24.8%	24.2%	24.5%	24.6%	26.8%	32.2%	27.3%	25.6%	25.2%	26.0%
29	27.6%	25.9%	26.5%	25.8%	25.8%	26.8%	26.1%	26.4%	26.5%	28.6%	34.3%	29.3%	27.6%	27.3%	28.0%
30	29.9%	28.4%	28.9%	28.2%	28.2%	28.9%	28.2%	28.4%	28.6%	30.5%	36.4%	31.4%	29.8%	29.6%	30.3%
31	32.5%	31.0%	31.5%	30.8%	30.8%	31.1%	30.3%	30.6%	30.8%	32.5%	38.4%	33.5%	32.1%	31.9%	32.6%
32	35.2%	33.9%	34.3%	33.6%	33.6%	33.4%	32.7%	32.9%	33.2%	34.6%	40.5%	35.8%	34.4%	34.3%	35.1%
33	38.1%	37.0%	37.3%	36.5%	36.5%	35.9%	35.2%	35.4%	35.6%	36.8%	42.5%	38.2%	36.9%	36.9%	37.7%
34	41.2%	40.2%	40.3%	39.6%	39.5%	38.4%	37.7%	37.9%	38.2%	39.1%	44.6%	40.5%	39.5%	39.5%	40.4%
35	48.7%	49.3%	43.7%	42.9%	42.7%	41.2%	40.5%	40.6%	41.1%	41.9%	47.2%	43.1%	42.3%	46.8%	60.8%
36	50.1%	50.1%	46.8%	46.0%	45.8%	43.3%	43.0%	43.2%	43.7%	44.1%	49.5%	45.6%	44.8%	47.4%	60.0%
37	52.3%	52.1%	49.8%	49.0%	48.7%	45.2%	45.6%	45.6%	46.3%	46.5%	51.8%	48.0%	47.3%	48.6%	58.6%
38	55.3%	55.0%	52.7%	51.8%	51.5%	46.6%	47.9%	48.0%	48.9%	48.8%	54.2%	50.3%	49.8%	50.3%	57.6%

Policy Year	Endorsement Fiscal Year														
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
39	58.5%	58.3%	55.2%	54.3%	53.8%	47.2%	50.0%	50.2%	51.3%	50.9%	56.3%	52.4%	52.0%	52.2%	57.5%
40	62.0%	61.7%	57.1%	56.2%	55.4%	47.0%	51.9%	52.0%	53.4%	52.8%	58.4%	54.1%	54.1%	54.0%	58.5%
41	65.5%	65.3%	57.8%	57.3%	56.1%	46.0%	53.2%	53.3%	55.3%	54.2%	60.1%	55.3%	55.8%	55.5%	60.2%
42	69.0%	68.8%	56.9%	57.5%	55.7%	44.4%	53.9%	54.3%	56.8%	55.3%	61.5%	55.9%	57.2%	56.7%	62.2%
43	72.6%	72.5%	54.2%	57.4%	53.9%	42.5%	54.3%	55.0%	58.1%	55.9%	62.4%	56.0%	58.5%	57.7%	64.4%
44	76.5%	76.3%	50.8%	56.9%	51.3%	41.0%	54.2%	55.5%	59.1%	56.1%	63.4%	55.6%	59.6%	58.3%	66.6%
45	81.4%	81.7%	47.5%	57.0%	49.1%	40.1%	54.1%	56.0%	60.1%	56.2%	64.1%	55.2%	60.8%	58.7%	69.1%
46	96.9%	96.6%	46.0%	58.5%	47.8%	40.1%	54.4%	56.8%	61.4%	56.5%	65.4%	55.3%	62.3%	59.0%	71.5%
47	96.9%	96.7%	45.7%	59.5%	47.1%	40.6%	54.5%	57.4%	62.0%	57.0%	65.5%	55.7%	63.6%	59.0%	72.6%
48	96.9%	96.7%	47.5%	62.5%	48.4%	42.0%	56.0%	59.0%	63.9%	58.6%	67.4%	57.5%	65.8%	59.7%	75.3%
49	97.0%	96.9%	49.8%	65.6%	50.4%	43.9%	58.0%	60.9%	65.9%	60.9%	69.4%	59.9%	68.3%	60.9%	77.9%
50	97.1%	97.0%	52.5%	68.8%	52.9%	46.3%	60.5%	63.1%	68.2%	63.7%	71.5%	62.6%	70.9%	62.5%	79.9%
51	97.2%	97.1%	55.5%	71.8%	55.8%	49.2%	63.3%	65.6%	70.5%	66.7%	73.6%	65.7%	73.5%	64.6%	82.7%
52	97.3%	97.3%	58.6%	74.7%	58.9%	52.3%	66.2%	68.3%	73.0%	69.9%	75.8%	68.8%	76.2%	67.1%	84.0%
53	97.5%	97.4%	61.9%	77.5%	62.2%	55.6%	69.2%	71.1%	75.5%	73.0%	77.5%	71.8%	78.7%	69.9%	87.3%
54	97.6%	97.6%	65.1%	80.0%	65.4%	59.1%	72.1%	73.9%	77.9%	76.0%	79.5%	74.8%	81.0%	72.7%	96.6%
55	97.8%	97.7%	68.4%	82.4%	68.5%	62.5%	74.8%	76.7%	80.3%	78.9%	81.5%	77.6%	83.3%	75.8%	94.8%
56	97.9%	97.9%	71.5%	84.5%	71.5%	65.8%	77.4%	79.3%	82.5%	81.5%	83.4%	80.3%	85.3%	78.5%	91.6%
57	98.1%	98.0%	74.5%	86.4%	74.3%	69.1%	79.9%	81.8%	84.6%	83.8%	85.6%	82.7%	87.2%	81.0%	97.6%
58	98.2%	98.2%	77.4%	88.2%	76.8%	72.1%	82.1%	84.0%	86.5%	85.9%	86.9%	84.8%	88.8%	83.3%	97.7%
59	98.3%	98.3%	80.0%	89.8%	79.2%	74.9%	84.2%	86.1%	88.2%	87.8%	88.4%	86.8%	90.1%	85.4%	97.9%
60	98.5%	98.5%	82.5%	91.1%	81.4%	77.5%	86.1%	87.8%	89.8%	89.5%	89.8%	88.5%	92.0%	87.3%	98.0%
61	98.6%	98.6%	84.7%	92.3%	83.4%	79.8%	87.8%	89.4%	91.1%	90.9%	91.1%	90.0%	92.8%	89.0%	98.2%
62	98.7%	98.7%	86.7%	93.4%	85.3%	81.8%	89.4%	90.8%	92.4%	92.2%	92.2%	91.3%	93.5%	90.4%	98.3%
63	98.9%	98.8%	88.5%	94.2%	86.8%	82.9%	90.8%	92.0%	93.4%	93.3%	93.2%	92.5%	98.1%	91.7%	98.4%
64	99.0%	99.0%	90.1%	95.2%	88.4%	84.1%	92.1%	93.1%	94.2%	94.2%	94.1%	93.6%	97.9%	92.9%	98.6%
65	99.1%	99.1%	91.4%	97.8%	89.9%	85.2%	93.1%	94.0%	95.0%	95.0%	94.9%	94.4%	97.4%	93.8%	98.7%
66	99.2%	99.2%	92.6%	97.8%	91.3%	86.2%	94.1%	94.8%	98.6%	96.6%	95.6%	95.2%	98.6%	94.7%	98.8%
67	99.3%	99.3%	93.7%	98.4%	92.5%	87.2%	94.9%	97.4%	98.7%	98.6%	98.7%	95.8%	98.7%	95.4%	98.9%
68	99.3%	99.3%	94.6%	98.3%	93.5%	88.3%	95.6%	96.6%	98.8%	98.7%	98.8%	98.7%	98.8%	96.1%	99.0%
69	99.4%	99.4%	95.4%	98.2%	94.5%	89.5%	96.2%	96.5%	98.9%	98.8%	98.9%	98.8%	98.9%	96.6%	99.1%
70	99.5%	99.5%	96.1%	98.9%	95.3%	90.7%	96.8%	96.9%	99.0%	98.9%	99.0%	98.9%	99.0%	98.9%	99.2%
71	99.5%	99.5%	96.7%	99.0%	96.0%	91.8%	97.2%	97.9%	99.1%	99.0%	99.0%	99.0%	99.1%	99.0%	99.3%
72	99.6%	99.6%	97.1%	99.1%	96.6%	92.9%	99.0%	99.0%	99.2%	99.1%	99.1%	99.1%	99.2%	99.1%	99.4%
73	99.6%	99.7%	97.6%	99.2%	97.1%	93.8%	99.1%	99.1%	99.2%	99.2%	99.2%	99.2%	99.3%	99.1%	99.5%
74	99.7%	99.7%	97.9%	99.3%	97.5%	94.7%	99.2%	99.2%	99.3%	99.3%	99.3%	99.3%	99.4%	99.2%	99.5%

Appendix C: HECM Loan Performance Projections

This appendix will discuss how the termination model, discussed in Appendix B, is used to forecast future terminations. It will also describe the future economic conditions and future cohort characteristics required to forecast termination rates in future years. This appendix discusses the forecasts and methodology used in projecting future loan performance.

C1. General Approach to Loan Termination Projections

Estimated terminations are developed for all future policy years for each active loan as of September 30, 2023. For example, in this review, for a loan endorsed in FY 2021 we estimate termination rates beginning in policy year three since the first two policy years have already elapsed by the end of FY 2023 and the termination behavior is included in actual experience. For each of these years, macroeconomic variables are derived based on loan characteristics and economic forecasts; these variables include loan duration, loan characteristics, and other economic assumptions. The PEA assumptions, the Moody's October 2023 forecast, and our simulated future paths of interest rates and house price appreciations are used to develop termination specifications. MSA level forecasts are used for house price appreciation and state level forecasts are used if the MSA level data is unavailable.

For every loan and future policy year, these parameter values are then applied to the multinomial logit models as specified in Appendix B. This generates a single conditional termination rate per policy year, representing the probability the loan will terminate in a policy year given it survived to the end of the prior policy year. The projected conditional termination rates for every loan and its future policy years are imported into the HECM cash flow model to estimate future terminations and associated cash flows of the HECM program.

C2. Economic Scenarios

We use the baseline assumption plus four alternative stochastic simulation scenarios. The Four scenarios for which we report economic net worth estimates are:

- Optimistic Upside Scenario in Simulation, the path that is most favorable to the HECM MMI fund.
- Moderate Upside Scenario in Simulation, the path that is moderately favorable to the HECM MMI fund.
- Moderate Downside Scenario in Simulation, the path that is moderately unfavorable to the HECM MMI fund.
- Pessimistic Downside Scenario in Simulation, the path that is most unfavorable to the HECM MMI fund.

C3. Maintenance-Risk Adjustments

Recent research on the HECM portfolio presents a revised approach to accounting for the maintenance risk posed by HECM borrowers. Maintenance-risk is the moral hazard where borrowers provide insufficient property maintenance on their home. Based on the work of Shiller and Weiss (2000) and Capone et al. (2010), the revised scheme measured the effect of maintenance-risk as the spread between the market-level house price appreciation rate and the HECM portfolio's house price appreciation rate.

Borrowers were divided into "stayers" and "movers" categories based on the borrower's expected tenure. The research found that "movers" homes appreciate at higher rates than the market average whereas "stayers" homes appreciate at lower rates than market average. Moreover, HECM properties with a higher value than the area's median value appreciates at higher rates than those with a lower value than the area's median value.

The maintenance-risk adjustment factors are provided by FHA. The adjustment factors are applied to the annual house price appreciation based on the age of the loan, which affects the amount of expected recovery at loan termination.

C4. 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 the 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 2003 through FY 2023 to model the borrower's conveyance and payoff selection choice. This is aggregated by the year of termination. There are 86,704 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 C-1 shows the estimation results.

The *ProbabilityOfPositiveEquity* is a binary variable based on the probability of negative equity greater than or less than ten percent. The probability of positive equity represents the likelihood of the estimated home value increasing above the projected loan balance during the period of observation. Historical experience suggests that HECM borrowers with higher probability of positive equity tend to pay off the loan than borrowers with lower probability of positive equity.

Two dummy variables for states CA and NY to indicate the loan in high house value area are less likely to convey the loan. The result indicates that HECM borrowers in areas with higher house prices relative to the national loan limit are more likely to pay off.

Exhibit C-1. HECM Conveyance Modeling

Analysis of Maximum Likelihood Estimates					
Description	Parameter	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
	Intercept	-9.1419	0.3209	811.4061	<.0001
Policy Year	Pol_conv_yr1	0.6569	0.0302	472.5801	<.0001
	Pol_conv_yr2	0.1043	0.00456	522.5663	<.0001
Age at Origination	Orig_Age	0.0485	0.0022	489.0737	<.0001
First Month Cash Draw Percentage	FM_pct_cashdd	0.3553	0.0441	64.9476	<.0001
Cumulative HPI Change	Cumulative_HPI_Chan g	-2.092	0.0359	3393.3302	<.0001
Current LTV	CLTV_cnvy1	-1.9271	0.0583	1093.1966	<.0001
	CLTV_cnvy2	5.6771	0.1896	896.1028	<.0001

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	81	Somers' D	0.621
Percent Discordant	19	Gamma	0.621
Percent Tied	0	Tau-a	0.163
Pairs	517851000	c	0.81

Appendix D: 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 cohort specific single effect rates (SERs) provide by FHA. These elements of cash flow and the present value calculations are described in this Appendix.

D1. Definition

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 ($1,089,300 for FY 2023).

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 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.

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.

D2. 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	

D3. Loan Balance

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

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

The UPB for each period t consists of the previous loan balance plus any new borrower cash drawn and accruals. The accruals include interest, mortgage insurance payments, and service fees. Future borrower draws are estimated by assigning draw patterns to loans based upon the first-month draw.

D4. 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 an HECM loan. Similarly, the recurring annual premiums are added to the balance of the loan.

D4.1. Upfront Premiums

Upfront premium is due to FHA at the time of closing, equal to a percentage of the MCA. For FY2009 and FY 2010 books-of-business, the upfront premium rate is two percent of the MCA. For FYs 2011 through 2013 endorsements the upfront premium rate for the standard option and the saver option is two percent and 0.01 percent (1 basis point), respectively. HECM saver program was discontinued in 2013. 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% of the initial principal limit, and 2.5 percent of MCA if the first-year cash draw is more than 60 % of the initial principal limit.

Effective from October 2017, to simplify the MIP structure and improve the sustainability of the MMI fund, HUD standardized the upfront MIP to a flat 2% of the maximum claim amount, irrespective of how much the homeowner drew from the reverse mortgage in the first year. Typically, the upfront premium is paid in full to FHA as a positive cash flow at the loan closing and financed by the HECM loan and hence added to the loan balance.

D4.2. Annual Premium

The annual premium is calculated as a percentage of the growing loan balance. For FY 2009 and FY 2010 books-of-business, the annual premium is 0.5 percent of the UPB. From FY 2011 and onward, the annual premium is 1.25 percent of the UPB for both the Standard and Saver options, the new program in 2014. The 1.25% annual premium remains the same in the simplified MIP structure in 2017 and afterwards. Typically, the annual premium is paid by the servicer, and it is added to the accruing loan balance.

D5. Claims

HECM claims consist of claim type 1's and claim type 2's.

D5.1. Claim Type 1

Claim type 1 factor into HECM cash flows as payments to the lender when a property is sold and the net proceeds from the sale are insufficient to cover the balance of the loan at termination. The number and amount of claim type 1's is estimated based on historical experience adjusted by insurance-in-force.

$$Claim\ Type\ I\ Payment = min(MCA, max(UPB - Net\ Property\ Sales\ Price, 0))$$

The net sales price of the property is:

$$Net\ Property\ Sales\ Price = Estimated\ Property\ Sales\ Price \times (1 - \%\ sales\ expenses)$$

D5.2. Claim Type 2 (Assignment)

Lenders can assign the loan to HUD when the UPB reaches 98 percent of the MCA. HUD acquires the note resulting in acquisition costs equal to the balance (up to the MCA). The majority of HECM investors require the loans to be assigned to HUD when the UPB reaches 98 percent of the MCA. The model estimates assignments to occur when the projected UPB reaches 98 percent of the MCA.

D6. Note Holding Expenses after Assignment

The note holding expenses include the additional cash drawn by the borrower after the loan has been assigned to HUD. Additional cash drawn 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.

D7. Recoveries from Assigned Loans

At note termination, the HECM loan is due and payable to FHA. The timing of loan terminations is based upon the results of the termination model. The details of the termination projections are discussed in Appendix B and Appendix C. The amount of recovery is estimated as the minimum of the loan balance and the net sales proceeds at termination, where net sales proceeds are estimated as the difference between projected property value less property holding and selling expenses.

D8. Net Future Cash Flows

The cash flow for a book-of-business can be found by aggregating the individual components.

$$\begin{aligned} Net\ Cash\ Flow_t \\ = Upfront\ Premium_t + Annual\ Premium_t + Recoveries_t - Claim\ Type1_t \\ - Claim\ Type2_t - Note\ Holding\ Expense_t \end{aligned}$$

Note that a negative net cash flow indicates that outflows have exceeded inflows, and a positive cash flow indicates the HECM program is generating a net income. To obtain the present value of cash flows, the cash flows are discounted for each policy year and cohort using the cohort specific single effective rate (SERs) supplied by FHA.

Appendix E: Stochastic Simulation Models

This Appendix describes the stochastic models used to generate the economic variables used in the Monte Carlo simulations of the FHA HECM Actuarial Review 2023. Based on the best fitted stochastic model, we use Monte Carlo simulation technique to simulate 1000 paths of future economic variables and obtain the 10th, 25th, 50th, 75th, and 90th percentiles of the simulated paths to present to a range of NPV values based on these percentile paths. In our Monte Carlo simulation, the simulated paths are centered on the baseline economic assumptions, this is, the 50th percentile of the simulated path is closest to the baseline PEA assumption. The estimated simulation models are identical for the Single-Family Forward and HECM with respect to Treasury rates and national and regional HPIs. Additional forecast models were developed for 30-year mortgage rates and unemployment rates to be applied to Single-Family Forward mortgages, while a forecast model of the SOFR was estimated for application to HECM loans.

The economic variables modeled herein as a stochastic process include:

- 1-year Treasury rates,
- 10-year Treasury rates,
- 1-year Secured Overnight Financing Rate (SOFR), and
- FHFA national Purchase Only house price appreciation rate (HPI-PO).

The simulated economic scenarios of the U.S. economy and the components of the forecast include:

- One-year CMT rate
- 10-year CMT rate
- One-year SOFR
- HPI at the MSA, state, regional and national levels

The stochastic models are estimated using historic data and are chosen based on standard criteria such as likelihood, AIC, and BIC values. Since all status transition probabilities are estimated and projected using the historically observed interest rates and house price appreciation for the same series, the model estimates and forecasting are internally consistent. This approach is appropriate for the Actuarial Review as we are computing the present value of projected future cash flows for liability valuation.

E1. Historical Data
E1.1. 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 the 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 E-1 shows historical interest rates from 1970Q1 to 2023Q2. The one- year Treasury rate (CMT1) fluctuated around 6% in the early 1970s 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 around 1.2% in 2004. From then, rates started a slow upward trend until the 2007 financial crisis and rates started a sharp downward trend reaching a historic low of 0.06% in CY 2021 Q2. Inflation turned up dramatically because of the COVID-19 pandemic. Monetary policy aimed to overturn the post-pandemic inflation and we saw the beginning of the Federal Reserve tightening where the one-year rate has been increasing to 4.94% in 2023 Q2.

Also shown in Exhibit E-1 are the 10-year Treasury rate (CMT10) and the 1-year SOFR rate (SOFR_1y). Since there is a short history of SOFR rate, we only have the data from 2006Q1. The data is used for estimating the ARMA-GARCH models for interest rates.

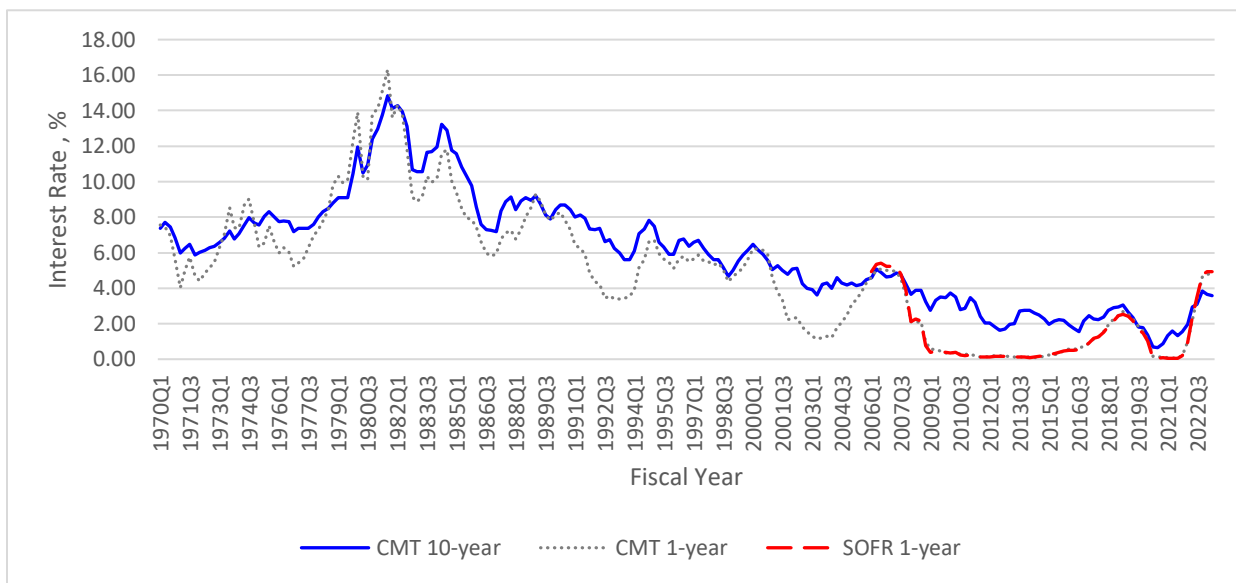Exhibit E-1 Historical Interest Rate (%)

Exhibit E-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 SOFR 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 SOFR over the 1-year Treasury rate fluctuates around zero with much smaller variation.

Exhibit E-2 Historical Interest Rate Spread (%) with the 1-Year CMT
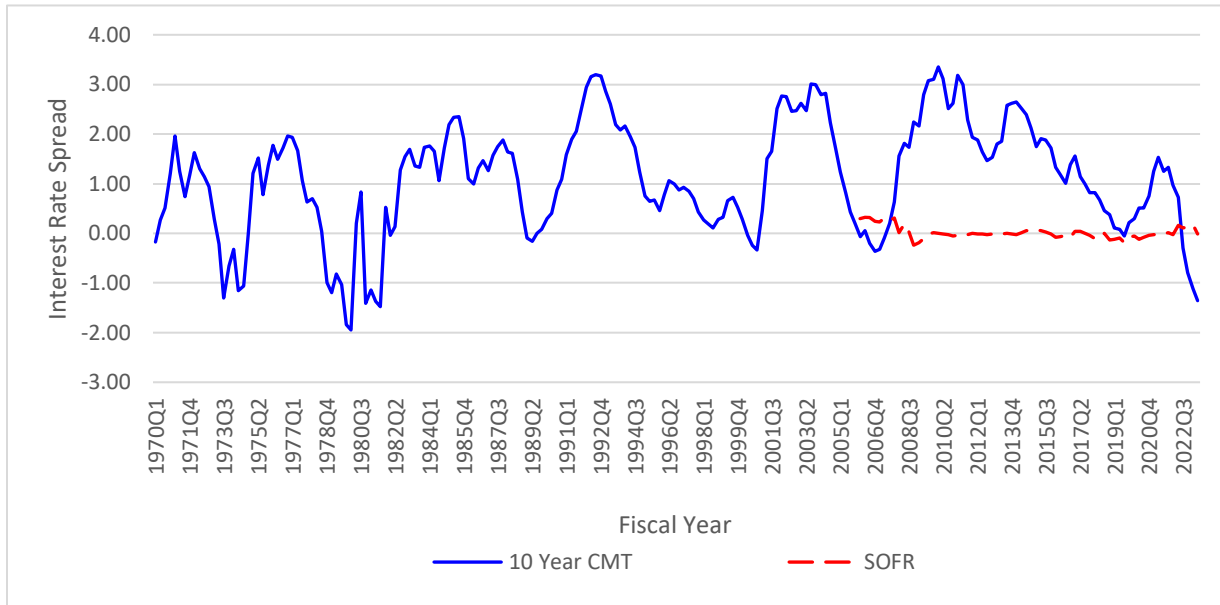
E1.2. House Price Appreciation Rates

The national house price appreciation rate (HPA) is derived from the FHFA repeat sales seasonally adjusted purchase-only (PO) house price indexes (HPIs). 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.

The HPA at time t is defined as:

$$HPA_t = \frac{HPI_t}{HPI_{t-1}} - 1$$

Exhibit E-3 shows the quarterly national HPI and HPA from CY 1991 Q1 to CY 2023 Q2. The long-term average quarterly HPA is around 1.085% (4.41% annual rate). The HPI increased steadily before 2004 with a quarterly appreciation rate of about 1.14%. Then house prices rose sharply starting in 2004. The average quarterly house price appreciation rate was 2.46% (10% annual rate) during the subprime mortgage expansion period from 2004 to 2005 and reached its peak of 2.64% in CY 2005 Q3. The house price appreciation slowed down in 2006. The overturn started in 2007 Q2 and the average growth rate of house prices became negative. Exhibit E-4 shows the average quarterly HPA by selected historical time periods.

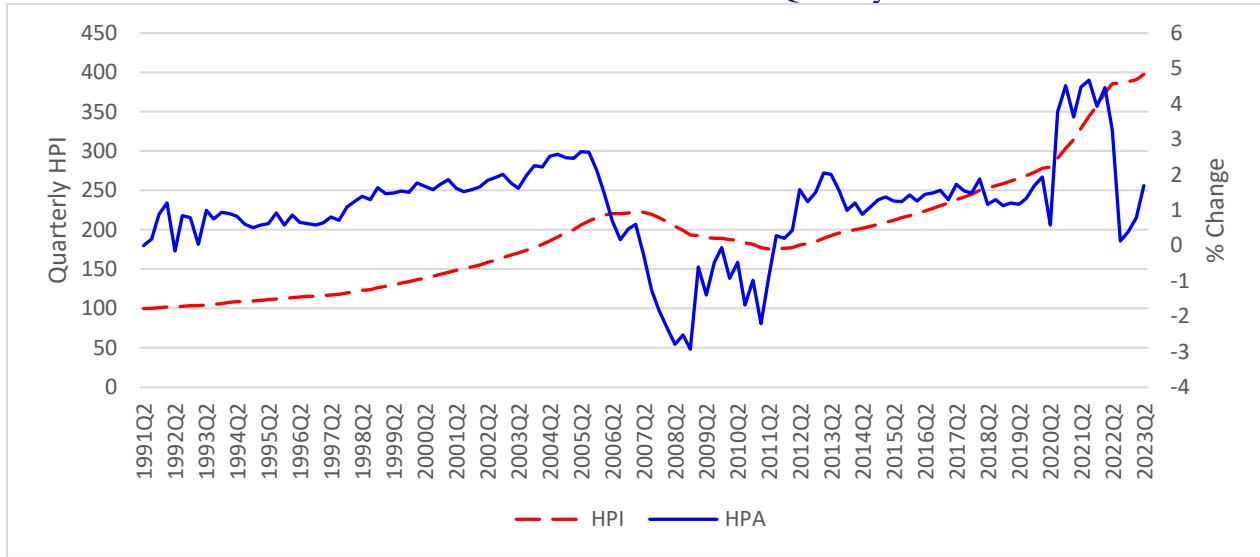## Exhibit E-3 Historical National HPI and Quarterly HPA

Exhibit E-3 Historical National HPI and Quarterly HPA

Exhibit E-4 Average Quarterly HPA by Time Span

Period	Average Quarterly HPA
1991 – 2003	1.14%
2004 – 2006	1.87%
2007 – 2010	-1.24%
2011 – 2019	1.15%
2020 – 2023Q2	2.73%

E2. 1-Year Treasury Rate

We have tested several Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) models and used an AR(2)- GARCH(1,1) with normal innovations and external regressor for conditional volatility to model the one-Year Treasury rate. The model is estimated using data from CY 1991 Q1 to CY 2023 Q2. Let $r_{1,t}$ be the one-year Treasury rate at time t. The stochastic process takes the following form:

$$r_{1,t} = a_{1,0} + a_{1,1}r_{1,t-1} + a_{1,2}r_{1,t-2} + \varepsilon_t$$

where ε_t is a normal innovation with mean 0 and variance σ_t^2 following a GARCH (1, 1) model with a constant term insignificant from zero, that is

$$\sigma_t^2 = \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2 + \gamma r_{1,t-1}$$

The estimated results are presented in Exhibit E-6.

Exhibit E-6 Estimation Results for 1-Year Rate Model

Parameter	Estimate	Std. Error	t value	Pr(>|t|)
$a_{1,0}$	7.499612	0.643427	11.655729	0
$a_{1,1}$	1.511694	0.002499	605.002494	0
$a_{1,2}$	-0.514032	0.001769	-290.63552	0
α	0.348016	0.091994	3.783022	0.000155
β	0.637303	0.043077	14.794469	0
γ	0.006137	0.002244	2.734625	0.006245

The model based on these parameters is used to simulate the one-year Treasury rates for the forecast period starting in FY 2023 Q3. When the simulation is implemented, the conditional mean is replaced by the PEA baseline forecast. This simulation method is to ensure the stochastic path of future one-year Treasury rate is centered on the PEA baseline forecast. We applied the same procedure for the conditional mean in the 10-year Treasure rate, SOFR rate and HPA rate. We simulated 1000 paths of the future 35 years[9] of one-year Treasury rates. The 10th, 25th, 75th, and 90th percentiles of the simulated paths are obtained. The 50th percentile path is close to the baseline forecast.

A lower bound of 0.01 percent was applied to the simulated future 1-year Treasury rates to avoid negative rates in the simulation. However, this constraint does not affect the obtained percentile paths. The percentile paths are obtained by sorting each path by the mean value of each path. The resulting forecasts for the one-year Treasury rates are shown in the following chart for the baseline PEA and the four alternative stochastic percentile paths.

[9] Projected rates remained constant after 35 years.

Forecast of 1-year CMT rate
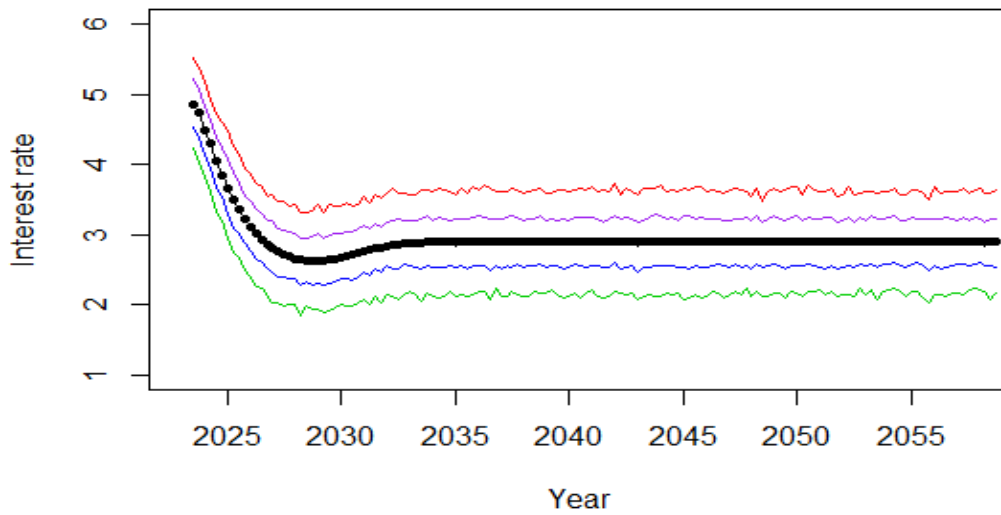
E3. 10-Year Treasury Rate

The 10-year Treasury rate is modeled by adding a stochastic spread term to the simulated one-year Treasure rate. We estimate the dynamics of the spread between the 10-year Treasury rate and one-year Treasury rate from the historical data. The best fitted GARCH model assumes the spread term depends on the one-year rate, the lagged values of the spread term and a random component. Let $s_{10,t}$ be the spread between the 10-year and one-year Treasury rates at time t. Mathematically, the model for $s_{10,t}$ is as follows.

$$s_{10,t} = a_{10,0} + a_{10,1}s_{10,t-1} + a_{10,2}s_{10,t-2} + \gamma r_{1,t} + \varepsilon_t,$$

where ε_t is a normal innovation with mean 0 and variance σ_t^2 following a GARCH (1, 1) model,

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2$$

The model is estimated based on historic spread data from CY 1970 Q1 to CY 2023Q2. parameters are shown in the following Exhibit E-7.

Exhibit E-7 Estimation Results for 10-Year Rate Spread Model

	Estimate	Std. Error	t value	Pr(>|t|)
$a_{10,0}$	3.550348	0.300177	11.8275	0
$a_{10,1}$	1.217277	0.068398	17.797	0
$a_{10,2}$	-0.242085	0.069533	-3.4816	0.000498
γ	-0.470274	0.030357	-15.4914	0
ω	0.007678	0.004895	1.5684	0.116785

α	0.086591	0.048048	1.8022	0.071517
β	0.826027	0.077643	10.6387	0

We used the estimated parameters to simulate the spread between the 10-year and one-year Treasury rates with the conditional mean equal to the PEA baseline forecast, such that the 1000 simulated paths are centered on the baseline estimation. The simulated spread paths are added to the simulated spread to the simulated one-year Treasury rate to give 1000 paths of 10-year Treasury rate. Five percentile paths are obtained therein. The resulting forecasts for the ten-year Treasury rates are shown in the following chart for the baseline PEA and the four alternative stochastic percentile paths.

Simulated CMT10 path percentiles
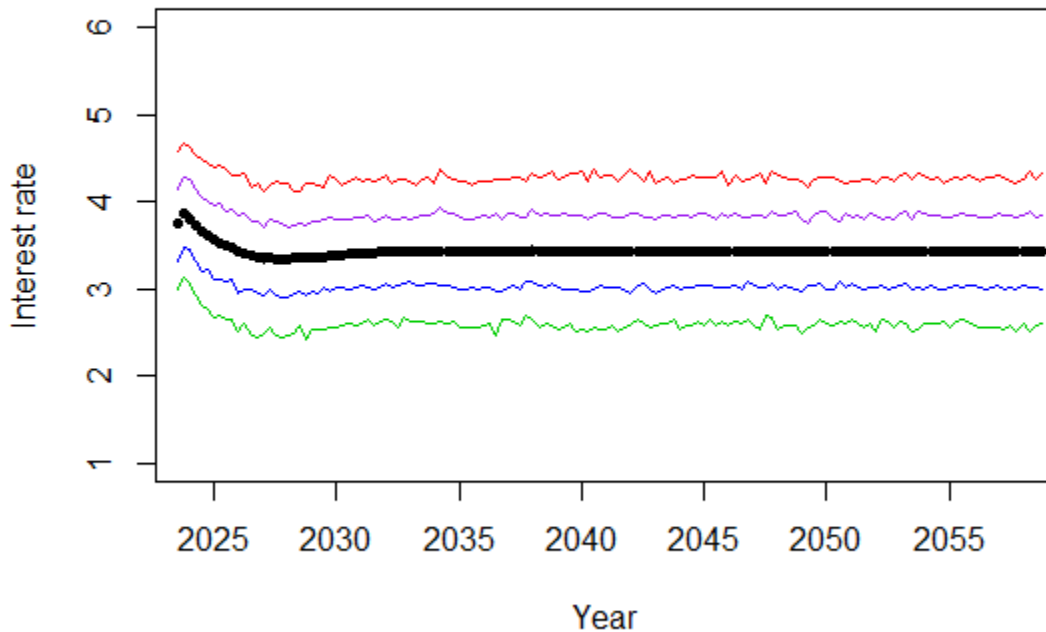
E4. SOFR

The one-year SOFR rate is modeled by simulating a spread percentile path added to the simulated one-year Treasure rate. We estimate the dynamics of the SOFR spread from historic data. Let $s_{s,t}$ be the spread between the One-year SOFR and 1-year Treasury rates at time t and $r_{1,t}$ one-year Treasury rate at time t. The one-year SOFR spread rate was modeled as a constant term plus a term proportional to the One -year Treasury rate and a GARCH (1,1) model for the conditional volatility:

$$s_{s,t} = a_{s,0} + \gamma\, r_{1,t} + \varepsilon_t$$

where ε_t is a normal innovation with mean 0 and variance $\sigma_t{}^2$ following a GARCH (1, 1) model,

$$\sigma_t{}^2 = \omega + \alpha \varepsilon_{t-1}{}^2 + \beta \sigma_{t-1}{}^2$$

Using historic data from CY 2006 Q1 to CY 2023Q2, the estimated parameters are shown in Exhibit E-8.

Exhibit E-8 Estimation Results for the SOFRR Rate Model

	Estimate	Std. Error	t value	Pr(>|t|)
$a_{s,0}$	-0.021099	0.006541	-3.2254	0.001258
γ	0.02964	0.003611	8.2085	0
ω	0.000411	0.00036	1.1428	0.253118
α	0.648184	0.255709	2.5348	0.01125
β	0.350816	0.104544	3.3557	0.000792

We used the estimated parameters to simulate the SOFR spread rate with the conditional mean equal to the baseline spread. The simulated spread paths are added to the simulated spread to the simulated one-year Treasury rate to give 1000 paths of one-year SOFR rate. Five percentile paths are obtained therein as shown in the following chart.

Simualted SOFR percentiles
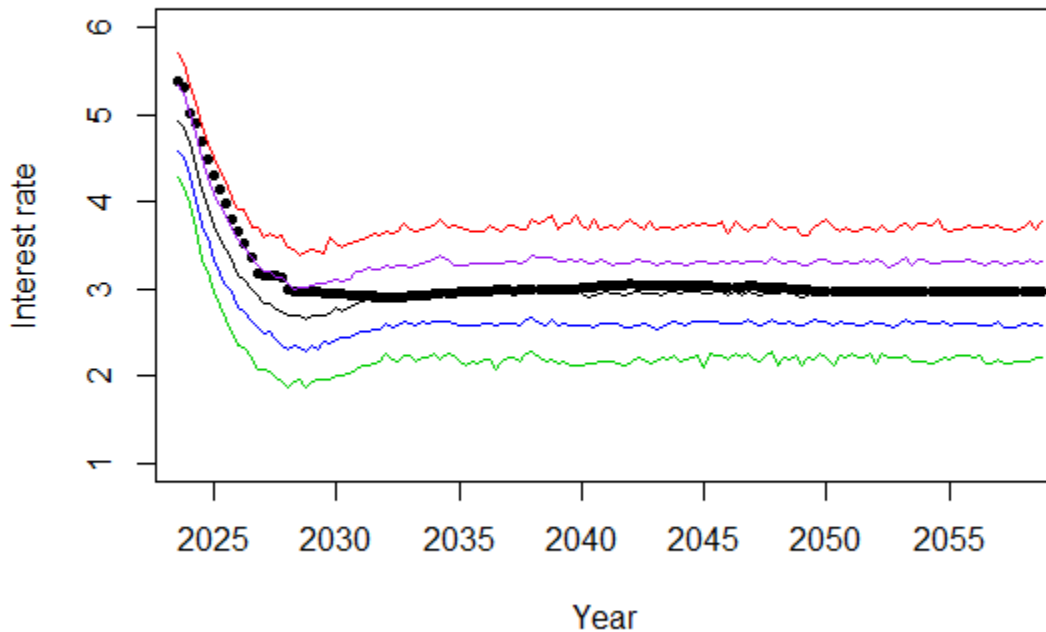
E5. House Price Appreciation Rate (HPA)

E5.1. National HPA

The best fitted GARCH model for the national HPA takes the following form:

$$HPA_t = a_{h,0} + a_{h,1}HPA_{t-1} + a_{h,2}HPA_{t-2} + \gamma r_{m,t-1} + \varepsilon_t$$

where ε_t is a skewed t-distributed innovation with variance σ_t^2 following a GARCH (1, 1) model,

$$\sigma_t^2 = \omega + \alpha\varepsilon_{t-1}^2 + \beta\sigma_{t-1}^2$$

In this model, the conditional mean of HPA_t depends on its own lags and the 30-year fixed mortgage rate in the previous quarter. The GARCH (1,1) model with skewed t-distributed innovations performs much better than the one with normal innovations in this model. Using the historic data from 1991Q1 to 2023Q, we estimate the model and have the results as shown in Exhibit E-9.

Exhibit E-9 Estimation Results for the National HPA Model

	Estimate	Std. Error	t value	Pr(>|t|)
$a_{h,0}$	1.826772	0.698034	2.617	0.00887
$a_{h,1}$	0.750368	0.091023	8.2437	0
$a_{h,2}$	0.237969	0.095685	2.487	0.012882
γ	-0.202023	0.06149	-3.2855	0.001018
ω	0.019442	0.011033	1.7622	0.078042
α	0.436746	0.174392	2.5044	0.012266
β	0.562254	0.129348	4.3468	0.000014
skew	0.815656	0.085814	9.5049	0
shape	3.75714	1.028493	3.6531	0.000259

We used the estimated model to simulate 1000 future HPA paths from FY 2023 Q3, with the conditional mean equal to the PEA baseline forecast and obtain the 10th, 25th, 75th, and 90th percentile paths. The resulting forecasts for the future HPA rates are shown in the following chart for the baseline PEA and the four alternative stochastic percentile paths.

Simulated House Price Appreciation Rate Percentiles
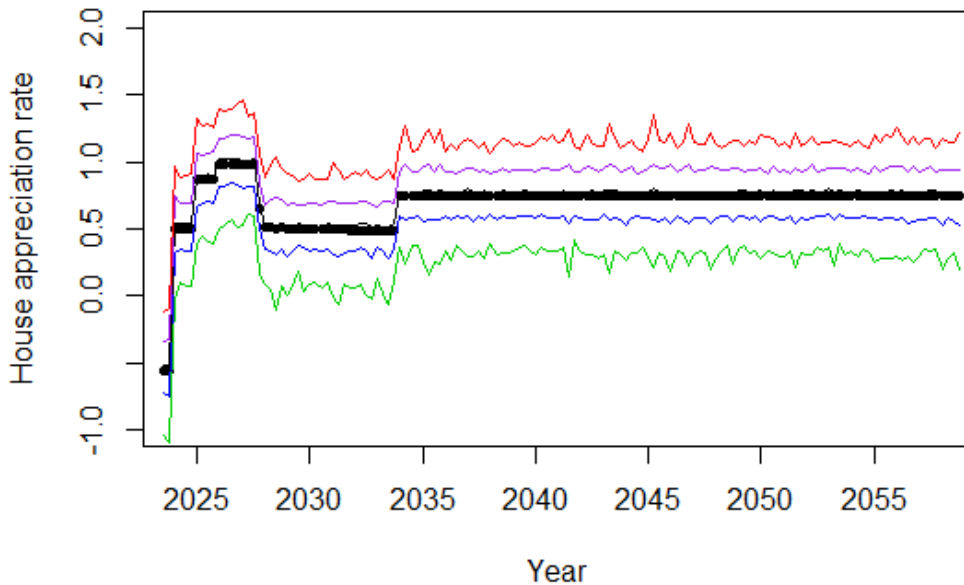
E5.2. Geographic Dispersion

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 ith MSA and the national forecast:

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

This dispersion forecast under Moody's baseline estimates was preserved for all local house price forecasts under individual future economic paths. That is, for economic path j, the HPA of the ith MSA at time t was computed as:

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

This approach retains the relative current housing market cycle among different geographic locations, and it allows us to capture the geographical concentration of FHA's current endorsement portfolio. This approach is also consistent with Moody's logic in creating local market HPA forecasts relative to the national HPA forecast under alternative economic scenario forecasts. 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 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.

E6. COVID-19 Pandemic Consideration

The impact from the COVID-19 pandemic is noticeable and dramatic when analyzing these economic indicators, causing higher volatility in these economic variables. Abrupt changes in the recent historic data of these economic measures present additional challenges when fitting stochastic models. Because of the historic nature of this event and the changing economic environment before and after the pandemic, it is difficult to ascertain which impacts might be attributed solely to the pandemic, and whether these changes will persist into the future or conditions or revert to pre-pandemic conditions. Rather than apply different models including and excluding the pandemic period to interpret COVID-19 impacts, we use customized GARCH models for the individual economic variables to capture the high volatility of the COVID-19 period and subsequent economic changes in the data and to develop the simulated diversions from the PEA baseline assumptions.

The 2022 HECM Actuarial Review, reported that there were no changes in portfolio composition or borrower behavior evident in the recent data, and therefore, based on the information available at that time, no adjustments were undertaken to account for potential COVID-19 impacts. We concur with this assessment and will continue this approach for the FY 2023 review. As more information becomes available in future years, we will continue to monitor and investigate the nature and long-term impacts of the COVID-19 pandemic on the economy and make appropriate adjustments to the models based on new data.