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November 15, 2018

The Honorable Brian D. Montgomery
Assistant Secretary for Housing – Federal Housing Commissioner
U.S. Department of Housing and Urban Development
451 Seventh Street, S.W., Room 9100
Washington, D.C. 20410

Commissioner Montgomery:

Pinnacle Actuarial Resources, Inc. (Pinnacle) has completed the Final Fiscal Year 2018 Independent Actuarial Review of the Mutual Mortgage Insurance Fund. The attached report details our estimate of the Cash Flow Net Present Value for Fiscal Year 2018.

Roosevelt C. Mosley, Jr., FCAS, MAAA and Thomas R. Kolde, FCAS, MAAA are responsible for the content and conclusions set forth in the report. We are Fellows of the Casualty Actuarial Society and Members of the American Academy of Actuaries, and are qualified to render the actuarial opinion contained herein.

It has been a pleasure working with you and your team to complete this study. We are available for any questions or comments you have regarding the report and its conclusions.

Respectfully Submitted,

Roosevelt Mosley

Roosevelt C. Mosley, Jr. FCAS, MAAA
Principal and Consulting Actuary

Thomas R. Kolde

Thomas R. Kolde, FCAS, MAAA
Consulting Actuary

# Fiscal Year 2018 Independent Actuarial Review of the Mutual Mortgage Insurance Fund: Cash Flow Net Present Value from Home Equity Conversion Mortgage Insurance-In-Force

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# Fiscal Year 2018 Independent Actuarial Review of the Mutual Mortgage Insurance Fund: Cash Flow Net Present Value from Home Equity Conversion Mortgage Insurance In Force

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# Fiscal Year 2018 Independent Actuarial Review of the Mutual Mortgage Insurance Fund: Cash Flow Net Present Value from Home Equity Conversion Mortgage Insurance In Force

## Summary of Findings

This report presents the results of Pinnacle Actuarial Resources, Inc.'s (Pinnacle) independent actuarial review of the Cash Flow Net Present Value (NPV) associated with Home Equity Conversion Mortgages (HECM) insured by the Mutual Mortgage Insurance Fund (MMIF) for fiscal year 2018. The Cash Flow NPV associated with forward mortgages are analyzed separately and are excluded from this report. In the remainder of this report, the term MMIF refers to HECMs and excludes forward mortgages.

Below, we summarize the findings associated with each of the required deliverables.

**Deliverable 1: Articulate the Actuary's conclusion regarding the reasonableness of the HECM Cash Flow NPV as presented in FHA's Annual Report to Congress and the Actuary's best estimate and range of reasonable estimates, including estimates at the 90th, 95th and 99th percentiles of the adverse tail of the distribution, and the basis of the range which led to the Actuary's conclusion. The study also must compare the Actuary's conclusions to the corresponding amounts in FHA's Annual Report.**

As of the end of Fiscal Year 2018, Pinnacle's Actuarial Central Estimate (ACE) of the MMIF HECM Cash Flow NPV is negative $14.217 billion. Pinnacle's ACE is based on the Economic Assumptions for the 2019 Budget Fall Baseline from the Office of Management and Budget (OMB Economic Assumptions).

Pinnacle also estimated additional Cash Flow NPV outcomes based on economic scenarios from Moody's Analytics (Moody's). The Cash Flow NPV results based on these scenarios are shown in Table 1.

*Table 1: Cash Flow NPV Outcomes Based on OMB Economic Assumptions and Moody's Scenarios*

| Economic Scenario | Fiscal Year 2018 Cash Flow NPV |
|---|---|
| Pinnacle ACE | -14,217,158,723 |
| Moody's Baseline | -11,489,789,437 |
| Moody's Exceptionally Strong Growth | -7,211,294,581 |
| Moody's Stronger Near-Term Rebound | -9,435,876,155 |
| Moody's Slower Near Term Growth | -11,773,104,959 |
| Moody's Moderate Recession | -11,894,405,578 |
| Moody's Protracted Slump | -20,487,180,861 |
| Moody's Below-Trend Long-Term Growtl | -13,064,863,338 |
| Moody's Stagflation | -15,675,226,372 |
| Moody's Next Cycle Recession | -12,733,281,940 |
| Moody's Low Oil Price | -11,343,537,632 |

The range of results based on Moody's economic scenarios is negative $20.487 billion to negative $7.211 billion.

In addition, Pinnacle has estimated a range of outcomes based on 100 randomly generated stochastic

simulations of key economic variables. Based on these simulations, we estimate that the range of reasonable Cash Flow NPV estimates is negative $21.181 billion to negative $1.904 billion. This range is based on an 80% likelihood that the ultimate Cash Flow NPV will fall within the lower and upper bound of the range. The 90th, 95th and 99th percentiles of the stochastic simulations are shown below:

- 90th percentile: - $1.904 billion
- 95th percentile: + $0.097 billion
- 99th percentile: + $0.908 billion

The Cash Flow NPV estimate provided by FHA to be used in the FHA's Annual Report to Congress is negative $15.747 billion. Based on Pinnacle's ACE and range of reasonable estimates, we conclude that the FHA estimate of Cash Flow NPV is reasonable.

**Deliverable 2: Contain the Actuary's best estimate and range of reasonable estimates of the HECM Cash Flow NPV by program and cohort beginning with the 2009 cohort and continuing through the most recent cohort.**

Pinnacle's ACE and range of reasonable estimates of the Cash Flow NPV by cohort are shown below. The range of estimates are based on the stochastic simulation results.

*Table 2: Range of Reasonable Estimates - HECM Cash Flow NPV*

| Cohort | 10th Percentile | 90th Percentile | Pinnacle ACE |
|---|---|---|---|
| 2009 | -3,734,019,482 | -1,359,171,721 | -2,767,895,839 |
| 2010 | -2,216,457,031 | -822,982,018 | -1,658,546,517 |
| 2011 | -1,756,745,735 | -557,946,862 | -1,280,041,592 |
| 2012 | -1,799,727,409 | -449,006,603 | -1,280,643,773 |
| 2013 | -2,499,090,706 | -467,688,424 | -1,767,219,874 |
| 2014 | -1,286,906,989 | 223,683,370 | -779,073,360 |
| 2015 | -1,641,907,414 | 346,827,850 | -915,472,176 |
| 2016 | -1,724,133,971 | 577,913,056 | -938,743,620 |
| 2017 | -2,467,737,175 | 524,859,418 | -1,501,871,014 |
| 2018 | -2,054,263,013 | 79,658,705 | -1,327,650,958 |
| | | | |
| Total | -21,180,988,925 | -1,903,853,229 | -14,217,158,723 |

**Deliverable 3: Reconcile the data used to prepare the Actuary's estimates with the data used by FHA to prepare its estimated MMIF liabilities for loan guaranty.**

Section 4 shows the reconciliation of the data used by Pinnacle with the data used by FHA. Please see the sub-heading titled Data Reconciliation.

**Deliverable 4: State clearly the assumptions and judgments on which the Actuary's estimates are based, the support for the assumptions and the sensitivity of the Actuary's estimates to alternative assumptions and judgments.**

The assumptions and judgments on which the estimates are based are summarized in Section 5. The section titled HECM Base Termination Model summarizes the specifications and assumptions related to the base termination models. The HECM Cash Flow Draw Projection Models section summarizes the cash draw models for HECM mortgages with lines of credit. Section 4 discusses the economic assumptions incorporated into the estimates. Lastly, the HECM Cash Flow Analysis section of Section 5 details the assumptions associated with the cash flow projections. Section 4 also shows the sensitivity of the estimates to alternative economic scenarios.

**Deliverable 5: Narrative and technical components. The narrative component should provide sufficient detail to clearly explain to FHA and HUD management and auditors, OMB and Congressional offices the findings, recommendations and conclusions as well as their significance. The technical component must trace the analysis from the basic data and assumptions to the conclusions.**

Sections 1 and 2 provide an explanation of the findings and the significance of the findings. Also, Section 5 traces the analysis from data to conclusions.

**Deliverable 6: Quantify in descending order of importance the underlying causes (changes in portfolio size, assumptions, economic conditions, methodology, loan performance, etc.) of change in the HECM Cash Flow NPVs from September 30, 2017, as presented in the 2017 actuarial review, through September 30, 2018.**

Table 3 provides a summary of the decomposition of changes in the Cash Flow NPV of the MMIF as of the end of fiscal year 2018 as compared to the Cash Flow NPV in the fiscal year 2017 report. The overall net change in the Cash Flow NPV is positive.

*Table 3: Changes in Projected Cash Flow NPV*

| | Change in NPV | Cash Flow NPV - 9/30/18 |
|---|---|---|
| **Baseline FY2009-FY2017** | | -14,223,318,906 |
| Impact of assumption change | 1,102,066,301 | -13,121,252,605 |
| Impact of model change | -1,035,614,824 | -14,156,867,429 |
| Impact of book change | 1,267,359,664 | -12,889,507,765 |
| FY2009-FY2017 | 1,333,811,141 | |
| FY2018 | -1,327,650,958 | -14,217,158,723 |
| **Cumulative Change** | 6,160,183 | |

**Deliverable 7: Comment thoroughly on trends indicating the presence or absence of risks and uncertainties that could result in material adverse changes in the condition of the Fund as measured by the HECM Cash Flow NPVs.**

Sections 2 and 4 provide a discussion of the economic conditions that could result in material adverse condition of the Cash Flow NPV.

**Deliverable 8: Validation of interim and final claim rates, non-claim termination rates, and loss severities.**

Appendix F shows the interim and final claim rates, non-claim termination rates and loss severities by cohort. Each of these elements is calculated for each year of developed experience, and final projections are also included.

**Deliverable 9: An appendix of all econometric estimations used to include variable definitions (including scale of units), equation specifications, and results including coefficients, goodness of fit measures and other evaluation statistics.**

Appendix B shows the predictive model parameters and goodness of fit measures for the Termination and Real Estate Sales models. Appendix C shows the parameters and goodness of fit measures for the Cash Draw models. See the Model Parameters and Model Validation sections.

**Deliverable 10: Two-way tables by loan cohort and policy year of claim rates, non-claim termination rates, loss severities by major product type including a blend of actual and projected values for fiscal years 1990 to 2067 for HECM mortgages.**

Two-way tables by loan cohort and policy year of claim rates, non-claim termination rates, and loss severities are shown in Appendix F.

# Executive Summary

FHA provides reverse mortgage insurance through the HECM program. HECMs enable senior homeowners to access the value of their homes. The program began as a pilot program in 1989 and became permanent in 1998. Between 2003 and 2008, the number of HECM endorsements grew because of increasingly widespread product awareness, lower interest rates, higher home values and higher FHA mortgage limits. Prior to fiscal year 2009, the HECM program was part of the General Insurance (GI) Fund. The FHA Modernization Act within the Housing and Economic Recovery Act of 2008 (HERA) moved all new HECM program endorsements into the MMIF effective October 1, 2008.

The Cranston-Gonzalez National Affordable Housing Act (NAHA), enacted in 1990, introduced a minimum capital requirement for MMIF[1]. By 1992, the capital ratio was to be at least 1.25%, and by 2000 the capital ratio was to be no less than 2.0%. The capital ratio is defined by NAHA as the ratio of capital plus Cash Flow NPV to unamortized insurance-in-force (IIF). NAHA also implemented the requirement that an independent actuarial study of the MMIF be completed annually. HERA also amended 12 USC 1708(a)-(4) to include the requirement for the annual actuarial study. Accordingly, an actuarial review must be conducted on HECM mortgages within the MMIF. In this report, we analyze the HECM portion of the MMIF, which is mortgages endorsed in fiscal year 2009 and later.

**Pinnacle projects that, as of the end of fiscal year 2017, the HECM Cash Flow NPV is negative $14.217 billion.**

To project the Cash Flow NPV, Pinnacle analyzed all HECM historical terminations and associated recoveries using mortgage-level HECM performance data provided by FHA through September 30, 2018. We developed mortgage-level models using various economic and mortgage-specific factors. We then estimated the future mortgage performance of all active mortgages as of the end of fiscal year 2018 using various assumptions, including macroeconomic forecasts from OMB, Moody's, and HECM portfolio characteristics.

## Impact of Economic and Mortgage Factors

The projected Cash Flow NPV depends on various economic and mortgage-specific factors. These include the following:

- House Price Index (HPI): HPI reflects the relative change in housing prices from period to period. HPI rates impact the recovery FHA receives upon mortgage terminations and the rate at which borrowers will refinance or move out of their property. HPI projections are obtained from OMB and Moody's Scenario projections.
- 1-year and 10-year Constant Maturity Treasury (CMT) rates and 1-year London Interbank Offered Rate (LIBOR) rate: Interest rates impact the growth rate of mortgage balances and the amount of equity available to borrowers at origination. Interest rate projections used in the cash flow projections are from the OMB projections and Moody's Scenario projections.

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

- Mortality Rates: Information on the date of death of borrowers and co-borrowers have either been directly obtained or derived from the U.S. Decennial Life Table for the 1990-1991, 1999-2001, and 2001-2012 populations, published by the Center for Disease Control and Prevention (CDC) or from the Social Security Administration.
- Cash Drawdown Rates: These rates represent the speed at which borrowers access the equity in their homes over time, which impacts the growth of the mortgage balance. Predictive models have been developed to estimate borrower cash draw rates based on past HECM program experience, borrower characteristics and the economic environment.

The realized Cash Flow NPV will vary from the estimates in this analysis if the actual drivers of mortgage performance deviate from the projections based on the OMB Economic Assumptions. Table 4 presents the Cash Flow NPV from the projections based on the OMB Economic Assumptions and ten scenarios from Moody's. Each scenario estimates the Cash Flow NPV under a specific future path of interest, unemployment and HPI. We have also developed a Cash Flow NPV estimate based on an aggregate analysis. The range of Cash Flow NPV estimates based on the alternative economic scenarios is negative $20.487 billion to negative $7.211 billion.

*Table 4: HECM Cash Flow NPV Based on Alternative Economic Scenarios*

| Economic Scenario | Fiscal Year 2018 Cash Flow NPV |
|---|---|
| Pinnacle ACE | -14,217,158,723 |
| Moody's Baseline | -11,489,789,437 |
| Moody's Exceptionally Strong Growth | -7,211,294,581 |
| Moody's Stronger Near-Term Rebound | -9,435,876,155 |
| Moody's Slower Near Term Growth | -11,773,104,959 |
| Moody's Moderate Recession | -11,894,405,578 |
| Moody's Protracted Slump | -20,487,180,861 |
| Moody's Below-Trend Long-Term Growtl | -13,064,863,338 |
| Moody's Stagflation | -15,675,226,372 |
| Moody's Next Cycle Recession | -12,733,281,940 |
| Moody's Low Oil Price | -11,343,537,632 |

The scenario that produces the highest (least negative) HECM Cash Flow NPV is the Exceptionally Strong Growth scenario. The Protracted Slump scenario produces the worst (most negative) Cash Flow NPV.

We also randomly generated 100 stochastic simulations of key economic variables. Based on these simulations, we estimate that the range of reasonable Cash Flow NPV estimates is negative $21.181 billion to negative $1.904 billion. This range is based on an 80% likelihood that the ultimate Cash Flow NPV will fall within the lower and upper bound of the range.

## Distribution and Use

This report is being provided to FHA for their use and the use of makers of public policy in evaluating the Cash Flow NPV of the MMIF. Permission is hereby granted for its distribution on the condition that the entire report, including the exhibits and appendices, is distributed rather than any excerpt. Pinnacle also acknowledges that excerpts of this report will be used in preparing summary comparisons for FHA's Annual Report to Congress, and permission is granted for this purpose as well. We are available to answer any questions that may arise regarding this report.

Any third parties receiving the report should recognize that the furnishing of this report is not a substitute for their own due diligence and should place no reliance on this report or the data contained herein that would result in the creation of any duty or liability by Pinnacle to the third party.

Our conclusions are predicated on a number of assumptions as to future conditions and events. These assumptions, which are documented in subsequent sections of the report, must be understood in order to place our conclusions in their appropriate context. In addition, our work is subject to inherent limitations, which are also discussed in this report.

## Reliances and Limitations

Listed in Section 5 are the data sources Pinnacle has relied on in our analysis. We have relied on the accuracy of these data sources in our calculations. If it is subsequently discovered that the underlying data or information is erroneous, then our calculations would need to be revised accordingly.

We have relied on a significant amount of data and information without auditing or verifying the accuracy of the data. This includes economic data projected over the next 30 years from Moody's and the OMB. However, we did review as many elements of the data and information as practical for reasonableness and consistency with our knowledge of the mortgage insurance industry. It is possible that the historical data used to develop our estimates may not be predictive of future default and loss experience. We have not anticipated any extraordinary changes to the legal, social or economic environment which might affect the number or cost of mortgage defaults beyond those contemplated in the economic scenarios described in this report. To the extent that realized experience deviates significantly from these assumptions, the actual results may differ, perhaps significantly, from estimated results.

The predictive models used in this analysis are based on a theoretical framework and certain assumptions. These models predict the termination rates, cash flow draws and net loss based on a number of individual mortgage characteristics and economic variables. The parameters of the predictive models are estimated over a wide variety of mortgages that originated since 1989 and their performance under the range of economic conditions and mortgage market environments experienced. The models are combined with assumptions about future mortgage endorsements and certain key economic assumptions to produce future projections of the Cash Flow NPV. Although the models are based on mortgages from as far back as 1989, the results presented in the report are only related to mortgages endorsed in fiscal year 2009 and later, as this is when the HECM mortgages

were added to the MMIF.

Pinnacle is not qualified to provide formal legal interpretation of federal legislation or FHA policies and procedures. The elements of this report that require legal interpretation should be recognized as reasonable interpretations of the available statutes, regulations and administrative rules.

# Section 1. Introduction

## Scope

FHA has engaged Pinnacle to perform an annual independent actuarial study of the MMIF. This study is required by 12 USC 1708(a)-(4) and must be completed in compliance with the Federal Credit Reform Act as implemented and all applicable Actuarial Standards of Practice (ASOPs).

The FHA Modernization Act within the HERA moved all new endorsements for FHA's HECM program from the GI Fund to the MMIF starting in fiscal year 2009. Therefore, an actuarial review must also be conducted on the HECM portfolio within the MMIF. This report provides the estimated HECM Cash Flow NPV as of June 30, 2018.

The MMIF is a group of accounts of the federal government which records transactions associated with the FHA's guaranty programs for single family mortgages. Currently, the FHA insures approximately 7.94 million forward mortgages under the MMIF and 392,000 reverse mortgages under the HECM program.

Per 12 USC 1711-(f), the FHA must ensure that the MMIF maintains a capital ratio of not less than 2.0%. The capital ratio is defined as the ratio of capital to MMIF obligations on outstanding mortgages (IIF). Capital is defined as cash available to the Fund plus the Cash Flow NPV that is expected to result from the outstanding HECMs insured by the MMIF.

The deliverables included in this study are:

1. Articulate the Actuary's conclusion regarding the reasonableness of the HECM Cash Flow NPV as presented in FHA's Annual Report to Congress and the Actuary's best estimate and range of reasonable estimates, including estimates at the 90th, 95th and 99th percentiles of the adverse tail of the distribution, and the basis of the range which led to the Actuary's conclusion. The study also must compare the Actuary's conclusions to the corresponding amounts in FHA's Annual Report.

2. Contain the Actuary's best estimate and range of reasonable estimates of the HECM Cash Flow NPV by program and cohort beginning with the 2009 cohort and continuing through the most recent cohort.

3. Reconcile the data used to prepare the Actuary's estimates with the data used by FHA to prepare its estimated MMIF liabilities for loan guaranty.

4. State clearly the assumptions and judgments on which the Actuary's estimates are based, the support for the assumptions and the sensitivity of the Actuary's estimates to alternative assumptions and judgments.

5. Contain narrative and technical components. The narrative component should provide sufficient detail to clearly explain to FHA and HUD management and auditors, OMB and Congressional offices the findings, recommendations and conclusions as well as their significance. The technical component must

trace the analysis from the basic data and assumptions to the conclusions.

6. Quantify in descending order of importance the underlying causes (changes in portfolio size, assumptions, economic conditions, methodology, loan performance, etc.) of change in the aggregate HECM Cash Flow NPVs from September 30, 2017, as presented in the 2017 actuarial review, through September 30, 2018.

7. Comment thoroughly on trends indicating the presence or absence of risks and uncertainties that could result in material adverse changes in the condition of the Fund as measured by the HECM Cash Flow NPVs.

8. Validation of interim and final claim rates, non-claim termination rates, and loss severities.

9. An appendix of all econometric estimations used to include variable definitions (including scale of units), equation specifications, and results including coefficients, goodness of fit measures and other evaluation statistics.

10. Two-way tables by loan cohort and policy year of claim rates, non-claim termination rates, loss severities by major product type including a blend of actual and projected values for fiscal years 2009 to 2067 for HECM mortgages.

## HECM Background

FHA insures reverse mortgages through the HECM program, which enables senior homeowners to borrow against the value of their homes. Since the inception of the HECM program in 1989, FHA has insured nearly 1.1 million reverse mortgages. The following conditions must be met to be eligible for a HECM:

1. at least one of the homeowners must be 62 years of age or older,
2. if there is an existing mortgage, the outstanding balance must be paid off with the HECM proceeds and
3. 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 as long as the borrowers continue to live in the home and meet FHA guidelines on requirements for paying property taxes and homeowner's insurance premiums and for maintaining the property in a reasonable condition. A HECM terminates for reasons including death, moving out of the home and refinance. The existence of negative equity does not require borrowers to pay off the mortgage and it 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. When a mortgage terminates and the mortgage balance is greater than the net sale price of the home, the lender can file a claim for loss up to the maximum claim amount (MCA). 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.

### Maximum Claim Amount

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 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.

### Principal Limits and Principal Limit Factors

FHA manages its insurance risk by limiting the percentage of the initial available equity that a HECM borrower can draw by use of a PLF. The PLF is similar conceptually to the loan-to-value (LTV) ratio applied to a traditional mortgage. For a HECM, the MCA is multiplied by the PLF, which is determined according to the HECM program features and the borrower's age and gender. The result is the maximum HECM Principal Limit (PL) available to be drawn by the applicant. The PLF increases with the borrower's age at HECM origination and decreases as the expected mortgage interest rate increases. Over the course of the mortgage, the PL grows at a rate equal to the sum of the mortgage interest, the Mortgage Insurance Premium (MIP) and the servicing fees. Borrowers can continue to draw cash as long as the mortgage balance is below the current PL (except for the tenure plan, which acts as an annuity)[2].

### Payment Plans

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

- Tenure plan: a fixed monthly cash payment as long as the borrowers stay in their home;

[2] Mortgagee Letter 97-15, April 24, 1997: Home Equity Conversion Mortgage (HECM) Insurance Program – Implementation of Final Rule and Other Information.

- Term plan: a fixed monthly cash payment over a specified number of years;
- Line of credit: the ability to draw on allowable funds at any time; and
- Any combination of the above.

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

### Unpaid Principal Balance 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.

### Mortgage Terminations

When a HECM terminates, the current mortgage balance becomes due. If the net sales proceeds from the home sale exceed the mortgage 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 mortgage 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. HECMs are non-recourse, so the property is the only collateral for the mortgage; no other assets or the income of the borrowers can be accessed to cover any shortfall.

### 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 as long as the mortgage balance is below the current PL. The only exception is that borrowers on the tenure plan are not constrained by the 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.

## Report Structure

The remainder of this report consists of the following sections:

- **Section 2. Summary of Findings** – presents the estimated Cash Flow NPV for the HECM portfolio as of the end of fiscal year 2017. It also provides a step-by-step analysis of changes from last year's Review.

- **Section 3. HECM NPV Based on Alternative Scenarios** – presents the HECM portfolio Cash Flow NPV using alternative economic scenarios.

- **Section 4. Characteristics of MMI HECMs** – presents various characteristics of HECM endorsements for fiscal years 2009 through 2018.

- **Section 5. Summary of Methodology** – presents an overview of the data processing and reconciliation, base termination models, cash draw models for mortgages with a line of credit and cash flow models used to estimate the Cash Flow NPV.

- **Appendix A: Data: Sources, Processing and Reconciliation** – provides a description of the data sources used for the analysis, the data processing required to prepare the data for analysis and the data reconciliation performed.

- **Appendix B. HECM Base Termination Model** – provides a technical description of the loan performance model for the causes of loan termination.

- **Appendix C. Cash Flow Draw Projection Model** – provides a description of the model to project the cash draws by period for loans that have a line of credit.

- **Appendix D. Economic Scenarios** – describes the forecast of future values of economic factors that affect the performance of the MMIF and presents the variation in estimated economic value based on the additional economic scenarios. We also present the details of the stochastic analysis.

- **Appendix E. HECM Cash Flow Analysis** – provides a technical description of the cash flow model covering the various sources of cash inflows and outflows that HECM loans generate.

- **Appendix F**: Summary of Historical and Projected Claim Rates, Non-Claim Termination Rates and Loss Severities

# Section 2. Summary of Findings

This section presents the projected HECM Cash Flow NPV for fiscal year 2018. This review covers mortgages that were endorsed in fiscal year 2009 and subsequent and are still in force as of the end of fiscal year 2018. Data through June 30, 2018 was used to estimate the Cash Flow NPV.

## Fiscal Year 2018 Net Present Value Estimate

The Cash Flow NPV of in-force HECM's consists of discounted cash inflows and outflows. HECM cash inflows consist of MIP and recoveries. Cash outflows consist of claims and note-holding expenses. The cash flow model projects cash inflows and outflows using economic forecasts and mortgage performance projections. The Cash Flow NPV is estimated to be negative $14.217 billion as of the end of fiscal year 2018. This estimate is the result of the cash flow projections based on the 2019 OMB Mid-Term Review of the President's Economic Assumptions.

According to NAHA, IIF is defined as the "obligation on outstanding mortgages." We calculate the IIF as the total UPB of all HECM's remaining in the insurance portfolio as of June 30, 2018. Table 5 shows the Cash Flow NPV and IIF for active HECM's by cohort.

*Table 5: Cash Flow NPV and IIF by Cohort*

| Cohort | Net Present Cash Flow of Future Cash Flows ($ Millions) | Insurance-In-Force ($ Millions) |
|---|---|---|
| 2009 | -2,768 | 11,951 |
| 2010 | -1,659 | 6,662 |
| 2011 | -1,280 | 6,647 |
| 2012 | -1,281 | 6,142 |
| 2013 | -1,767 | 7,891 |
| 2014 | -779 | 5,582 |
| 2015 | -915 | 6,752 |
| 2016 | -939 | 6,448 |
| 2017 | -1,502 | 8,078 |
| 2018 | -1,328 | 6,225 |
| | | |
| Total | -14,217 | 72,378 |

The Pinnacle Cash Flow NPV estimate compared to the FHA estimate by cohort is shown below.

*Table 6: Comparison of Cash Flow NPV by Cohort*

| | Cash Flow NPV | | |
|---|---|---|---|
| Cohort | Pinnacle | FHA | Difference |
| 2009 | -2,768 | -3,276 | 509 |
| 2010 | -1,659 | -1,729 | 71 |
| 2011 | -1,280 | -1,421 | 141 |
| 2012 | -1,281 | -1,308 | 27 |
| 2013 | -1,767 | -1,716 | -51 |
| 2014 | -779 | -801 | 22 |
| 2015 | -915 | -1,040 | 124 |
| 2016 | -939 | -1,099 | 160 |
| 2017 | -1,502 | -1,811 | 309 |
| 2018 | -1,328 | -1,546 | 219 |
| | | | |
| Total | -14,217 | -15,747 | 1,530 |

The difference between the Pinnacle and FHA estimate is $1.530 billion, which is 2.1% of the HECM IIF. The Pinnacle estimates of Cash Flow NPV by cohort are lower (more negative) than the FHA estimates for cohort 2013, and are higher (less negative) for the remaining cohorts.

## Change in the Cash Flow NPV

Table 7 shows the comparison of our estimate of the Cash Flow NPV at the end of fiscal year 2017 and the current estimate. The present value of future cash flows of the current book of business is estimated to be negative $14.217 billion.

*Table 7: Estimate of Cash Flow NPV as of the end of Fiscal Year 2018 ($ in millions)*

| Item | 2017 | 2018 | Percent Change |
|---|---|---|---|
| Cash Flow NPV | -14,223 | -14,217 | 0.0% |
| Insurance-In-Force | 70,291 | 72,378 | 3.0% |

As seen in Table 7, the estimated fiscal year 2018 Cash Flow NPV has increased by $6 million from the level estimated in fiscal year 2017, from -$14.223 billion to -$14.217 billion. The unamortized IIF decreased by 3.0% – from $70.291 billion to $72.378 billion. The change in the Cash Flow NPV represents the net impact of several significant factors, which are described in detail in the next section.

## Sources of Change from the Fiscal Year 2017 Review to the Fiscal Year 2018 Review

Table 8 provides a summary of the decomposition of changes in the Cash Flow NPV of the MMIF as of the end of fiscal year 2018 as compared to the Cash Flow NPV in the fiscal year 2017 report. The overall net change in the Cash Flow NPV is negative.

*Table 8: Changes in Projected Cash Flow NPV ($ in Millions)*

| | Change in NPV | Cash Flow NPV - 9/30/18 |
|---|---|---|
| **Baseline FY2009-FY2017** | | -14,223,318,906 |
| Impact of assumption change | 1,102,066,301 | -13,121,252,605 |
| Impact of model change | -1,035,614,824 | -14,156,867,429 |
| Impact of book change | 1,267,359,664 | -12,889,507,765 |
| FY2009-FY2017 | 1,333,811,141 | |
| FY2018 | -1,327,650,958 | -14,217,158,723 |
| **Cumulative Change** | 6,160,183 | |

This section describes the sources of change in estimates of Cash Flow NPV between this year's review and last year's review. Separating out the specific impacts can be done only up to a certain degree of accuracy, because it depends on the order in which the decomposition is done. The interdependency among the various components of the analysis prevents us from identifying and analyzing these as purely independent effects. Given this limitation, this section presents a description of the approximate differences in the Cash Flow NPV from that presented in the fiscal year 2017 review by source of change.

## Update Economic Scenario Forecast

For this decomposition step, we updated the forecasts for the purchase-only HPI, and the interest and unemployment rates from 2018 PEA forecast to the 2019 PEA forecast. There was not a significant change in the HPA forecast. Short term treasury rate projected are lower than the projections used in the 2017 Actuarial Report, and the projected mortgage rates are also lowered in the PEA's forecast this year. The net impact of these changes is an increase of $1.102 billion in the projected Cash Flow NPV.

## Update Predictive Models

In fiscal year 2018, we continued to refine the predictive models to better capture the termination and cash draw behavior of loans in the MMIF. We re-estimated the models using updated data and revised variable specifications. The model changes with the largest impacts including the refining of note holding expenses and including debenture interest on CT1 claim costs. For details about these model updates and refinements, refer to Appendices B, C and E.

These model changes led to a decrease in estimated economic value in the Cash Flow NPV of $1.036 billion.

## Actual Performance of Fiscal Year 2017 to Fiscal Year 2018

The actual performance of the MMIF for cohorts 2009 – 2017 realized during fiscal year 2017 affects the Cash Flow NPV of the MMIF estimate of the in-force portfolio. The actual experience for this period was $1.267 billion better than expected.

## Fiscal Year 2018 Origination Volume

The addition of the origination volume for the fiscal year 2018 book of business decreased the Cash Flow NPV projection by $1.328 billion.

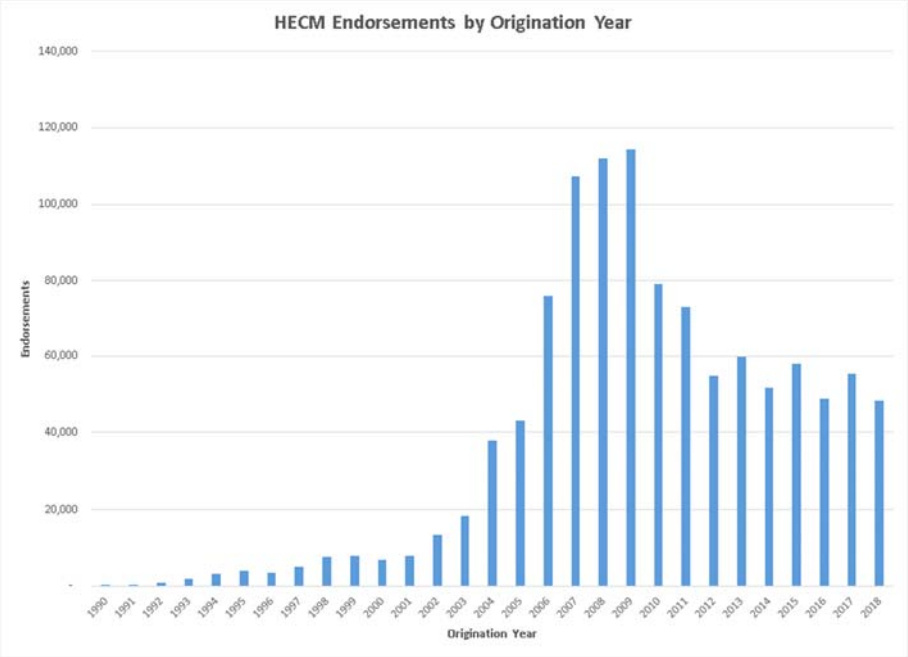
# Section 3. Characteristics of HECM Fund Endorsements

This section presents the characteristics of the HECM portfolio for the HECM loans endorsed from fiscal year 2009 through fiscal year 2018. HECM loans were first included in the MMIF in fiscal year 2009. The loans from these books of business that are still active constitute the HECM Fund portfolio as of the end of fiscal year 2018. A review of the characteristics of these cohorts helps define the current risk profile of HECM Fund. Some of the characteristics of previous books are shown as well to demonstrate trends.

## Volume and Share of Mortgage Originations

FHA endorsed 48,327 HECM loans in fiscal year 2018, with a total MCA of $16.189 billion. The total number of endorsements for fiscal years 2009 to 2018 was 643,444. The corresponding MCA was $175.398 billion. Since the inception of the HECM program, this program has been the largest reverse mortgage product in the U.S. market, representing the vast majority of reverse mortgages. Figure 1 presents the count of HECM endorsements by fiscal year.

*Figure 1: Number of HECM Endorsements by Cohort*




## Payment Types

HECM borrowers receive loan proceeds by selecting from term, line of credit, and tenure payment plans. Borrowers can also choose a combination of payment plan types. Table 9 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 90% of the endorsements since fiscal year 2009.

*Table 9: Distribution of HECM Loans by Payment Type*

| Origination Year | Term | Line of Credit | Tenure | Term Plus Line of Credit | Tenure Plus Line of Credit |
|---|---|---|---|---|---|
| 2009 | 0.8% | 91.8% | 1.6% | 3.7% | 2.1% |
| 2010 | 0.5% | 94.2% | 0.9% | 2.8% | 1.6% |
| 2011 | 0.4% | 94.4% | 0.9% | 2.8% | 1.5% |
| 2012 | 0.3% | 94.8% | 0.9% | 2.6% | 1.4% |
| 2013 | 0.4% | 94.9% | 0.9% | 2.4% | 1.3% |
| 2014 | 0.7% | 93.2% | 1.5% | 3.0% | 1.6% |
| 2015 | 0.7% | 93.6% | 1.2% | 2.8% | 1.7% |
| 2016 | 0.8% | 93.3% | 1.3% | 3.0% | 1.7% |
| 2017 | 0.8% | 93.2% | 1.3% | 2.9% | 1.8% |
| 2018 | 0.9% | 94.0% | 1.1% | 2.4% | 1.6% |

## Interest Rate Types

HECM borrowers can select fixed or adjustable rate mortgages. Table 10 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 the significant drop in interest rates beginning in the last half of 2008. This percentage persisted in fiscal years 2011 - 2013. Subsequent to this, 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 2018 it has dropped to 10%.

The LIBOR indexed loans were in the 30 to 40% range for fiscal years 2009 to 2013. In fiscal year 2014, the percentage of LIBOR indexed loans increased to 81%, as the fixed-rate option correspondingly declined in popularity. As of fiscal year 2018, this percentage has increased to 90%. Monthly adjustable LIBOR loans were more popular in fiscal year 2014, however in fiscal years 2016 - 2018 the annually adjustable LIBOR loans are significantly more popular. This is due, in part, to the fact that in 2014 HUD limited the insurability of fixed interest rate mortgages under the HECM program to mortgages with the Single Disbursement Lump Sum payment option.

*Table 10: Distribution of HECM Loans by Interest Rate Type*

| Origination Year | Libor Indexed | | Treasury Indexed | | Fixed |
|---|---|---|---|---|---|
| | Annually Adjustable | Monthly Adjustable | Annually Adjustable | Monthly Adjustable | |
| 2009 | 0.02% | 34.61% | 0.65% | 53.09% | 11.63% |
| 2010 | 0.01% | 30.58% | 0.01% | 0.50% | 68.90% |
| 2011 | 0.01% | 31.89% | 0.00% | 0.06% | 68.03% |
| 2012 | 0.00% | 30.46% | 0.01% | 0.12% | 69.41% |
| 2013 | 0.00% | 39.35% | 0.00% | 0.02% | 60.63% |
| 2014 | 2.40% | 78.93% | 0.00% | 0.00% | 18.67% |
| 2015 | 39.92% | 44.28% | 0.05% | 0.01% | 15.75% |
| 2016 | 75.25% | 13.90% | 0.21% | 0.00% | 10.64% |
| 2017 | 86.13% | 3.53% | 0.01% | 0.00% | 10.34% |
| 2018 | 88.43% | 1.42% | 0.01% | 0.00% | 10.15% |

## Product Type

Almost all the loans endorsed in fiscal years 2009 through 2018 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 Table 11. The distribution of HECMs for Purchase loans had been increasing slowly from 2009 – 2016, but have leveled off since 2016. The percentage of HECMs for Purchase with first month cash draws over 90% has increased since 2009. In our analysis, the traditional and for-purchase HECMs are treated the same.

*Table 11: Distribution of HECM Loans by Product Type*

| Origination Year | Traditional HECMs | HECMs for Purchase | |
|---|---|---|---|
| | | First Month Cash Draw < 90% of Initial Principal Limit | First Month Cash Draw >= 90% of Initial Principal Limit |
| 2009 | 99.51% | 0.06% | 0.42% |
| 2010 | 98.24% | 0.12% | 1.64% |
| 2011 | 97.90% | 0.04% | 2.07% |
| 2012 | 97.03% | 0.06% | 2.91% |
| 2013 | 96.51% | 0.04% | 3.45% |
| 2014 | 96.46% | 0.05% | 3.49% |
| 2015 | 95.84% | 0.13% | 4.03% |
| 2016 | 95.16% | 0.34% | 4.51% |
| 2017 | 95.24% | 0.36% | 4.40% |
| 2018 | 95.15% | 0.40% | 4.45% |

## State

Among all endorsements in fiscal years 2009 through 2018, over half were originated in the top 10 states as

measured by loan counts. California had the highest endorsement volume every year over this period, while Florida has had the second highest endorsement volume since 2016. The endorsement volume in Texas increased significantly from fiscal year 2009 to fiscal year 2017 and is now about 1% lower than Florida. The endorsement volume in New York has decreased from a high of 7.2% in fiscal year 2012 to 3.8% in fiscal year 2018. The endorsement breakdown of the top 10 states is shown in Table 12.

*Table 12: Distribution of HECM Loans by State*

| State | Origination Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| California | 13.7% | 14.0% | 13.5% | 12.7% | 14.1% | 17.5% | 20.3% | 21.8% | 23.7% | 22.7% |
| Florida | 13.2% | 9.0% | 6.8% | 6.1% | 6.5% | 6.9% | 8.3% | 8.8% | 8.7% | 8.4% |
| Texas | 6.6% | 8.0% | 9.1% | 8.9% | 8.6% | 7.4% | 7.0% | 7.6% | 7.6% | 7.4% |
| Colorado | 1.8% | 1.8% | 1.9% | 2.0% | 2.1% | 2.3% | 2.4% | 3.7% | 5.4% | 5.9% |
| Washington | 2.8% | 3.0% | 2.5% | 2.3% | 2.3% | 2.1% | 2.3% | 2.7% | 3.2% | 4.3% |
| Arizona | 3.1% | 2.1% | 2.0% | 1.8% | 2.4% | 2.9% | 3.2% | 3.6% | 3.7% | 4.0% |
| New York | 5.3% | 5.9% | 5.9% | 7.2% | 6.4% | 5.9% | 5.7% | 4.8% | 4.2% | 3.8% |
| Oregon | 2.7% | 2.3% | 1.8% | 1.7% | 1.4% | 1.4% | 1.4% | 1.9% | 2.4% | 2.6% |
| Pennsylvania | 3.2% | 3.7% | 4.5% | 4.8% | 4.7% | 4.5% | 3.9% | 2.9% | 2.5% | 2.5% |
| North Carolina | 1.8% | 2.0% | 2.6% | 2.8% | 3.1% | 2.6% | 2.4% | 2.5% | 2.3% | 2.5% |

## Maximum Claim Amount

The MCA is the minimum of the FHA HECM loan limit and the appraised value (or if a HECM for Purchase, the minimum of the purchase price and appraised value, not to exceed the HECM loan limit). It is used as the basis of the initial principal limit determination and as the cap on the potential insurance claim amount. Table 13 shows the distribution of HECM endorsements by the MCA. Approximately 65% of loans endorsed in fiscal year 2009 had an MCA of less than $300,000, and this percentage increased to 73% by fiscal year 2012. Since then, the percentage of endorsements less than $300,000 have decreased steadily to 51% for fiscal year 2018.

The percentage of endorsements with an MCA between $300,000 and $417,000 dropped from 23% in 2009 and had been around 12% - 13% percent for fiscal years 2010 through 2014, but has since risen to 19.4% in 2018. The percentage of endorsements with an MCA greater than $417,000 has increased consistently since 2012, and now is at 30.3%.

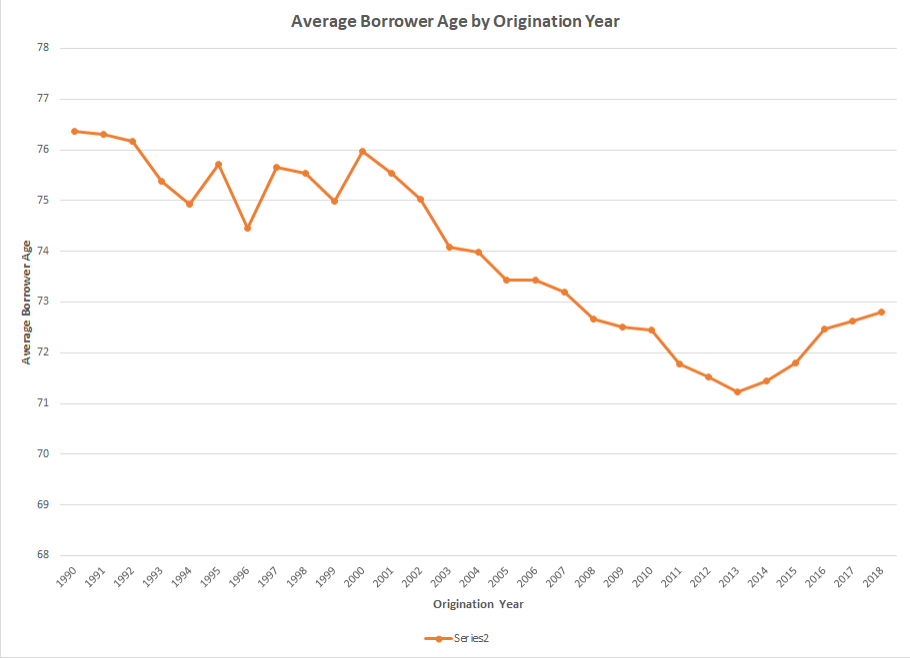
*Table 13: Distribution of HECM Loans by MCA*

| Origination Year | Less Than $100K | $100K to $200K | $200K to $300K | $300K to $417K | Greater Than $417K |
|---|---|---|---|---|---|
| 2009 | 10.2% | 32.4% | 22.7% | 23.3% | 11.3% |
| 2010 | 12.9% | 34.3% | 19.9% | 12.9% | 20.0% |
| 2011 | 15.7% | 35.9% | 19.3% | 12.0% | 17.1% |
| 2012 | 17.0% | 37.0% | 18.7% | 11.8% | 15.5% |
| 2013 | 16.5% | 36.4% | 18.7% | 12.2% | 16.2% |
| 2014 | 13.7% | 34.3% | 19.6% | 13.2% | 19.1% |
| 2015 | 11.6% | 31.7% | 20.6% | 14.5% | 21.6% |
| 2016 | 8.3% | 28.6% | 21.8% | 16.0% | 25.3% |
| 2017 | 5.9% | 25.3% | 22.6% | 17.8% | 28.4% |
| 2018 | 4.4% | 23.2% | 23.2% | 19.0% | 30.3% |

## Borrower Age Distribution

The borrower age profile of an endorsement year affects loan termination rates and the PL available to the borrower. Figure 2 shows the average borrower age at origination over fiscal years 1990 through 2018. The average borrower age has been declining over the entire period. Younger borrowers represent a higher financial risk exposure for FHA as they have a longer life expectancy. To manage this risk, the PLFs, which limit the percentage of initial equity available to the borrower, are lower for younger borrowers, limiting their access to a smaller portion of the equity in the house. The average borrower age has been around 72 years old since fiscal years 2008.

*Figure 2: Average Borrower Age at Origination Year*



## Borrower Gender

Gender also affects termination behavior due to differences in mortality rates. The gender distribution of the HECM portfolio has remained steady over time. HECM loan behavior indicates that single males tend to terminate their loans the quickest, followed by single females, with couples terminating the slowest. Table 14 shows the gender distribution of HECM endorsements. Single females comprised the largest gender cohort of the fiscal year 2010 endorsements at 42%, followed by couples at 35%, and single males at 21%. A similar pattern is observed for fiscal years 2011 and 2012. In fiscal years 2013 to 2015, couples comprise 39%, surpassing single females to become the largest gender cohort. The single female share fell to around 37% while single males remained the lowest at 21%, about the same as in prior years. The concentration in couples has risen to 41% in 2018.

*Table 14: Distribution of HECM Loans by Borrower Gender*

| Origination Year | Male | Female | Couple | Missing |
|---|---|---|---|---|
| 2009 | 21.69% | 40.92% | 36.75% | 0.63% |
| 2010 | 21.47% | 41.87% | 35.25% | 1.41% |
| 2011 | 20.86% | 40.25% | 37.07% | 1.81% |
| 2012 | 21.20% | 39.14% | 37.34% | 2.32% |
| 2013 | 21.14% | 37.55% | 38.95% | 2.35% |
| 2014 | 20.63% | 38.73% | 38.65% | 1.99% |
| 2015 | 21.85% | 38.51% | 38.89% | 0.74% |
| 2016 | 21.64% | 36.82% | 41.05% | 0.48% |
| 2017 | 20.93% | 37.14% | 40.92% | 1.00% |
| 2018 | 20.45% | 36.26% | 41.31% | 1.98% |

## Cash Draw Distribution

Data show that loans which have drawn a higher percentage of the initial amount of equity available tend to have a higher likelihood of refinancing. Table 15 shows the distribution of the cash draw in the first month as a percentage of the initial PL by age group for HECM endorsements.

Younger borrowers tend to draw a higher percentage of the initial amount of equity available than older borrowers. In fiscal year 2009, 69% of the 62-65 age group drew over 60% of their initial PL, compared with 58% for the greater-than-85-year-old age group. The incidence of initial draws above 60% of the PL rose sharply to nearly 80% for all age groups for fiscal years 2010 through 2013. This was mainly driven by the disproportionally high initial draws incurred by most fixed-rate HECMs during that period. In 2014 HUD limited the insurability of fixed interest rate mortgages under the HECM program to mortgages with the Single Disbursement Lump Sum payment option. Also in the same year, HUD introduced a higher MIP charge of 2.50% if the initial draw amount exceeds 60% of the available PL, as compared to the 0.50% MIP rate if the initial draw amount was less than or equal to 60% of the available PL. The overall first-month draw over 60% fell from 80% in fiscal year 2013 to 50% in fiscal year 2018.

Although younger borrowers typically draw a higher percentage of the initial PL in the first month, the amount

of cash drawn represents a smaller percentage of the MCA because the PLF is lower for younger borrowers to account for the risk implied by their longer life expectancy.

*Table 15: First-Month Cash Draw as a Percentage of Initial PL*

| Origination Year | Age Group | Variable Rate Loans | | | Fixed Rate Loans | |
|---|---|---|---|---|---|---|
| | | 0-40% | 40-60% | 60-100% | 0-60% | 60-100% |
| 2009 | 62-65 | 20.02% | 10.72% | 58.76% | 0.11% | 10.39% |
| | 66-70 | 15.23% | 10.48% | 57.55% | 0.67% | 16.06% |
| | 71-75 | 12.65% | 10.44% | 63.62% | 0.08% | 13.22% |
| | 76-85 | 19.20% | 11.62% | 57.48% | 0.03% | 11.67% |
| | 86+ | 29.42% | 12.02% | 49.36% | 0.10% | 9.10% |
| | Total | 19.10% | 11.12% | 58.15% | 0.10% | 11.53% |
| 2010 | 62-65 | 16.18% | 6.49% | 11.65% | 0.27% | 65.41% |
| | 66-70 | 7.77% | 4.72% | 8.60% | 0.28% | 78.63% |
| | 71-75 | 8.68% | 4.78% | 8.71% | 0.20% | 77.63% |
| | 76-85 | 14.27% | 6.65% | 11.00% | 0.11% | 67.97% |
| | 86+ | 24.57% | 8.38% | 13.25% | 0.14% | 53.66% |
| | Total | 14.16% | 6.23% | 10.71% | 0.19% | 68.71% |
| 2011 | 62-65 | 18.85% | 6.27% | 9.76% | 0.21% | 64.90% |
| | 66-70 | 8.54% | 5.32% | 9.96% | 0.31% | 75.87% |
| | 71-75 | 10.08% | 5.70% | 9.78% | 0.22% | 74.22% |
| | 76-85 | 16.81% | 6.88% | 10.42% | 0.10% | 65.78% |
| | 86+ | 28.17% | 8.57% | 10.72% | 0.10% | 52.44% |
| | Total | 15.48% | 6.40% | 10.09% | 0.19% | 67.85% |
| 2012 | 62-65 | 17.88% | 6.72% | 9.66% | 0.15% | 65.59% |
| | 66-70 | 8.58% | 5.28% | 10.31% | 0.20% | 75.64% |
| | 71-75 | 10.74% | 5.60% | 9.72% | 0.13% | 73.81% |
| | 76-85 | 16.70% | 6.65% | 9.53% | 0.12% | 66.99% |
| | 86+ | 26.31% | 7.65% | 9.84% | 0.17% | 56.03% |
| | Total | 14.59% | 6.21% | 9.80% | 0.15% | 69.26% |
| 2013 | 62-65 | 16.46% | 6.81% | 18.96% | 0.32% | 57.45% |
| | 66-70 | 8.17% | 5.76% | 21.38% | 0.16% | 64.54% |
| | 71-75 | 10.68% | 5.58% | 19.95% | 0.16% | 63.62% |
| | 76-85 | 16.15% | 6.71% | 18.89% | 0.18% | 58.07% |
| | 86+ | 25.31% | 7.14% | 17.56% | 0.16% | 49.82% |
| | Total | 13.40% | 6.24% | 19.74% | 0.19% | 60.44% |
| 2014 | 62-65 | 19.95% | 30.00% | 33.37% | 1.90% | 14.79% |
| | 66-70 | 12.80% | 25.47% | 38.77% | 2.05% | 20.91% |
| | 71-75 | 16.66% | 24.50% | 38.96% | 1.93% | 17.95% |
| | 76-85 | 22.37% | 25.69% | 35.91% | 2.05% | 13.97% |
| | 86+ | 33.02% | 26.23% | 30.03% | 2.38% | 8.34% |
| | Total | 18.64% | 26.05% | 36.65% | 2.02% | 16.65% |
| 2015 | 62-65 | 17.70% | 38.91% | 29.04% | 0.69% | 13.66% |
| | 66-70 | 13.39% | 35.21% | 31.82% | 0.62% | 18.96% |
| | 71-75 | 16.60% | 33.91% | 31.89% | 0.59% | 17.01% |
| | 76-85 | 21.86% | 33.69% | 31.12% | 0.60% | 12.72% |
| | 86+ | 30.87% | 35.18% | 25.61% | 1.07% | 7.26% |
| | Total | 18.33% | 35.22% | 30.70% | 0.65% | 15.10% |
| 2016 | 62-65 | 19.80% | 38.13% | 31.29% | 0.79% | 9.98% |
| | 66-70 | 17.35% | 33.36% | 35.07% | 0.55% | 13.67% |
| | 71-75 | 19.31% | 32.11% | 36.80% | 0.32% | 11.46% |
| | 76-85 | 23.25% | 32.49% | 36.09% | 0.36% | 7.81% |
| | 86+ | 32.26% | 34.17% | 29.77% | 0.66% | 3.15% |
| | Total | 20.93% | 33.73% | 34.69% | 0.50% | 10.15% |
| 2017 | 62-65 | 19.25% | 34.70% | 33.62% | 1.06% | 11.36% |
| | 66-70 | 17.03% | 30.08% | 40.08% | 0.45% | 12.36% |
| | 71-75 | 18.80% | 28.64% | 41.13% | 0.48% | 10.94% |
| | 76-85 | 22.02% | 30.08% | 40.44% | 0.37% | 7.09% |
| | 86+ | 31.31% | 32.72% | 32.57% | 0.49% | 2.91% |
| | Total | 20.15% | 30.77% | 38.73% | 0.55% | 9.81% |
| 2018 | 62-65 | 19.36% | 33.11% | 37.11% | 0.63% | 9.80% |
| | 66-70 | 17.32% | 28.25% | 43.21% | 0.38% | 10.84% |
| | 71-75 | 19.71% | 27.14% | 44.36% | 0.30% | 8.48% |
| | 76-85 | 21.69% | 29.56% | 42.54% | 0.41% | 5.80% |
| | 86+ | 32.64% | 31.92% | 32.80% | 0.16% | 2.49% |
| | Total | 20.36% | 29.47% | 41.49% | 0.40% | 8.27% |

# Section 4. HECM Cash Flow NPV Based on Alternative Scenarios

The Cash Flow NPV of the MMIF will vary from our estimates if the actual drivers of mortgage performance deviate from the baseline projections associated with the OMB Economic Assumptions. In this section, we develop additional estimates of the Cash Flow NPV based on the following approaches:

1. Moody's economic scenarios
2. Stochastic simulation of key economic variables
3. Sensitivity testing of key economic variables

We use these additional estimates of the Cash Flow NPV to develop a range of estimates and associated percentiles. These alternative estimates were then compared to the Cash Flow NPV resulting from the OMB Economic Assumptions to determine the sensitivity of the Cash Flow NPV estimate to alternative assumptions.

Each Moody's scenario produces an estimate of the Cash Flow NPV using future interest, unemployment and HPI rates as a deterministic path.

The Moody's scenarios are:

- Baseline
- Exceptionally Strong Growth
- Stronger Near-Term Rebound
- Slower Near-Term Growth
- Moderate Recession
- Protracted Slump
- Below-Trend Long-Term Growth
- Stagflation
- Next-Cycle Recession
- Low Oil Price

The resulting Cash Flow NPV associated with each alternative scenario is summarized in Table 16. Below, we discuss the characteristics of each Moody's scenario.

## Moody's Baseline Assumptions

In this scenario, the HPI increases over the entire projection period, and the rate of change is consistently between 2.5% and 3.5%. The mortgage interest rate increases and settles at a long-term average of about 5.9%. The unemployment rate decreases to 3.4% over the next year, and then increases to a long-term average of around 5.0%.

## Exceptionally Strong Growth Scenario

In Moody's Exceptionally Strong Growth scenario, the HPI is projected to increase more quickly than under the

Baseline scenario. In addition, mortgage interest rates are projected to increase throughout the entire projection period. The unemployment rate also is lower than projected in the Baseline scenario throughout the entire projection period.

## Stronger Near-Term Rebound Scenario

In Moody's Stronger Near-Term Rebound scenario, the HPI is projected to increase at a higher rate than the Moody's scenario through the entire projection period. In addition, mortgage interest rates are projected to be higher than the Baseline scenario through 2022, then projected to be the same as the Baseline for the remainder of the projection period. The unemployment rate also is lower than projected in the Moody's scenario throughout the entire projection period.

## Slower Near-Term Growth Scenario

In Moody's Slower Near-Term Growth scenario, the HPI increases slowly than the Baseline scenario. Mortgage interest rates are projected to be flat through 2020, and then increase for the remainder of the projection period. The unemployment rate is projected to be higher than the Moody's assumptions for the entire projection period.

## Moderate Recession Scenario

In the Moderate Recession scenario, the HPI decreases through the end of 2019, and then begins to increase. Mortgage interest rates drop significantly through the end of 2019, and then begin to slowly increase until they reach the long-term average of about 6.0%. The unemployment rate spikes to 7.4% by 2020, and then recovers to a long-term average of just over 5%.

## Protracted Slump

In Moody's Protracted Slump scenario, the HPI decreases significantly over the next 18 months, and then begins to increase again. Mortgage interest rates drop until the second quarter of 2020, then begin to slowly increase until they reach the long-term average of just under 6%. The unemployment rate spikes to 8.3% by 2020, and then recovers to a long-term average of just over 5%.

## Below-Trend Long-Term Growth

In Moody's Below-Trend Long-Term Growth scenario, the HPI increases more slowly than in the Baseline scenario. Mortgage interest rates increase gradually and settle at a long-term average of about 5.6%. The unemployment rate increases to 5.9% by 2021, and then decreases to a long-term average of approximately 5.1%.

## Stagflation

In Moody's Stagflation scenario, the HPI decreases through the third quarter of 2020, and then begins to increase. Mortgage interest rates increase sharply to 6.4% by the first quarter of 2019, and then drop through the second quarter of 2021. They then begin to slowly increase to the long-term average of just under 6.0%. Unemployment rates increase significantly to just over 7.4% by 2020, and then decrease to a long-term average

of 5%.

## Next-Cycle Recession

In Moody's Next-Cycle Recession scenario, the HPI increases through the end of 2021, and then decreases significantly through the second quarter of 2022. The HPI then increases again. The mortgage interest rates increase through 2020, and then increase significantly to 6.2% in 2020. The rates then drop significantly, and then settle in at a long term average of about 6.0%. The unemployment rate is lower than the Baseline assumptions through the first quarter of 2020, and then increases sharply to over 8% by 2022. It then decreases to under 5% by 2025.

## Low Oil Price

In Moody's Low Oil Price scenario, the HPI increases throughout the entire projection period. Mortgage interest rates increase at a slow rate through 2020, and then increase at a higher rate through the remainder of the projection period. Unemployment rates decrease through 2019, and then increase for the remainder of the projection period, settling at a long-term average of 5%.

## Summary of Alternative Scenarios

Table 16 shows the projected Cash Flow NPV from the ten deterministic scenarios. The range of projected results is between negative $20.487 billion and negative $7.211 billion.

*Table 16: Cash Flow NPV Summaries from Alternative Scenarios*

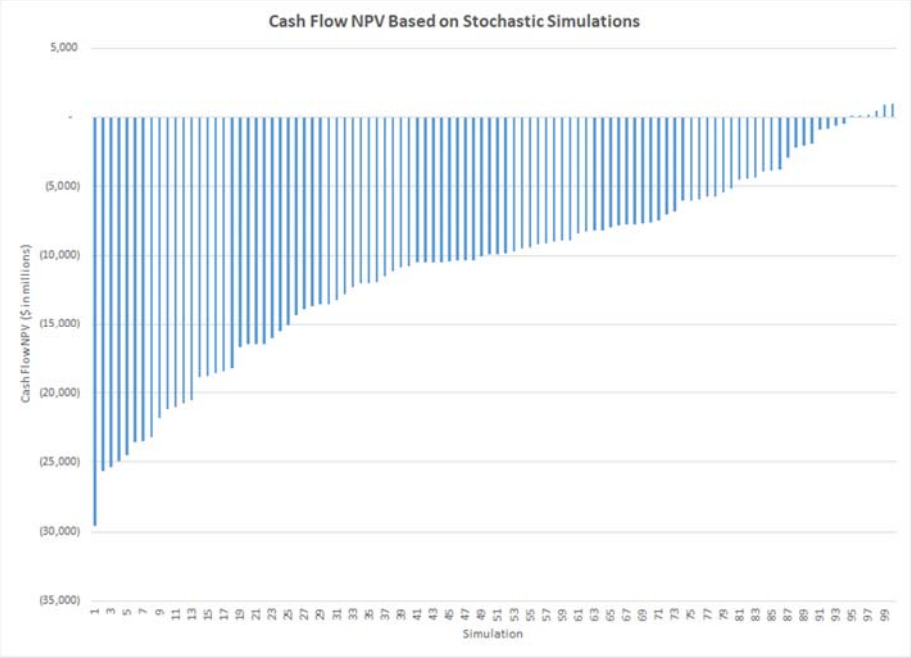
| Cohort | Pinnacle ACE | Moody's Baseline | Moody's Exceptionally Strong Growth | Moody's Stronger Near-Term Rebound | Slower Near Term Growth | Moderate Recession | Protracted Slump | Below-Trend Long-Term Growth | Stagflation | Next Cycle Recession | Low Oil Price |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | -2,767,895,839 | -2,588,667,739 | -2,142,573,477 | -2,411,165,668 | -2,583,117,998 | -2,440,507,671 | -3,385,248,341 | -2,750,184,535 | -3,325,126,846 | -2,793,039,731 | -2,528,086,800 |
| 2010 | -1,658,546,517 | -1,501,717,428 | -1,177,835,667 | -1,366,155,670 | -1,537,828,327 | -1,602,159,237 | -2,178,608,195 | -1,639,497,043 | -1,828,725,293 | -1,626,822,025 | -1,500,645,178 |
| 2011 | -1,280,041,592 | -1,161,465,412 | -896,162,508 | -1,038,148,721 | -1,180,065,408 | -1,196,043,376 | -1,719,642,321 | -1,261,528,696 | -1,442,990,923 | -1,256,072,613 | -1,157,264,580 |
| 2012 | -1,280,643,773 | -1,134,407,473 | -823,647,762 | -994,851,452 | -1,183,571,556 | -1,230,426,109 | -1,809,426,495 | -1,262,339,527 | -1,406,050,830 | -1,232,209,739 | -1,133,403,212 |
| 2013 | -1,767,219,874 | -1,554,690,704 | -1,067,672,988 | -1,335,791,277 | -1,588,725,713 | -1,663,226,140 | -2,505,728,029 | -1,687,535,918 | -1,956,602,628 | -1,687,229,266 | -1,535,205,510 |
| 2014 | -779,073,360 | -575,467,199 | -238,535,311 | -402,307,339 | -564,031,635 | -558,496,007 | -1,231,765,662 | -657,118,181 | -905,474,993 | -662,671,229 | -556,205,718 |
| 2015 | -915,472,176 | -622,134,390 | -188,130,731 | -391,605,259 | -630,732,437 | -646,014,179 | -1,569,275,544 | -776,662,235 | -1,040,397,604 | -748,859,703 | -606,263,617 |
| 2016 | -938,743,620 | -538,593,066 | -21,922,002 | -267,341,443 | -582,025,631 | -607,615,892 | -1,717,582,196 | -745,039,308 | -970,981,953 | -653,332,280 | -498,961,436 |
| 2017 | -1,501,871,014 | -905,479,030 | -227,861,597 | -562,470,838 | -978,105,590 | -1,038,274,414 | -2,425,342,653 | -1,202,147,647 | -1,486,348,960 | -1,080,341,816 | -907,412,403 |
| 2018 | -1,327,650,958 | -907,166,995 | -426,952,537 | -666,038,489 | -944,900,666 | -911,642,553 | -1,944,561,424 | -1,082,810,248 | -1,312,526,342 | -992,703,538 | -920,089,178 |
| | | | | | | | | | | | |
| Total | -14,217,158,723 | -11,489,789,437 | -7,211,294,581 | -9,435,876,155 | -11,773,104,959 | -11,894,405,578 | -20,487,180,861 | -13,064,863,338 | -15,675,226,372 | -12,733,281,940 | -11,343,537,632 |

## Stochastic Simulation

The stochastic simulation approach provides information about the probability distribution of the HECM Cash Flow NPV with respect to different possible future economic conditions and the corresponding terminations, cash flow draws and loss rates. The simulation provides the Cash Flow NPV associated with each one of the 100 possible future economic paths. The distribution of Cash Flow NPV based on these scenarios allows us to gain insights into the sensitivity of the Cash Flow NPV to different economic conditions.

The figure below shows the range of Cash Flow NPV resulting from the 100 simulated scenarios.

*Figure 3: Stochastic Simulation Results*




Based on these simulations, we estimate that the range of reasonable Cash Flow NPV estimates is negative $21.181 billion to negative $1.904 billion. This range is based on an 80% likelihood that the ultimate Cash Flow NPV will fall within the lower and upper bound of the range. The 90th, 95th and 99th percentiles of the stochastic simulation results are shown below:

- 90th percentile: - $1.904 billion
- 95th percentile: + $0.097 billion
- 99th percentile: + $0.908 billion

The Cash Flow NPV estimate provided by FHA to be used in the FHA's Annual Report to Congress is negative $15.747 billion. Based on Pinnacle's ACE estimate and range of reasonable estimates, we conclude that the FHA estimate of Cash Flow NPV is reasonable.

## Sensitivity Tests of Economic Variables

The above scenario analyses were conducted to estimate the distribution of the Cash Flow NPV of the MMIF with different possible combinations of economic variable movements in the future. It is also useful to understand the marginal impact of a change in each single economic factor on the Cash Flow NPV. Below, we show the sensitivity of the Cash Flow NPV with respect to the change of a single economic factor at a time. This sensitivity test is conducted for the House Price Appreciation (HPA) and interest rates.

The marginal impact is measured by the change of the Cash Flow NPV based on the OMB scenario. These simulations change each of these variables one at a time from the OMB scenario. The changes are parallel shifts in the path of each variable in the OMB scenario, where all three interest rates are shifted together and at the same magnitudes, but are kept from going negative.

Figure 4 reports the sensitivity of the Cash Flow NPV with respect to changes in the HPA forecast. Specifically, we applied a parallel shift to the annualized HPA rates from the base scenario up and down by 20, 50, 100 and 200 basis points. The sensitivity to shifts in the annualized HPA from the base scenario has a positive slope. A negative 100 basis points parallel shift in HPA will decrease Cash Flow NPV by $4.839 billion, and a positive 100 basis points parallel shift in HPA will increase Cash Flow NPV by $4.809 billion. Figure 5 shows the change in Cash Flow NPV as a percentage of the IIF. The change as a percentage of IIF ranges from -13.52% to +13.49%.

Figure 4 also reports the sensitivity of the Cash Flow NPV with respect to changes in interest rates. Specifically, we applied a parallel shift to the annualized CMT and mortgage rates from the base scenario up and down by 20, 50, 100 and 200 basis points. The sensitivity to shifts in the interest rates from the base scenario has a negative slope. A negative 100 basis points parallel shift in interest rates will increase Cash Flow NPV by $1.3 billion, and a positive 100 basis points parallel shift in HPA will decrease Cash Flow NPV by $0.9 billion. Figure 5 shows the change in Cash Flow NPV as a percentage of the IIF. The change as a percentage of IIF ranges from -2.21% to +4.03%.

*Figure 4: HECM Sensitivity Analysis – Change in Cash Flow NPV*

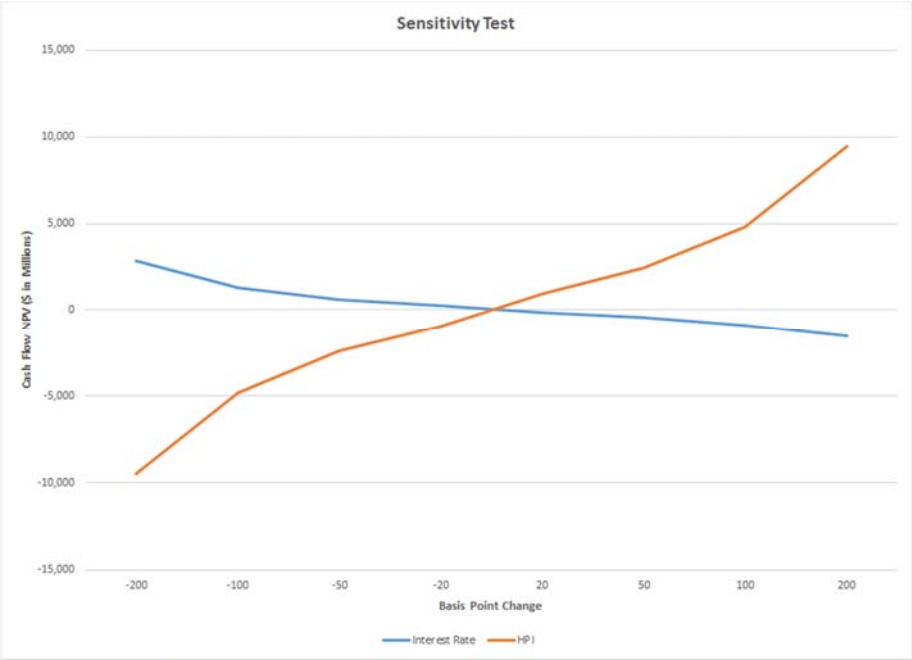
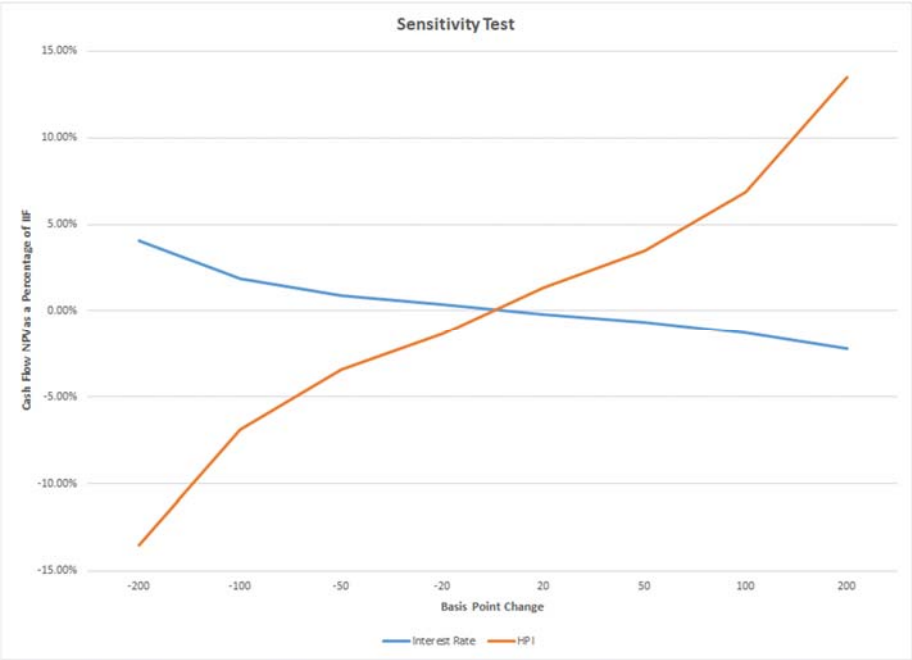



*Figure 5: HECM Sensitivity Analysis – Change in Cash Flow NPV as a Percentage of IIF*



# Section 5. Summary of Methodology

This section describes the analytical approach implemented in this analysis.

## Data Sources (Appendix A)

In our analysis, we have relied on data from FHA, Summit-Milliman, Moody's and OMB.

From FHA, we have received the following data tables.

1. hermit_case_detail: case level data for HECM's.
2. hermit_claim_detail: data for electronically processed HECM claims.
3. hermit_transactions_balance: HECM balance transactions data.
4. hermit_transactions_setaside: HECM setaside transactions data.
5. hermit_transactions_growth: HECM growth transactions data.
6. hermit_payment_plan: payment plan information on HECM's.
7. hermit_lender_detail: supporting lender information for HECM's.
8. sams_case_record: Union of sams_monthly_record and sams_archive_record.
9. hecm_claim_detail: data for paper claims for HECM's.
10. assigned_f12_transactions: historical F12 transaction records for HECM cases that were assigned prior to October 3, 2012.
11. idb_1_and_coborr: Integrated Database (IDB) idb_1_and_coborr is a composite of five Single Family legacy systems
12. Consolidated Balance Transfer Files

From Moody's, we have received the following data elements.

1. Historical Economic Data
2. Baseline Economic Scenario Projections
3. Alternative Economic Scenario Projections

From OMB, we received the Economic Assumptions for the 2019 Mid-Term Review as of March, 2018.

The economic data that is included in the analysis is shown below.

1. HPI
2. CMT rates
3. LIBOR

## Data Processing – Mortgage-Level Modeling

Starting with the raw data, Pinnacle processed the data to create datasets for developing the mortgage-level transition and loss severity models. The steps below describe the data processing that occurred to prepare the data that was used for this analyses.

1. Pre-Processing: fields from supplemental tables were added to main HECM Case file
2. HECM Quarterly: a number of calculated fields and flags are added to the dataset
3. Transaction Processing: quarterly historical transactions are then processed
4. Claim Processing: historical claim amounts are calculated based on claims transactions
5. Historical quarterly UPB is calculated for each mortgage
6. MIP Processing: Initial and subsequent MIP inflows are summarized by case number and period from the Consolidated Balance Transfer File
7. Cash Draw Processing: Incremental and cumulative cash draws are calculated by case number and period
8. Taxes and Insurance Processing: Incremental and cumulative taxes and insurance are calculated by case number and period
9. Line of Credit Processing: Incremental and cumulative line of credit draws are calculated by case number and period
10. Table Joins: tables generated in steps 3 – 9 were joined to the main table created in step 2

## Data Reconciliation

To reconcile the data processed by Pinnacle with the data provided by FHA, Pinnacle compared summaries of key data elements with the summaries provided by FHA. The summaries for the IIF, number of active assignments and the number of claims to date are shown in the following tables.[3]

The reconciliation tables were based on data as of September 30, 2018, which was the data file used to develop the predictive models.

[3] Comparison data from FHA was not available as of the date of this draft report

*Table 17: Data Validation – Insurance in Force*

| Insurance in Force ($M) = Total Loan Amount on Active Loans | | | | |
|---|---|---|---|---|
| Credit Subsidy Cohort | Federal Housing Administration | Independent Actuary | Absolute Difference (Actuary - FHA) | Percent Difference (Actuary - FHA) / FHA |
| 2009 | $11,951 | $11,951 | (0) | 0.00% |
| 2010 | $6,667 | $6,662 | (5) | -0.07% |
| 2011 | $6,652 | $6,647 | (4) | -0.06% |
| 2012 | $6,142 | $6,142 | (0) | 0.00% |
| 2013 | $7,892 | $7,891 | (1) | -0.01% |
| 2014 | $5,582 | $5,582 | 0 | 0.00% |
| 2015 | $6,753 | $6,752 | (1) | -0.01% |
| 2016 | $6,448 | $6,448 | (0) | 0.00% |
| 2017 | $8,078 | $8,078 | (0) | 0.00% |
| 2018 | $6,225 | $6,225 | (0) | 0.00% |
| Total | 72,389 | 72,378 | (11) | -0.02% |

*Table 18: Data Reconciliation - Number of Active Assignments*

| Number of Active Assignments | | | | |
|---|---|---|---|---|
| Credit Subsidy Cohort | Federal Housing Administration | Independent Actuary | Absolute Difference (Actuary - FHA) | Percent Difference (Actuary - FHA) / FHA |
| 2009 | 11,075 | 11,080 | 5 | 0.05% |
| 2010 | 19,238 | 19,236 | (2) | -0.01% |
| 2011 | 17,214 | 17,220 | 6 | 0.03% |
| 2012 | 7,524 | 7,527 | 3 | 0.04% |
| 2013 | 2,280 | 2,281 | 1 | 0.04% |
| 2014 | 17 | 17 | - | 0.00% |
| 2015 | 4 | 4 | - | 0.00% |
| 2016 | - | - | - | |
| 2017 | - | - | - | |
| 2018 | - | - | - | |
| Total | 57,352 | 57,365 | 13 | 0.02% |

*Table 19: Data Reconciliation – Number of Claims to Date*

| Number of Claims to Date | | | | |
|---|---|---|---|---|
| Credit Subsidy Cohort | Federal Housing Administration | Independent Actuary | Absolute Difference (Actuary - FHA) | Percent Difference (Actuary - FHA) / FHA |
| 2009 | 34,028 | 34,014 | (14) | -0.04% |
| 2010 | 32,759 | 32,743 | (16) | -0.05% |
| 2011 | 25,557 | 25,555 | (2) | -0.01% |
| 2012 | 11,768 | 11,773 | 5 | 0.04% |
| 2013 | 5,023 | 5,023 | - | 0.00% |
| 2014 | 743 | 743 | - | 0.00% |
| 2015 | 300 | 300 | - | 0.00% |
| 2016 | 61 | 61 | - | 0.00% |
| 2017 | 9 | 9 | - | 0.00% |
| 2018 | - | 0 | - | |
| Total | 110,248 | 110,221 | (27) | -0.02% |

## HECM Base Termination Model (Appendix B)

Pinnacle developed predictive models to estimate future HECM terminations. No repayment of principal is required on a HECM while the mortgage is active. Termination of a HECM typically occurs due to death of the borrower, the borrower moving out, or voluntary termination via refinance or payoff. The termination model estimates the probabilities of the three mutually exclusive HECM termination events denoted as mortality, mobility and refinance. The modeling approach is as follows:

1. If there is a borrower, we develop 2 binomial models to determine refinance ("refi" model) or non-mortality termination ("othr" model). These models are combined into a single competing hazards probability draw for simulation purposes.

2. If no borrowers are alive going into the period, run-off probabilities are used to determine if the loan terminates. No cash draws or refinances are allowed if the there are no borrowers remaining on the loan. If a termination is simulated then the loan follows the non-mortality termination path described in #4.

3. If the loan ends up in a non-mortality termination, there are two possible paths:
    a. If the loan is assigned, the "CT2c" model determines the probability the loan ends in conveyance of the property (a CT2c termination) or in repayment of the loan (a CT2p termination)
    b. If the loan is not assigned, the "CT1" incident model determines if the loan results in a Claim Type 1 (a CT1 termination) or no claim (a NClm termination). If it is a CT1, a CT1 sales model determines the sales price of the home relative to UPB which is used in the calculation of the CT1 loss amount.

4. If the loan does not terminate then we determine if it becomes assigned and/or if any of the borrowers

die.

The models incorporate four main categories of explanatory variables:

- Fixed initial borrower characteristics, such as borrower age at origination and gender.
- Fixed initial mortgage characteristics, such as mortgage interest rate, and origination year and quarter.
- Dynamic variables based on mortgage/borrower characteristics, such as mortgage age and borrower and co-borrower ages.
- Dynamic variables derived by combining mortgage characteristics with external macroeconomic data, such as interest rates, HPI, the amount of additional equity available to the borrower through refinancing and the updated ratio of UPB to home value.

## HECM Cash Flow Draw Projection Models (Appendix C)

Over 90% of HECM's have a line of credit associated with them. To estimate the present value of future cash flows on the existing portfolio of HECM's, we need to estimate the future cash draws associated with the line of credit. As these cash draws are not certain as they would be for a term product, we have developed predictive models to forecast cash draws. We have incorporated the following modeling approach:

1. A binomial model is developed to estimate the likelihood of a cash draw occurring in a period

2. If a cash draw is simulated, then the next step determines whether it is a full draw of all funds available through the LOC. There are two separate logistic models built for this: 1) A model built only on data from cohorts 2014 and subsequent for the first 8 quarters ("FD8" model), and 2) a model built on all data for quarters 9+ ("FD9+" model). The reason for the split is to account for the First 12-Month Disbursement Period on the funds available for distribution from the LOC.

3. A Generalized Linear Model (GLM) is then developed to estimate the amount of the cash draw for the period if the cash draw is not a full draw.

Using the historical HECM data, for each quarter we develop indicators of whether or not a net positive unscheduled cash draw was taken from the line of credit during that quarter, and also the amount of the cash draw. We then develop models to predict the amount of future cash draws based on a series of explanatory variables.

## HECM Cash Flow Analysis (Appendix E)

HECM termination rates are projected for all future policy years for each active mortgage. The variables used in the projection are derived from mortgage characteristics and economic forecasts. Moody's June 2018 forecasts of interest, and HPI are combined with the mortgage-level data to simulate the projected economic paths and create the necessary forecasted variables. MSA-level forecasts of HPI apply to mortgages in metropolitan areas; otherwise mortgages use the state-level HPI forecasts. Moody's house price forecasts are generated

simultaneously with various macroeconomic variables.

For each mortgage during future policy years, the derived mortgage variables serve as independent variables to the multinomial logistic termination models described in the Base Termination Model section. The termination projections by claim type are then calculated to generate the probability of mortgage termination in a policy year by different modes of termination given that it survives to the end of the prior policy year. The HECM cash flow model uses these forecasted termination rates to project the cash flows associated with different termination events. Based on the specific characteristics of the mortgage, the probability of each termination is calculated. Then, a random number between 0 and 1 is generated, and based on this random draw a mortgage transition is determined. The projection process continues for each mortgage until the mortgage ends by termination or claim.

## Cash Flow Components

There are four major components of HECM cash flows:

1. MIP,
2. claims,
3. note holding expenses, and
4. recoveries on notes in inventory (after assignment).

Premiums consist of upfront and annual MIPs, which are inflows to the HECM program. Recoveries are the property recovery amount received by FHA at the time of note termination after assignment, which is the minimum of the mortgage balance and the predicted net sales proceeds at termination. The recovery amount for refinance termination is always the mortgage balance. Claim Type 1 payments are cash outflows paid to the lender when the net proceeds of a property sale are insufficient to cover the balance of the mortgage. Claim Type 2 payments result from assignment of mortgages to HUD and note holding payments are additional outflows.

## Net Future Cash Flows

The Cash Flow NPV for the HECM book of business is computed by summing the individual components as they occur over time:

$$\textit{Net Cash Flow}_t = \textit{Annual Premiums}_t + \textit{Recoveries}_t - \textit{Claim Type 1}_t - \textit{Claim Type 2}_t - \textit{Note Holding Expenses}_t$$

## Discount Factors

The discount factors applied were provided by FHA and reflect the most recent Treasury yield curve, which captures the Federal government's cost of capital in raising funds. These factors reflect the capital market's expectation of the consolidated interest risk of U.S. Treasury securities. Our simulations aggregated each future quarter's cash flows, which are treated as being received at the end of the quarter.

# List of Appendices

A. Data: Sources, Processing and Reconciliation
B. HECM Base Termination Model
C. HECM Cash Flow Draw Model
D. HECM Loan Performance Projections
E. HECM Cash Flow Analysis
F. Summary of Historical and Projected Claim Rates, Non-Claim Termination Rates and Loss Severities

# Appendix A: Data Sources, Processing and Reconciliation

In our analysis, we have relied on data from FHA, Moody's and OMB.

From FHA, we have received the following data tables.

1. hermit_case_detail: case level data for HECM mortgages.
2. hermit_claim_detail: data for electronically processed HECM claims.
3. hermit_transactions_balance: HECM balance transactions data.
4. hermit_transactions_setaside: HECM setaside transactions data.
5. hermit_transactions_growth: HECM growth transactions data.
6. hermit_payment_plan: payment plan information on HECM mortgages.
7. hermit_lender_detail: supporting lender information for HECM mortgages.
8. sams_case_record: Union of sams_monthly_record and sams_archive_record.
9. hecm_claim_detail: data for paper claims for HECM mortgages.
10. assigned_f12_transactions: historical F12 transaction records for HECM cases that were assigned prior to October 3, 2012.
11. idb_1_and_coborr: Integrated Database (IDB) idb_1_and_coborr is a composite of five Single Family legacy systems
12. Consolidated Balance Transfer Files

From Moody's, we have received the following data elements.

1. Historical Economic Data
2. Baseline Economic Scenario Projections
3. Alternative Economic Scenario Projections

From OMB, we received the Economic Assumptions for the 2019 Budget Fall Baseline as of March, 2018.

The economic data that is included in the analysis is shown below.

1. HPI
2. CMT rates
3. LIBOR

## Data Processing – Mortgage Level Modeling

Beginning with the data tables provided by FHA, the data was processed to create datasets for developing the mortgage level transition and cash draw models. The steps below describe the data processing that occurred to prepare the data that was used for these analyses.

1. Pre-Processing: fields from supplemental tables were added to main HECM Case file
2. HECM Quarterly: a number of calculated fields and flags are added to the dataset
3. Transaction Processing: quarterly historical transactions are then processed
4. Claim Processing: historical claim amounts are calculated based on claims transactions
5. Historical quarterly UPB is calculated for each mortgage
6. MIP Processing: Initial and subsequent MIP inflows are summarized by case number and period from the Consolidated Balance Transfer File
7. Cash Draw Processing: Incremental and cumulative cash draws are calculated by case number and period
8. Taxes and Insurance Processing: Incremental and cumulative taxes and insurance are calculated by case number and period
9. Line of Credit Processing: Incremental and cumulative line of credit draws are calculated by case number and period
10. Table Joins: tables generated in steps 3 – 9 were joined to the main table created in step 2

## Data Reconciliation

To reconcile the data processed by Pinnacle with the data provided by FHA, Pinnacle compared summaries of key data elements with the summaries provided by FHA. The summaries for the IIF, number of active assignments and the number of claims to date are shown in the following tables. The data processed by Pinnacle matches the FHA data totals within 2%.

The reconciliation tables were based on data as of September 30, 2018, which was the data file used to develop the predictive models.

*Table 20: Data Validation – IIF*

| Insurance in Force ($M) = Total Loan Amount on Active Loans | | | | |
|---|---|---|---|---|
| Credit Subsidy Cohort | Federal Housing Administration | Independent Actuary | Absolute Difference (Actuary - FHA) | Percent Difference (Actuary - FHA) / FHA |
| 2009 | $11,951 | $11,951 | (0) | 0.00% |
| 2010 | $6,667 | $6,662 | (5) | -0.07% |
| 2011 | $6,652 | $6,647 | (4) | -0.06% |
| 2012 | $6,142 | $6,142 | (0) | 0.00% |
| 2013 | $7,892 | $7,891 | (1) | -0.01% |
| 2014 | $5,582 | $5,582 | 0 | 0.00% |
| 2015 | $6,753 | $6,752 | (1) | -0.01% |
| 2016 | $6,448 | $6,448 | (0) | 0.00% |
| 2017 | $8,078 | $8,078 | (0) | 0.00% |
| 2018 | $6,225 | $6,225 | (0) | 0.00% |
| Total | 72,389 | 72,378 | (11) | -0.02% |

*Table 21: Data Reconciliation - Number of Active Assignments*

| Number of Active Assignments | | | | |
|---|---|---|---|---|
| Credit Subsidy Cohort | Federal Housing Administration | Independent Actuary | Absolute Difference (Actuary - FHA) | Percent Difference (Actuary - FHA) / FHA |
| 2009 | 11,075 | 11,080 | 5 | 0.05% |
| 2010 | 19,238 | 19,236 | (2) | -0.01% |
| 2011 | 17,214 | 17,220 | 6 | 0.03% |
| 2012 | 7,524 | 7,527 | 3 | 0.04% |
| 2013 | 2,280 | 2,281 | 1 | 0.04% |
| 2014 | 17 | 17 | - | 0.00% |
| 2015 | 4 | 4 | - | 0.00% |
| 2016 | - | - | - | |
| 2017 | - | - | - | |
| 2018 | - | - | - | |
| Total | 57,352 | 57,365 | 13 | 0.02% |

*Table 22: Data Reconciliation – Number of Claims to Date*

| Number of Claims to Date | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| Credit Subsidy Cohort | Federal Housing Administration | Independent Actuary | Absolute Difference (Actuary - FHA) | Percent Difference (Actuary - FHA) / FHA |
| 2009 | 34,028 | 34,014 | (14) | -0.04% |
| 2010 | 32,759 | 32,743 | (16) | -0.05% |
| 2011 | 25,557 | 25,555 | (2) | -0.01% |
| 2012 | 11,768 | 11,773 | 5 | 0.04% |
| 2013 | 5,023 | 5,023 | - | 0.00% |
| 2014 | 743 | 743 | - | 0.00% |
| 2015 | 300 | 300 | - | 0.00% |
| 2016 | 61 | 61 | - | 0.00% |
| 2017 | 9 | 9 | - | 0.00% |
| 2018 | - | 0 | - | |
| | | | | |
| Total | 110,248 | 110,221 | (27) | -0.02% |

# Appendix B: HECM Base Termination Model

HECM mortgages terminate due to borrower mortality (death), the borrowers refinancing the mortgage, or other reasons including the borrower(s) moving out of their home (mobility). A series of binomial logistic models are specified and estimated to capture the mortgage termination behavior.

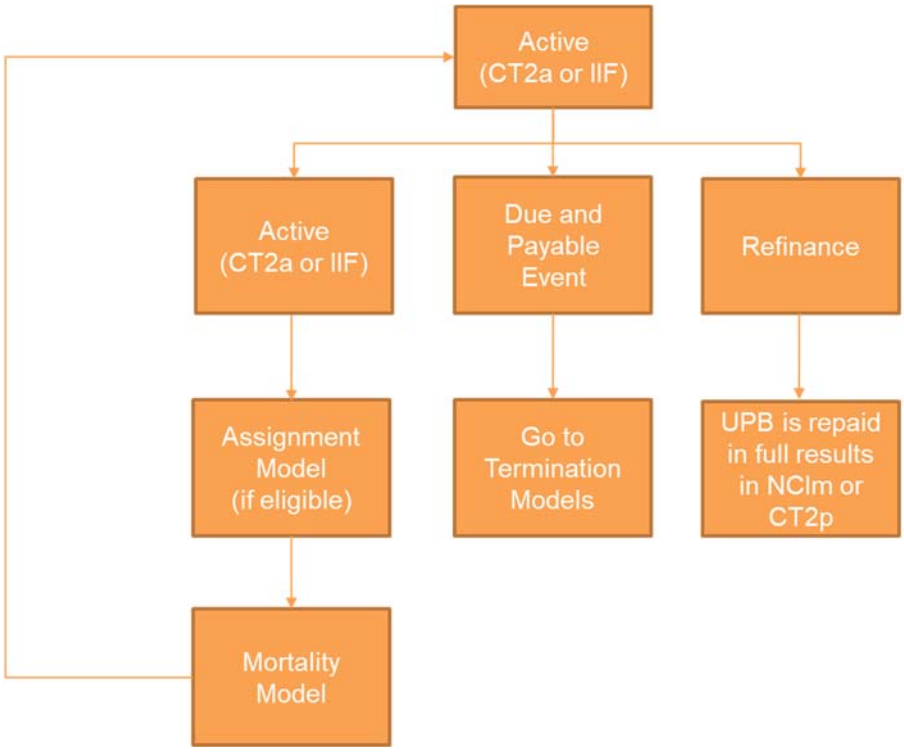
The available FHA historical HECM termination data was used to develop the base termination model. This data includes mortgages that were endorsed under the GI Fund between fiscal years 1990 and 2008, and mortgages endorsed under the MMIF from fiscal year 2009 through June 30, 2018. Only mortgages endorsed under the MMIF, however, are used in the calculation of the Cash Flow NPV in this analysis.

## Model Specification

To model the possible transitions, we first specify two binomial models and a mortality run-off model. The binomial models determine the probability of a due and payable event other than mortality and the probability of refinance.

Figure 6 shows the modeling scheme for this structure:

*Figure 6: Transition Model Scheme*




To model the possible transitions shown above, we incorporate the following approach.

1. If there are borrower(s) alive on the loan going into the period, we develop 2 binomial models to

determine refinance ("refi" model) or non-mortality termination ("othr" model). These models are combined into a single competing hazards probability draw for simulation purposes. If neither a refinance nor a due and payable event is simulated the loan continues.

2. If the loan is not assigned and the UPB has reached 98% of the maximum claim amount on the loan we simulate if the loan is assigned. If assignment is simulated the loan moves to "CT2a" status indicating the loan has been assigned but has not yet terminated and a CT2 loss occurs. If the loan is not assigned in the simulation, it continues as "IIF" indicating that the loan is still insured and in-force.

3. At the end of each simulated period we determine if any of the remaining borrowers die based on probabilities derived from mortality tables. If no borrowers remain at the end of the period, the model follows item 4 below in the next period.

4. If no borrowers are alive going into the period, we calculate run-off probabilities that determine if the loan terminates. No cash draws or refinances are allowed if the there are no borrowers. If a termination is simulated the loan follows the due and payable termination path described in item 5.

5. If the loan ends up in a due and payable termination, there are two possible paths:
    a. If the loan is assigned, the "CT2c" model determines the probability the loan ends in conveyance of the property (a CT2c termination) or in repayment of the loan (a CT2p termination)
    b. If the loan is not assigned, the "CT1" incident model determines if the loan results in a Claim Type 1 (a CT1 termination) or no claim (a NClm termination). If it is a CT1, a CT1 sales model determines the sales price of the home relative to UPB which is used in the calculation of the CT1 loss amount.

## Explanatory Variables

The following explanatory variables are used in the transition models for assigned and unassigned claims.

- The youngest age amongst the borrower and co-borrowers (min_age)
- The number of quarters since the inception of the mortgage (PeriodNbr)
- The payment type i.e., Line of Credit, Term, Tenure, etc… (loantyp)
- Gender of the borrower and co-borrower (gender)
- Number of borrowers and co-borrowers that are alive (alive)
- Ratio of UPB to the current principal limit (LTV)

- Change in the 1 year treasury rate over the past 4 quarters (delta1yr4q)
- Change in the 1 year treasury rate since loan origination (delta1yrinit)
- Maximum Claim Amount (MCA)
- Refinance Incentive: the ratio of the expected gain in principal limit from refinancing to the expected transaction cost (Refi_var)
- Home equity ratio: the current indexed property value less UPB less the unused principal limit divided by the current indexed property value (mob)
- The quarter of the year (season)
- UPB ratio: The ratio of the UPB to the indexed property value (UPBRatio)
- The indexed property value divided by 10,000 (propval)

## Model Parameters

### Likelihood of Refinance

The model parameters for the likelihood of refinance are shown below.

*Table 23: Model Parameters – Likelihood of Refinance*

| Variable | ClassVal0 | DF | Estimate | StdErr | WaldChiSq | ProbChiSq |
|---|---|---|---|---|---|---|
| Intercept | | 1 | -9.597693113 | 0.073729196 | 16945.5130 | 0.0000 |
| vminage_refi_pw2 | | 1 | 0.0097209 | 0.00234879 | 17.1287 | 0.0000 |
| vminage_refi_pw4 | | 1 | -0.041484644 | 0.011744061 | 12.4778 | 0.0004 |
| vrefi_refi_pw2 | | 1 | -0.106061697 | 0.008417563 | 158.7612 | 0.0000 |
| vrefi_refi_pw3 | | 1 | 0.930219076 | 0.056968324 | 266.6267 | 0.0000 |
| vrefi_refi_pw4 | | 1 | 0.6504113 | 0.016003355 | 1651.7871 | 0.0000 |
| vrefi_refi_pw4*vrefi_refi_pw4 | | 1 | -0.047721624 | 0.001889984 | 637.5500 | 0.0000 |
| vPeriodNbr_pw1 | | 1 | 0.05518425 | 0.003315237 | 277.0773 | 0.0000 |
| vPeriodNbr_pw2 | | 1 | -0.088474774 | 0.001321257 | 4483.9857 | 0.0000 |
| vPeriodNbr_pw3 | | 1 | 0.024805199 | 0.00291967 | 72.1802 | 0.0000 |
| vPeriodNbr_pw4 | | 1 | 0.016500439 | 0.013382429 | 1.5203 | 0.2176 |
| vltv_pw1 | | 1 | 0.021403327 | 0.000926932 | 533.1709 | 0.0000 |
| vltv_pw2 | | 1 | 0.023138175 | 0.001034652 | 500.1143 | 0.0000 |
| vltv_pw3 | | 1 | 0.011899397 | 0.004675739 | 6.4766 | 0.0109 |
| vltv_pw4 | | 1 | 0.00119491 | 0.0368878 | 0.0010 | 0.9742 |
| vltv_pw5 | | 1 | -0.245177417 | 0.019489611 | 158.2540 | 0.0000 |
| vMob_pw | | 1 | -0.273558558 | 0.012444454 | 483.2245 | 0.0000 |
| mDeltaTy14Q | L01_.35 | 1 | 1.528137123 | 0.018204991 | 7046.0174 | 0.0000 |
| mDeltaTy1Init | L02_2.0 | 1 | 0.383257569 | 0.018766974 | 417.0547 | 0.0000 |
| mloantyp | L01_01 | 1 | 0.393441869 | 0.023394156 | 282.8436 | 0.0000 |
| MGender | L01_M | 1 | 0.066445193 | 0.013071717 | 25.8382 | 0.0000 |
| mAlive | L02_2 | 1 | -0.048296556 | 0.012730055 | 14.3937 | 0.0001 |
| vMCA_pw1 | | 1 | 0.00458382 | 0.000308877 | 220.2341 | 0.0000 |
| vMCA_pw2 | | 1 | 0.002567404 | 6.36543E-05 | 1626.7964 | 0.0000 |
| vrefi_refi_pw2*mDeltaTy14Q | L01_.35 | 0 | 0 | | | |
| vrefi_refi_pw4*mDeltaTy14Q | L01_.35 | 0 | 0 | | | |

## Likelihood of Non-Mortality Termination

The model parameters for the likelihood of non-mortality termination are shown below.

*Table 24: Model Parameters – Likelihood of Non-Mortality Termination*

| Variable | ClassVal0 | DF | Estimate | StdErr | WaldChiSq | ProbChiSq |
|---|---|---|---|---|---|---|
| Intercept | | 1 | -4.722198039 | 0.059363514 | 6327.7483 | 0.0000 |
| vminage_pw1 | | 1 | 0.07656558 | 0.002597238 | 869.0479 | 0.0000 |
| vminage_pw2 | | 1 | 0.08683769 | 0.001135416 | 5849.3312 | 0.0000 |
| vminage_pw3 | | 1 | 0.071349567 | 0.004911848 | 211.0050 | 0.0000 |
| vmob_pw0 | | 1 | 0.009918954 | 0.000684171 | 210.1854 | 0.0000 |
| vmob_pw1 | | 1 | 0.011916164 | 0.000476607 | 625.1028 | 0.0000 |
| vmob_pw2 | | 1 | 0.039998387 | 0.001235252 | 1048.5125 | 0.0000 |
| vmob_pw2*vmob_pw2 | | 1 | -0.000173637 | 3.02332E-05 | 32.9849 | 0.0000 |
| vmob_pw0*vmob_pw0 | | 1 | 8.67399E-06 | 8.47208E-07 | 104.8233 | 0.0000 |
| vminage_pw1*vmob_pw2 | | 1 | -0.003962819 | 0.000128781 | 946.9073 | 0.0000 |
| vmob_pw0*mSeason | L02 | 1 | 0.002321935 | 0.00104044 | 4.9804 | 0.0256 |
| vmob_pw0*mSeason | L03 | 1 | 0.005952113 | 0.001179059 | 25.4842 | 0.0000 |
| vmob_pw2*mSeason | L02 | 1 | 0.003978616 | 0.000878129 | 20.5280 | 0.0000 |
| vmob_pw2*mSeason | L03 | 1 | 0.006070821 | 0.000934499 | 42.2024 | 0.0000 |
| vltv_pw1 | | 1 | -0.140047348 | 0.011502108 | 148.2501 | 0.0000 |
| vltv_pw2 | | 1 | -0.009336834 | 0.000252567 | 1366.6184 | 0.0000 |
| vltv_pw3 | | 1 | -0.012988902 | 0.001791794 | 52.5495 | 0.0000 |
| vltv_pw4 | | 1 | 0.142606996 | 0.004694559 | 922.7670 | 0.0000 |
| vltv_pw5 | | 1 | 0.089673261 | 0.00146783 | 3732.2797 | 0.0000 |
| min_age65 | L01__62 | 1 | -0.296393006 | 0.074232132 | 15.9423 | 0.0001 |
| min_age65 | L02__63 | 1 | -0.292625358 | 0.041169762 | 50.5204 | 0.0000 |
| min_age65 | L03__64 | 1 | -0.247445361 | 0.033178977 | 55.6202 | 0.0000 |
| min_age65 | L04__65 | 1 | -0.223156155 | 0.029423865 | 57.5199 | 0.0000 |
| min_age65 | L05__72 | 1 | -0.088733833 | 0.015301124 | 33.6304 | 0.0000 |
| mloantyp | L01_01 | 1 | -0.042092077 | 0.01095503 | 14.7630 | 0.0001 |
| MGender | L01_M | 1 | 0.069584309 | 0.007466725 | 86.8485 | 0.0000 |
| mSeason | L02 | 1 | 0.106582998 | 0.009661975 | 121.6870 | 0.0000 |
| mSeason | L03 | 1 | 0.040734661 | 0.010213549 | 15.9065 | 0.0001 |
| mOrigFY | L01_2001 | 1 | -0.09875148 | 0.053256174 | 3.4383 | 0.0637 |
| mOrigFY | L02_2002 | 1 | -0.090772709 | 0.03991131 | 5.1727 | 0.0229 |
| mOrigFY | L03_2003 | 1 | 0.068649303 | 0.035089718 | 3.8275 | 0.0504 |
| mOrigFY | L04_2004 | 1 | 0.045264209 | 0.023381299 | 3.7478 | 0.0529 |
| mOrigFY | L05_2005 | 1 | -0.016092017 | 0.020663392 | 0.6065 | 0.4361 |
| mOrigFY | L06_2006 | 1 | 0.066779679 | 0.014161354 | 22.2371 | 0.0000 |
| mOrigFY | L07_2007 | 1 | -0.104851096 | 0.01338227 | 61.3884 | 0.0000 |
| mOrigFY | L08_2008 | 1 | -0.197500689 | 0.013033706 | 229.6156 | 0.0000 |
| mOrigFY | L09_2009 | 1 | -0.093160759 | 0.012190329 | 58.4030 | 0.0000 |
| mOrigFY | L10_2010 | 1 | -0.002825329 | 0.012988761 | 0.0473 | 0.8278 |
| mperiod_num | L01_02 | 1 | -0.967540003 | 0.028885317 | 1121.9760 | 0.0000 |
| mperiod_num | L02_03 | 1 | -0.489163672 | 0.024127677 | 411.0336 | 0.0000 |
| mperiod_num | L03_04 | 1 | -0.212716729 | 0.021989492 | 93.5778 | 0.0000 |
| mperiod_num | L04_05 | 1 | -0.078487762 | 0.021231896 | 13.6655 | 0.0002 |
| vperiodnbr_othr_pw1 | | 1 | 0.016146166 | 0.000942083 | 293.7384 | 0.0000 |
| vperiodnbr_othr_pw2 | | 1 | 0.013763921 | 0.000566259 | 590.8183 | 0.0000 |

## CT2c Model

The model parameters for the likelihood that an assigned loan ends with a CT2c at termination.

*Table 25: Model Parameters – Likelihood of CT2c*

| Variable | ClassVal0 | DF | Estimate | StdErr | WaldChiSq | ProbChiSq |
|---|---|---|---|---|---|---|
| Intercept | | 1 | -7.487125527 | 0.277443975 | 728.2486 | 0.0000 |
| vUPBRatio_MRA_pw1 | | 1 | 7.986987175 | 0.299770224 | 709.8866 | 0.0000 |
| vUPBRatio_MRA_pw2 | | 1 | 1.953114015 | 0.151006882 | 167.2868 | 0.0000 |
| mMinage | L01_Miss | 1 | 0.674000305 | 0.170446195 | 15.6367 | 0.0001 |
| vmin_age_pw1 | | 1 | 0.036876616 | 0.006331061 | 33.9273 | 0.0000 |
| vmin_age_pw2 | | 1 | -0.050541136 | 0.037295154 | 1.8365 | 0.1754 |

## CT2c Sales Price Model

The model parameters for the CT2c sales price model as a percentage of the UPB are shown below. This model includes an offset term of the natural log of the UPB.

*Table 26: Model Parameters – CT2c Sales Price Model*

| Parameter | DF | Estimate | StdErr | LowerWaldCL | UpperWaldCL | ChiSq | ProbChiSq |
|---|---|---|---|---|---|---|---|
| Intercept | 1 | 1.7016 | 0.0823 | 1.5404 | 1.8628 | 427.90 | 0.0000 |
| vperiodnbr_pw1 | 1 | -0.0029 | 0.0011 | -0.0050 | -0.0008 | 7.17 | 0.0074 |
| vpropval_pw1 | 1 | -0.3369 | 0.0119 | -0.3603 | -0.3135 | 795.19 | 0.0000 |
| vpropval_pw2 | 1 | 0.2497 | 0.0215 | 0.2075 | 0.2919 | 134.41 | 0.0000 |
| vpropval_pw3 | 1 | 0.0185 | 0.0067 | 0.0055 | 0.0316 | 7.75 | 0.0054 |
| vpropval_pw4 | 1 | 0.0136 | 0.0018 | 0.0100 | 0.0172 | 55.00 | 0.0000 |
| vpropval_pw5 | 1 | -0.0097 | 0.0026 | -0.0149 | -0.0046 | 13.61 | 0.0002 |
| vpropval_pw6 | 1 | -0.0036 | 0.0001 | -0.0039 | -0.0034 | 1057.42 | 0.0000 |
| Scale | 0 | 5.3362 | 0.0000 | 5.3362 | 5.3362 | | |

## CT1 Claim Model

The model parameters for the likelihood of a CT1 claim given the loan has terminated in due and payable status and is not assigned are shown below.

*Table 27: Model Parameters – Likelihood of CT1 Claim*

| Variable | ClassVal0 | DF | Estimate | StdErr | WaldChiSq | ProbChiSq |
|---|---|---|---|---|---|---|
| Intercept | | 1 | -10.3505376 | 0.945045932 | 119.9554 | 0.0000 |
| vUPBRatio_MRA_pw1 | | 1 | -7.114038119 | 0.563581153 | 159.3380 | 0.0000 |
| vUPBRatio_MRA_pw2 | | 1 | -6.623614073 | 0.544690118 | 147.8737 | 0.0000 |
| vUPBRatio_MRA_pw3 | | 1 | 9.362848101 | 0.192947314 | 2354.7157 | 0.0000 |
| vUPBRatio_MRA_pw4 | | 1 | 9.531447281 | 0.078089276 | 14898.2379 | 0.0000 |
| vUPBRatio_MRA_pw5 | | 1 | 3.51875653 | 0.176482593 | 397.5344 | 0.0000 |
| mMinage | L01_Miss | 1 | 1.154803804 | 0.014438729 | 6396.7367 | 0.0000 |
| vmin_age_pw1 | | 1 | 0.094217605 | 0.022001225 | 18.3388 | 0.0000 |
| vperiodnum_mra_pw1 | | 1 | 0.960052737 | 0.239073974 | 16.1260 | 0.0001 |
| vperiodnum_mra_pw2 | | 1 | 0.617813483 | 0.029200166 | 447.6557 | 0.0000 |
| vperiodnum_mra_pw3 | | 1 | 0.140863906 | 0.002670493 | 2782.3814 | 0.0000 |
| vperiodnum_mra_pw4 | | 1 | 0.048829179 | 0.002377327 | 421.8724 | 0.0000 |
| vperiodnum_mra_pw5 | | 1 | -0.028595699 | 0.002979275 | 92.1256 | 0.0000 |
| vperiodnum_mra_pw6 | | 1 | 0.006921205 | 0.004776077 | 2.1000 | 0.1473 |

### CT1 Sales Price Model

The model parameters for the CT1 sales price model are shown below. This model includes an offset term of the natural log of the UPB.

*Table 28: Model Parameters – CT1 Sales Price Model*

| Parameter | Level1 | DF | Estimate | StdErr | LowerWaldCL | UpperWaldCL | ChiSq | ProbChiSq |
|---|---|---|---|---|---|---|---|---|
| Intercept | | 1 | -1.1072 | 0.6901 | -2.4599 | 0.2454 | 2.57 | 0.1086 |
| vperiodnbr_pw1 | | 1 | -0.0130 | 0.0011 | -0.0151 | -0.0109 | 151.02 | 0.0000 |
| vperiodnbr_pw2 | | 1 | 0.0025 | 0.0003 | 0.0019 | 0.0032 | 57.06 | 0.0000 |
| vperiodnbr_pw3 | | 1 | -0.0012 | 0.0002 | -0.0016 | -0.0009 | 46.94 | 0.0000 |
| vperiodnbr_pw4 | | 1 | 0.0006 | 0.0002 | 0.0002 | 0.0010 | 10.01 | 0.0016 |
| vperiodnbr_pw5 | | 1 | -0.0205 | 0.0046 | -0.0294 | -0.0115 | 20.15 | 0.0000 |
| vpropval_pw1 | | 1 | 0.0273 | 0.0042 | 0.0191 | 0.0355 | 42.22 | 0.0000 |
| vpropval_pw2 | | 1 | 0.0621 | 0.0052 | 0.0519 | 0.0723 | 142.51 | 0.0000 |
| vpropval_pw3 | | 1 | 0.0359 | 0.0015 | 0.0330 | 0.0388 | 578.37 | 0.0000 |
| vpropval_pw4 | | 1 | 0.0088 | 0.0004 | 0.0081 | 0.0096 | 496.95 | 0.0000 |
| vpropval_pw5 | | 1 | -0.0032 | 0.0006 | -0.0043 | -0.0020 | 28.19 | 0.0000 |
| vpropval_pw6 | | 1 | -0.0025 | 0.0003 | -0.0031 | -0.0019 | 70.13 | 0.0000 |
| vUPB_Ratio_pw1 | | 1 | 0.0020 | 0.0003 | 0.0014 | 0.0026 | 44.23 | 0.0000 |
| vUPB_Ratio_pw2 | | 1 | -0.0100 | 0.0030 | -0.0159 | -0.0040 | 10.83 | 0.0010 |
| vUPB_Ratio_pw3 | | 1 | 0.0108 | 0.0021 | 0.0067 | 0.0148 | 26.75 | 0.0000 |
| vUPB_Ratio_pw4 | | 1 | 0.0058 | 0.0018 | 0.0024 | 0.0093 | 10.92 | 0.0010 |
| vUPB_Ratio_pw5 | | 1 | 0.0009 | 0.0004 | 0.0000 | 0.0017 | 4.30 | 0.0380 |
| vUPB_Ratio_pw6 | | 1 | -0.0023 | 0.0010 | -0.0042 | -0.0004 | 5.46 | 0.0195 |
| vUPB_Ratio_pw7 | | 1 | -0.0009 | 0.0004 | -0.0018 | 0.0000 | 4.28 | 0.0386 |
| vUPB_Ratio_pw8 | | 1 | 0.0026 | 0.0009 | 0.0007 | 0.0044 | 7.31 | 0.0069 |
| mMinage | L01_Miss | 1 | -0.0736 | 0.6897 | -1.4253 | 1.2782 | 0.01 | 0.9151 |
| mMinage | Z00_Base | 0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | |
| vminage_pw1 | | 1 | -0.0811 | 0.2314 | -0.5346 | 0.3725 | 0.12 | 0.7261 |
| vminage_pw2 | | 1 | 0.0199 | 0.0090 | 0.0023 | 0.0376 | 4.90 | 0.0268 |
| vminage_pw3 | | 1 | 0.0079 | 0.0021 | 0.0038 | 0.0120 | 14.47 | 0.0001 |
| vminage_pw4 | | 1 | 0.0080 | 0.0008 | 0.0064 | 0.0095 | 97.73 | 0.0000 |
| vminage_pw5 | | 1 | -0.0064 | 0.0019 | -0.0101 | -0.0026 | 11.03 | 0.0009 |
| Scale | | 0 | 4.7912 | 0.0000 | 4.7912 | 4.7912 | | |

## Model Validation

Model validation was accomplished by applying the models developed using the training set to the validation dataset. The application of this model to the validation data produces the predicted target variable for each model. The actual target variable is then compared to the predicted target variable to ensure the model fits the transition process without over-fitting the actual data.

Specifically, we calculate the predicted probability of each transition for the logistic model and the expected sales price for each sales price model.

Decile charts are then created for each final model. All records are sorted, or ranked, by the predicted value. Ten equal sized decile groups are created with 10% of the records in each group. The sum of the actual result and

the sum of the predicted result within each decile is calculated. The actual and predicted numbers are then compared for consistency. The objective of a model is to have a significant spread in predicted values while maintaining a close relationship between the resulting actual and predicted values.

The validation charts for the claim terminations models are shown below.

*Figure 7: Model Validation – Likelihood of Refinance*

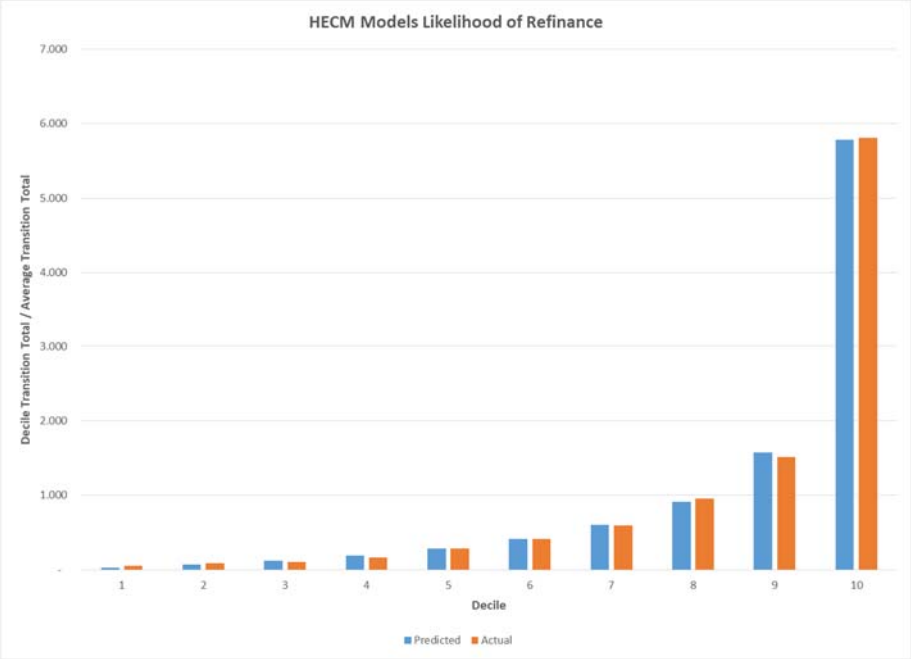


*Figure 8: Model Validation - Likelihood of Non-Mortality Termination*

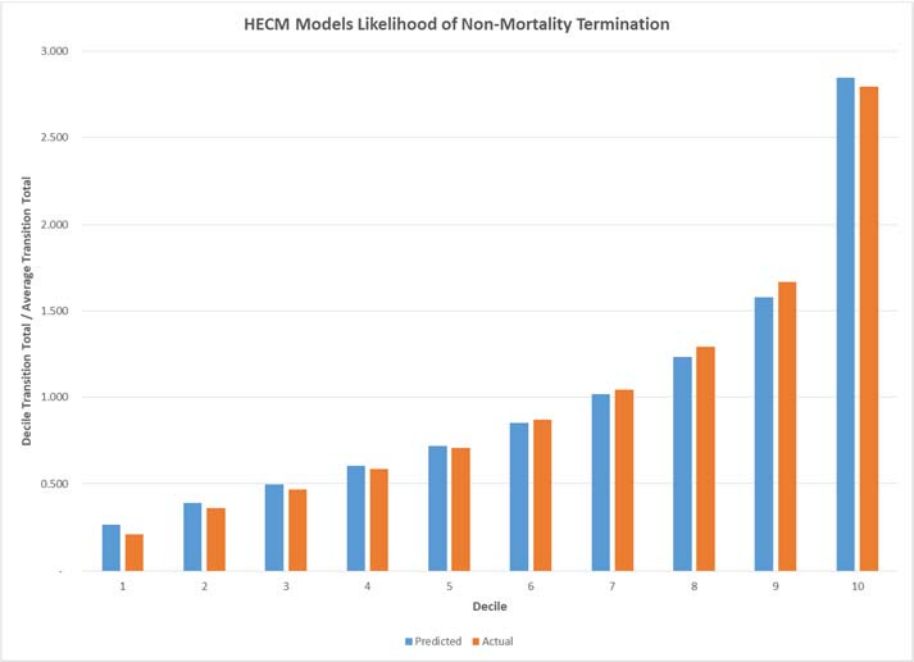



*Figure 9: Model Validation - Likelihood of CT2c Claim*

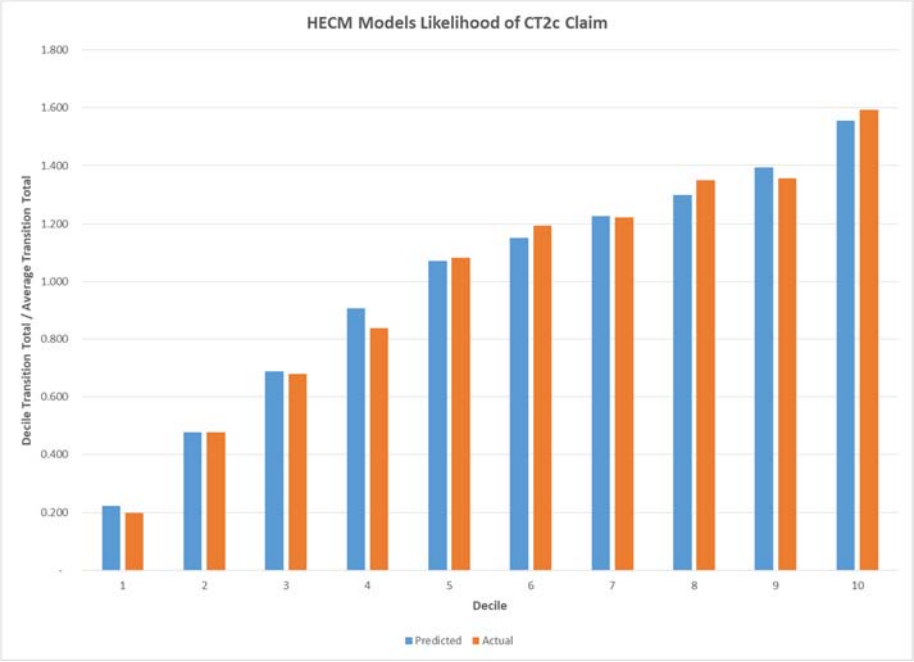


*Figure 10: Model Validation – CT2c Sales Amount Model*

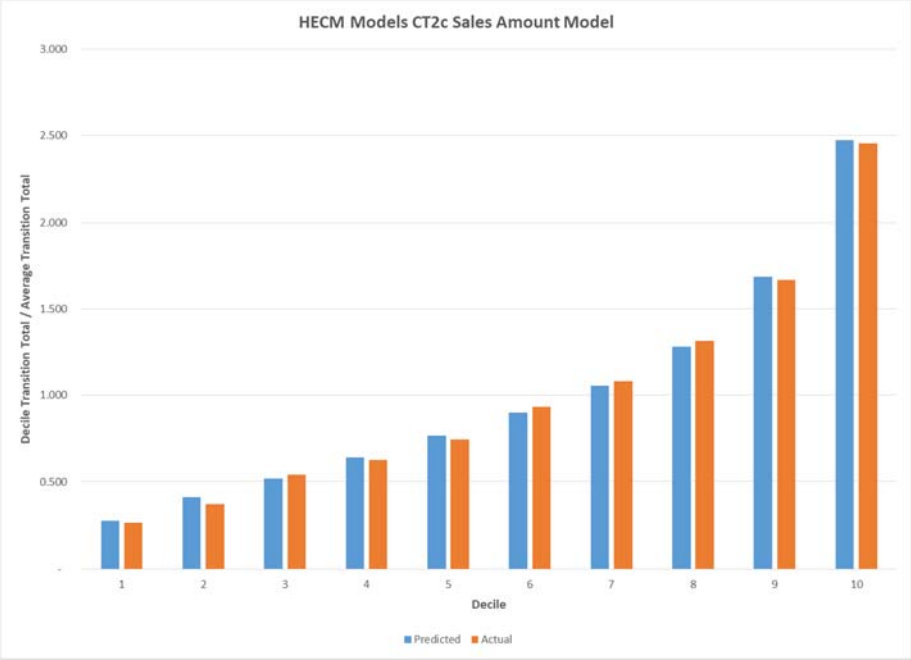



*Figure 11: Model Validation – Likelihood of CT1 Claim*

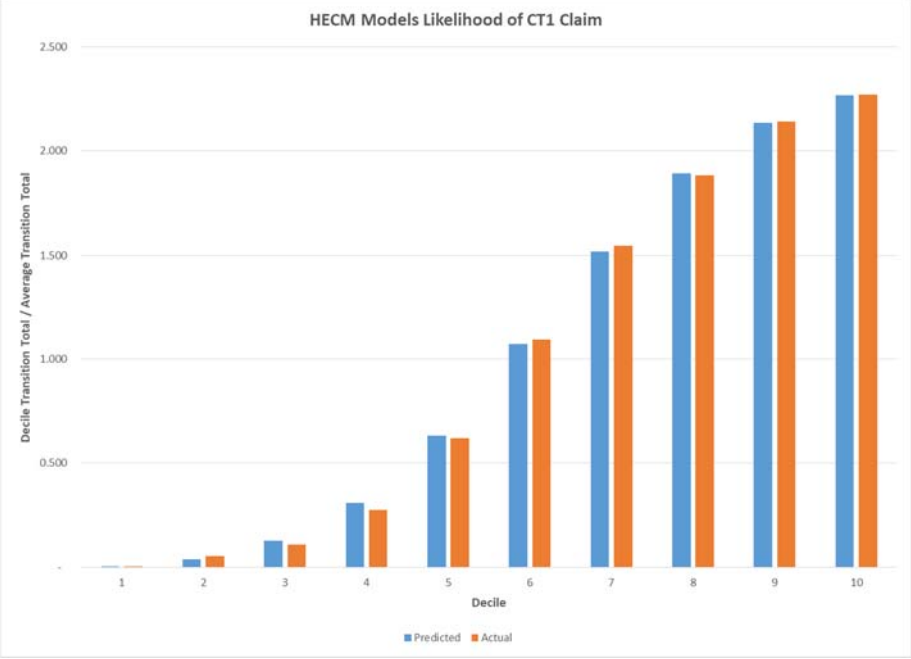
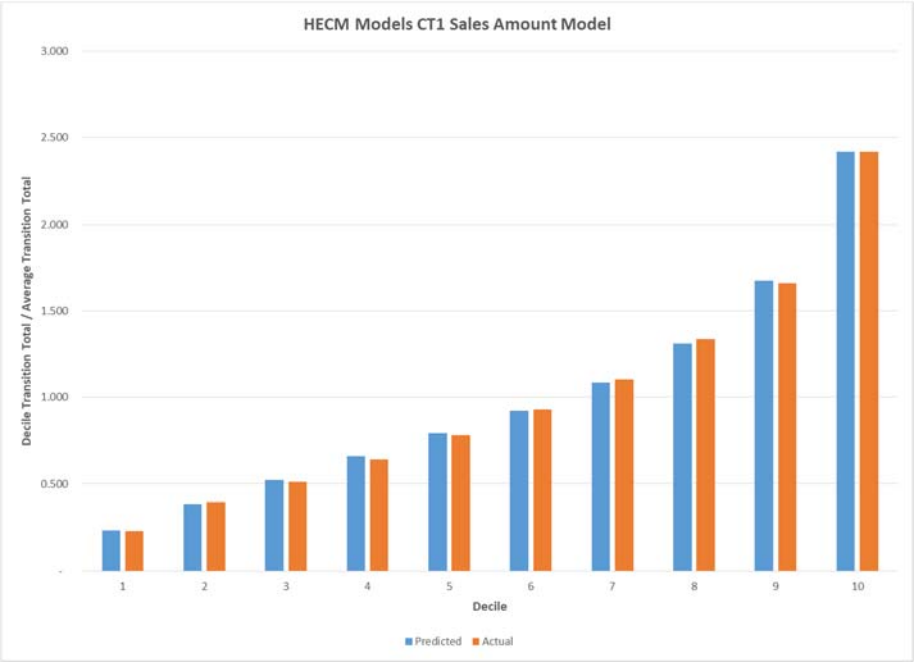


*Figure 12: Model Validation – CT1 Sales Amount Model*



# Appendix C: HECM Cash Draw Projection Models

Over 90% of HECM's have a line of credit associated with them. To estimate the Cash Flow NPV on the existing portfolio of HECM mortgages, we need to estimate the future unscheduled cash draws associated with mortgages with a line of credit. As these cash draws are not certain, we have developed predictive models to forecast unscheduled cash draws for HECM with a line of credit. We have incorporated the following approach:

1. A binomial model is developed to estimate the likelihood of a cash draw occurring in a period

2. If a cash draw is simulated, then the next step determines whether it is a full draw of all funds available through the LOC. There are two separate logistic models built for this: 1) A model built only on data from cohorts 2014 and subsequent for the first 8 quarters ("FD8" model), and 2) a model built on all data for quarters 9+ ("FD9+" model). The reason for the split is to account for the First 12-Month Disbursement Period on the funds available for distribution from the LOC.

3. A Generalized Linear Model (GLM) is then developed to estimate the amount of the cash draw for the period if the cash draw is not a full draw.

For the historical HECM database, for each quarter we develop an indicator of whether or not a net positive unscheduled cash draw was taken from the line of credit during that quarter. We use this data to develop the binomial logistic models described above to estimate the likelihood of an unscheduled cash draw occurring during the quarter based on a series of explanatory variables, and to estimate the likelihood that this cash draw is a full draw. The explanatory variables used in the model are the similar to those used for the termination models. These variables are described in Appendix B. Additionally, we include the amount remaining on the line of credit (LOCCap) as an explanatory variable in the Cash Draw likelihood models.

For the estimated cash draw amount, we developed a model using the incremental line of credit cash draw from the historical HECM database. This incremental cash draw was used as the target variable, and we estimated the predicted amount of the cash draw based on a series of explanatory variables. The explanatory variables used in the model are the same as those for the termination models described in Appendix B and the Cash Draw likelihood models described above.

## Model Parameters

### Likelihood of Cash Draw

The model parameters for the likelihood of a cash draw are shown below.

*Table 29: Model Parameters – Likelihood of Cash Draw*

| Variable | ClassVal0 | ClassVal1 | DF | Estimate | StdErr | WaldChiSq | ProbChiSq |
|---|---|---|---|---|---|---|---|
| Intercept | | | 1 | -3.19822815 | 0.016194283 | 39002.7690 | 0.0000 |
| mMinage | L01_62 | | 1 | 0.16345041 | 0.014707328 | 123.5107 | 0.0000 |
| mMinage | L02_63 | | 1 | 0.14640703 | 0.009150123 | 256.0177 | 0.0000 |
| mMinage | L03_64 | | 1 | 0.09228672 | 0.007736996 | 142.2767 | 0.0000 |
| mMinage | L04_65 | | 1 | 0.03856462 | 0.006999581 | 30.3553 | 0.0000 |
| mMinage | L05_95 | | 1 | -0.03339241 | 0.00712308 | 21.9766 | 0.0000 |
| mMinage | L06_99 | | 1 | -0.02381254 | 0.016884391 | 1.9890 | 0.1584 |
| mSeason | L01 | | 1 | -0.16016268 | 0.003183527 | 2531.0784 | 0.0000 |
| mSeason | L02 | | 1 | -0.10906661 | 0.003158152 | 1192.6622 | 0.0000 |
| mSeason | L03 | | 1 | -0.04350945 | 0.003210361 | 183.6790 | 0.0000 |
| mAlive | L02_2 | | 1 | -0.22039552 | 0.002380618 | 8570.8908 | 0.0000 |
| MGender | L01_M | | 1 | -0.04443746 | 0.002561023 | 301.0727 | 0.0000 |
| mDeltaTy1Init | L02_2.0 | | 1 | -0.02544653 | 0.003704862 | 47.1751 | 0.0000 |
| mloantyp | L01_01 | | 1 | -0.46134834 | 0.004600117 | 10058.1961 | 0.0000 |
| vLOCCap_pw1 | | | 1 | 0.00038665 | 1.82373E-06 | 44947.8097 | 0.0000 |
| vLOCCap_pw2 | | | 1 | 0.00004092 | 7.87416E-07 | 2700.0180 | 0.0000 |
| vLOCCap_pw3 | | | 1 | 0.00000181 | 2.71818E-08 | 4435.3893 | 0.0000 |
| vLOCRemain_pw1 | | | 1 | 1.41029542 | 0.044550566 | 1002.1062 | 0.0000 |
| vLOCRemain_pw2 | | | 1 | 1.19144502 | 0.015256668 | 6098.5785 | 0.0000 |
| vLOCRemain_pw3 | | | 1 | -0.04498040 | 0.004329435 | 107.9404 | 0.0000 |
| vLOCRemain_pw4 | | | 1 | -0.02350087 | 0.000699694 | 1128.1101 | 0.0000 |
| vLOCRemain_pw5 | | | 1 | -0.01615747 | 0.000245811 | 4320.5996 | 0.0000 |
| vLOCRemain_pw6 | | | 1 | -0.01839630 | 0.000150184 | 15004.1924 | 0.0000 |
| vLOCRemain_pw7 | | | 1 | -0.02622946 | 0.000390104 | 4520.8162 | 0.0000 |
| vLOCRemain_pw8 | | | 1 | -0.12322486 | 0.001796764 | 4703.4280 | 0.0000 |
| vLOCRemain_pw9 | | | 1 | -0.46801678 | 0.014856665 | 992.3850 | 0.0000 |
| vLOCRemain_pw10 | | | 1 | 1.43496820 | 0.105214673 | 186.0081 | 0.0000 |
| mperiod_num | L01_02 | | 1 | 0.25232370 | 0.011984872 | 443.2506 | 0.0000 |
| mperiod_num | L02_03 | | 1 | -0.01446057 | 0.012353797 | 1.3702 | 0.2418 |
| mperiod_num | L03_04 | | 1 | 0.09869886 | 0.012251467 | 64.9005 | 0.0000 |
| mperiod_num | L04_05 | | 1 | 0.90375201 | 0.008662913 | 10883.5528 | 0.0000 |
| vPeriodNbr_pw1 | | | 1 | -0.05006364 | 0.000256529 | 38086.4711 | 0.0000 |
| vPeriodNbr_pw2 | | | 1 | -0.03276973 | 0.00040402 | 6578.6832 | 0.0000 |
| vPeriodNbr_pw3 | | | 1 | -0.02757859 | 0.001340736 | 423.1139 | 0.0000 |
| vPeriodNbr_pw4 | | | 1 | -0.01929283 | 0.004689891 | 16.9226 | 0.0000 |
| vLTV_cdf_pw1 | | | 1 | 0.01997314 | 0.000750925 | 707.4556 | 0.0000 |
| vLTV_cdf_pw2 | | | 1 | -0.00258604 | 0.000117515 | 484.2679 | 0.0000 |
| vLTV_cdf_pw3 | | | 1 | -0.02239655 | 0.00028269 | 6276.8329 | 0.0000 |
| vLTV_cdf_pw4 | | | 1 | -0.04072200 | 0.002303324 | 312.5704 | 0.0000 |
| mLTV | 0 | | 1 | 0.44194639 | 0.01742641 | 643.1664 | 0.0000 |
| mPeriod_Yr | Prior_2012 | | 1 | -0.05044103 | 0.003082779 | 267.7214 | 0.0000 |
| mperiod_num*mOrigFY | L01_02 | L01_2001 | 1 | 0.51341576 | 0.012842613 | 1598.2017 | 0.0000 |
| mperiod_num*mOrigFY | L02_03 | L01_2001 | 1 | 0.48637013 | 0.013453877 | 1306.8896 | 0.0000 |
| mperiod_num*mOrigFY | L03_04 | L01_2001 | 1 | 0.19013307 | 0.013531653 | 197.4302 | 0.0000 |
| mperiod_num*mOrigFY | L04_05 | L01_2001 | 1 | -0.73768719 | 0.010545294 | 4893.5842 | 0.0000 |

## Likelihood of Full Cash Draw

The model parameters for the likelihood of a full cash draw in the first eight quarters are shown below.

*Table 30: Model Parameters – Likelihood of Full Cash Draw (Quarters 1 – 8)*

| Variable | ClassVal0 | DF | Estimate | StdErr | WaldChiSq | ProbChiSq |
|---|---|---|---|---|---|---|
| Intercept | | 1 | -0.222203952 | 0.088995388 | 6.2340 | 0.0125 |
| vLOCCap_cd100_pw0 | | 1 | -0.001147871 | 2.72708E-05 | 1771.6977 | 0.0000 |
| vLOCCap_cd100_pw1 | | 1 | -0.000498206 | 1.1546E-05 | 1861.8910 | 0.0000 |
| vLOCCap_cd100_pw2 | | 1 | -0.000104793 | 5.08292E-06 | 425.0471 | 0.0000 |
| vLOCCap_cd100_pw3 | | 1 | -6.54654E-05 | 3.20248E-06 | 417.8782 | 0.0000 |
| vLOCCap_cd100_pw4 | | 1 | -1.50732E-05 | 5.5384E-07 | 740.6957 | 0.0000 |
| vLOCCap_cd100_pw6 | | 1 | -6.37947E-06 | 1.21473E-06 | 27.5810 | 0.0000 |
| vLTV_cd100_pw1 | | 1 | -0.000670683 | 0.001361309 | 0.2427 | 0.6222 |
| vLTV_cd100_pw2 | | 1 | 0.00425177 | 0.001179416 | 12.9959 | 0.0003 |
| vLTV_cd100_pw3 | | 1 | -0.078834888 | 0.004838981 | 265.4172 | 0.0000 |
| vminage_cd100_pw1 | | 1 | 0.009595812 | 0.001733819 | 30.6306 | 0.0000 |
| vminage_cd100_pw2 | | 1 | 0.034468099 | 0.00174569 | 389.8526 | 0.0000 |
| vPeriodNbr_pw1 | | 1 | -0.040759207 | 0.001016679 | 1607.2501 | 0.0000 |
| vPeriodNbr_pw2 | | 1 | 0.018232005 | 0.002118487 | 74.0657 | 0.0000 |
| mSeason | L01 | 1 | 0.119073964 | 0.017100248 | 48.4874 | 0.0000 |
| mSeason | L02 | 1 | 0.17341777 | 0.016913919 | 105.1232 | 0.0000 |
| mSeason | L03 | 1 | 0.255084626 | 0.016837418 | 229.5185 | 0.0000 |
| MGender | L01_M | 1 | 0.05571756 | 0.013551327 | 16.9052 | 0.0000 |
| mAlive | L02_2 | 1 | 0.097762792 | 0.013316249 | 53.8993 | 0.0000 |
| mloantyp | L01_01 | 1 | 0.517797081 | 0.027900563 | 344.4239 | 0.0000 |

The model parameters for the likelihood of a full cash draw in the ninth and subsequent quarters are shown below.

*Table 31: Model Parameters – Likelihood of Full Cash Draw (Quarters 9+)*

| Variable | ClassVal0 | ClassVal1 | DF | Estimate | StdErr | WaldChiSq | ProbChiSq |
|---|---|---|---|---|---|---|---|
| Intercept | | | 1 | -3.19822815 | 0.016194283 | 39002.7690 | 0.0000 |
| mMinage | L01_62 | | 1 | 0.16345041 | 0.014707328 | 123.5107 | 0.0000 |
| mMinage | L02_63 | | 1 | 0.14640703 | 0.009150123 | 256.0177 | 0.0000 |
| mMinage | L03_64 | | 1 | 0.09228672 | 0.007736996 | 142.2767 | 0.0000 |
| mMinage | L04_65 | | 1 | 0.03856462 | 0.006999581 | 30.3553 | 0.0000 |
| mMinage | L05_95 | | 1 | -0.03339241 | 0.00712308 | 21.9766 | 0.0000 |
| mMinage | L06_99 | | 1 | -0.02381254 | 0.016884391 | 1.9890 | 0.1584 |
| mSeason | L01 | | 1 | -0.16016268 | 0.003183527 | 2531.0784 | 0.0000 |
| mSeason | L02 | | 1 | -0.10906661 | 0.003158152 | 1192.6622 | 0.0000 |
| mSeason | L03 | | 1 | -0.04350945 | 0.003210361 | 183.6790 | 0.0000 |
| mAlive | L02_2 | | 1 | -0.22039552 | 0.002380618 | 8570.8908 | 0.0000 |
| MGender | L01_M | | 1 | -0.04443746 | 0.002561023 | 301.0727 | 0.0000 |
| mDeltaTy1Init | L02_2.0 | | 1 | -0.02544653 | 0.003704862 | 47.1751 | 0.0000 |
| mloantyp | L01_01 | | 1 | -0.46134834 | 0.004600117 | 10058.1961 | 0.0000 |
| vLOCCap_pw1 | | | 1 | 0.00038665 | 1.82373E-06 | 44947.8097 | 0.0000 |
| vLOCCap_pw2 | | | 1 | 0.00004092 | 7.87416E-07 | 2700.0180 | 0.0000 |
| vLOCCap_pw3 | | | 1 | 0.00000181 | 2.71818E-08 | 4435.3893 | 0.0000 |
| vLOCRemain_pw1 | | | 1 | 1.41029542 | 0.044550566 | 1002.1062 | 0.0000 |
| vLOCRemain_pw2 | | | 1 | 1.19144502 | 0.015256668 | 6098.5785 | 0.0000 |
| vLOCRemain_pw3 | | | 1 | -0.04498040 | 0.004329435 | 107.9404 | 0.0000 |
| vLOCRemain_pw4 | | | 1 | -0.02350087 | 0.000699694 | 1128.1101 | 0.0000 |
| vLOCRemain_pw5 | | | 1 | -0.01615747 | 0.000245811 | 4320.5996 | 0.0000 |
| vLOCRemain_pw6 | | | 1 | -0.01839630 | 0.000150184 | 15004.1924 | 0.0000 |
| vLOCRemain_pw7 | | | 1 | -0.02622946 | 0.000390104 | 4520.8162 | 0.0000 |
| vLOCRemain_pw8 | | | 1 | -0.12322486 | 0.001796764 | 4703.4280 | 0.0000 |
| vLOCRemain_pw9 | | | 1 | -0.46801678 | 0.014856665 | 992.3850 | 0.0000 |
| vLOCRemain_pw10 | | | 1 | 1.43496820 | 0.105214673 | 186.0081 | 0.0000 |
| mperiod_num | L01_02 | | 1 | 0.25232370 | 0.011984872 | 443.2506 | 0.0000 |
| mperiod_num | L02_03 | | 1 | -0.01446057 | 0.012353797 | 1.3702 | 0.2418 |
| mperiod_num | L03_04 | | 1 | 0.09869886 | 0.012251467 | 64.9005 | 0.0000 |
| mperiod_num | L04_05 | | 1 | 0.90375201 | 0.008662913 | 10883.5528 | 0.0000 |
| vPeriodNbr_pw1 | | | 1 | -0.05006364 | 0.000256529 | 38086.4711 | 0.0000 |
| vPeriodNbr_pw2 | | | 1 | -0.03276973 | 0.00040402 | 6578.6832 | 0.0000 |
| vPeriodNbr_pw3 | | | 1 | -0.02757859 | 0.001340736 | 423.1139 | 0.0000 |
| vPeriodNbr_pw4 | | | 1 | -0.01929283 | 0.004689891 | 16.9226 | 0.0000 |
| vLTV_cdf_pw1 | | | 1 | 0.01997314 | 0.000750925 | 707.4556 | 0.0000 |
| vLTV_cdf_pw2 | | | 1 | -0.00258604 | 0.000117515 | 484.2679 | 0.0000 |
| vLTV_cdf_pw3 | | | 1 | -0.02239655 | 0.00028269 | 6276.8329 | 0.0000 |
| vLTV_cdf_pw4 | | | 1 | -0.04072200 | 0.002303324 | 312.5704 | 0.0000 |
| mLTV | 0 | | 1 | 0.44194639 | 0.01742641 | 643.1664 | 0.0000 |
| mPeriod_Yr | Prior_2012 | | 1 | -0.05044103 | 0.003082779 | 267.7214 | 0.0000 |
| mperiod_num*mOrigFY | L01_02 | L01_2001 | 1 | 0.51341576 | 0.012842613 | 1598.2017 | 0.0000 |
| mperiod_num*mOrigFY | L02_03 | L01_2001 | 1 | 0.48637013 | 0.013453877 | 1306.8896 | 0.0000 |
| mperiod_num*mOrigFY | L03_04 | L01_2001 | 1 | 0.19013307 | 0.013531653 | 197.4302 | 0.0000 |
| mperiod_num*mOrigFY | L04_05 | L01_2001 | 1 | -0.73768719 | 0.010545294 | 4893.5842 | 0.0000 |

## Cash Draw Amount Model

The model parameters for the cash draw amount are shown below.

*Table 32: Model Parameters –Cash Draw Amount*

| Parameter | Level1 | DF | Estimate | StdErr | LowerWaldCL | UpperWaldCL | ChiSq | ProbChiSq |
|---|---|---|---|---|---|---|---|---|
| Intercept | | 1 | 6.2958 | 0.0182 | 6.2600 | 6.3315 | 119200.03 | 0.0000 |
| vLOCCap_cds_pw1 | | 1 | 0.1397 | 0.0120 | 0.1161 | 0.1633 | 134.95 | 0.0000 |
| vLOCCap_cds_pw2 | | 1 | -0.0479 | 0.0036 | -0.0549 | -0.0409 | 179.18 | 0.0000 |
| vLOCCap_cds_pw3 | | 1 | -0.0350 | 0.0012 | -0.0373 | -0.0327 | 902.53 | 0.0000 |
| vLOCCap_cds_pw4 | | 1 | -0.0226 | 0.0012 | -0.0250 | -0.0202 | 340.48 | 0.0000 |
| vLOCCap_cds_pw5 | | 1 | -0.0167 | 0.0003 | -0.0174 | -0.0161 | 2832.59 | 0.0000 |
| vLOCCap_cds_pw6 | | 1 | -0.0050 | 0.0000 | -0.0051 | -0.0049 | 11053.01 | 0.0000 |
| vLOCCap_cds_pw7 | | 1 | -0.0013 | 0.0001 | -0.0014 | -0.0011 | 262.12 | 0.0000 |
| vLOCCap_cds_pw8 | | 1 | -0.0011 | 0.0001 | -0.0012 | -0.0009 | 229.92 | 0.0000 |
| vLOCRemain_pw1 | | 1 | -0.0176 | 0.0016 | -0.0208 | -0.0143 | 113.66 | 0.0000 |
| vLOCRemain_pw2 | | 1 | -0.0202 | 0.0009 | -0.0219 | -0.0184 | 497.67 | 0.0000 |
| vLOCRemain_pw3 | | 1 | -0.0121 | 0.0004 | -0.0129 | -0.0114 | 903.17 | 0.0000 |
| vLOCRemain_pw4 | | 1 | -0.0066 | 0.0002 | -0.0070 | -0.0062 | 1238.26 | 0.0000 |
| vLOCRemain_pw5 | | 1 | -0.0059 | 0.0002 | -0.0062 | -0.0056 | 1471.22 | 0.0000 |
| vLOCRemain_pw6 | | 1 | -0.0143 | 0.0022 | -0.0186 | -0.0100 | 42.19 | 0.0000 |
| vLOCRemain_pw7 | | 1 | -0.0107 | 0.0013 | -0.0132 | -0.0081 | 67.45 | 0.0000 |
| vLOCRemain_pw8 | | 1 | 0.1399 | 0.0098 | 0.1206 | 0.1592 | 201.96 | 0.0000 |
| vLOCRemain_pw9 | | 1 | 0.1737 | 0.0043 | 0.1652 | 0.1822 | 1605.56 | 0.0000 |
| vminage_cds_pw1 | | 1 | -0.0109 | 0.0014 | -0.0136 | -0.0082 | 63.86 | 0.0000 |
| vminage_cds_pw2 | | 1 | -0.0076 | 0.0005 | -0.0085 | -0.0066 | 264.64 | 0.0000 |
| vminage_cds_pw3 | | 1 | 0.0092 | 0.0004 | 0.0084 | 0.0099 | 627.09 | 0.0000 |
| vminage_cds_pw4 | | 1 | 0.0285 | 0.0007 | 0.0272 | 0.0298 | 1751.13 | 0.0000 |
| vPeriodNbr_pw1 | | 1 | -0.0763 | 0.0007 | -0.0776 | -0.0750 | 12859.54 | 0.0000 |
| vPeriodNbr_pw2 | | 1 | -0.0243 | 0.0004 | -0.0250 | -0.0236 | 4687.94 | 0.0000 |
| vPeriodNbr_pw3 | | 1 | -0.0074 | 0.0002 | -0.0078 | -0.0070 | 1188.30 | 0.0000 |
| vPeriodNbr_pw4 | | 1 | -0.0062 | 0.0053 | -0.0166 | 0.0042 | 1.36 | 0.2433 |
| vLTV_cds_pw1 | | 1 | -0.0009 | 0.0007 | -0.0022 | 0.0005 | 1.62 | 0.2025 |
| vLTV_cds_pw2 | | 1 | 0.0089 | 0.0001 | 0.0087 | 0.0091 | 9013.86 | 0.0000 |
| vLTV_cds_pw3 | | 1 | 0.0032 | 0.0003 | 0.0026 | 0.0039 | 96.19 | 0.0000 |
| mltv | L01_60 | 1 | 0.5910 | 0.0166 | 0.5584 | 0.6236 | 1262.37 | 0.0000 |
| mSeason | L01 | 1 | -0.0005 | 0.0027 | -0.0057 | 0.0047 | 0.03 | 0.8618 |
| mSeason | L02 | 1 | 0.0263 | 0.0026 | 0.0212 | 0.0315 | 100.21 | 0.0000 |
| mSeason | L03 | 1 | 0.0326 | 0.0027 | 0.0274 | 0.0378 | 149.74 | 0.0000 |
| MGender | L01_M | 1 | 0.0366 | 0.0022 | 0.0324 | 0.0408 | 287.81 | 0.0000 |
| mAlive | L02_2 | 1 | 0.0462 | 0.0020 | 0.0422 | 0.0503 | 511.51 | 0.0000 |
| mloantyp | L01_01 | 1 | -0.1118 | 0.0042 | -0.1200 | -0.1035 | 708.45 | 0.0000 |
| Scale | | 0 | 0.9729 | 0.0000 | 0.9729 | 0.9729 | | |

## Tax and Insurance Default Model

The model parameters for the Tax and Insurance Default model are shown below.

*Table 33: Model Parameters – Tax and Insurance Default Model*

| Variable | ClassVal0 | DF | Estimate | StdErr | WaldChiSq | ProbChiSq | _ESTTYPE_ |
|---|---|---|---|---|---|---|---|
| Intercept | | 1 | -4.2678 | 0.000546 | 61067920.7 | <.0001 | MLE |
| mSeason | L01 | 1 | -0.0534 | 0.00104 | 2626.9463 | <.0001 | MLE |
| mSeason | L02 | 1 | -0.0305 | 0.00118 | 667.9765 | <.0001 | MLE |
| mSeason | L03 | 1 | 0.0404 | 0.00109 | 1370.2308 | <.0001 | MLE |
| mTICnt | L01 | 1 | 1.3449 | 0.00179 | 566869.271 | <.0001 | MLE |
| mTICnt | L02 | 1 | 3.0545 | 0.00161 | 3594731.73 | <.0001 | MLE |
| mTICnt | L03 | 1 | 3.5943 | 0.00183 | 3844501.86 | <.0001 | MLE |
| mTICnt | L04 | 1 | 4.3816 | 0.00226 | 3773882.76 | <.0001 | MLE |
| mTICnt | L05 | 1 | 5.9982 | 0.00418 | 2058588.06 | <.0001 | MLE |
| mTICnt | L06 | 1 | 6.085 | 0.00528 | 1328274.04 | <.0001 | MLE |
| mTICnt | L07 | 1 | 5.2083 | 0.00466 | 1251183.27 | <.0001 | MLE |
| mTICnt | L08 | 1 | 6.5224 | 0.00989 | 435225.809 | <.0001 | MLE |
| mTICnt | L09 | 1 | 2.4478 | 0.00993 | 60787.018 | <.0001 | MLE |
| mTICnt | L10 | 1 | 11.4853 | 0.2029 | 3204.4453 | <.0001 | MLE |
| mTICnt | L11 | 1 | 14.6721 | 1.3199 | 123.5727 | <.0001 | MLE |
| mTICnt | L12 | 1 | 12.2902 | 0.306 | 1613.1827 | <.0001 | MLE |
| mTICnt | L13 | 1 | 17.6539 | 5.9511 | 8.8002 | 0.003 | MLE |
| mTICnt | L14 | 1 | 7.7939 | 0.0416 | 35163.7411 | <.0001 | MLE |
| mTICnt | L15 | 1 | 2.4497 | 0.0253 | 9366.2132 | <.0001 | MLE |
| mTICnt | L16 | 1 | 10.5198 | 0.2126 | 2449.114 | <.0001 | MLE |
| vperiodnbr_TIDF_pw1 | | 1 | -0.00263 | 0.000044 | 3564.3463 | <.0001 | MLE |
| vperiodnbr_TIDF_pw2 | | 1 | -0.0134 | 0.000126 | 11218.1027 | <.0001 | MLE |
| vperiodnbr_TIDF_pw3 | | 1 | -0.0253 | 0.000229 | 12230.0038 | <.0001 | MLE |
| vperiodnbr_TIDF_pw4 | | 1 | -0.00806 | 0.000873 | 85.1349 | <.0001 | MLE |
| vperiodnbr_TIDF_pw5 | | 1 | -0.0164 | 0.00126 | 167.8276 | <.0001 | MLE |

## Model Validation

Model validation was accomplished by applying the models developed using the training set to the validation dataset. The application of this model to the validation data produces the probability of a cash draw or a predicted cash draw amount. The actual target variable is then compared to the predicted target variable to ensure the model fits the transition process without over-fitting the actual data.

Specifically we calculate the predicted probability of the cash draw or the predicted amount for the cash draw amount models. The actual result is 1.0 if the cash draw was taken and 0.0 if it was not, or an actual cash draw amount for the cash draw amount model. The probability of each transition or claim type for each record in the validation dataset is derived from the model parameters. The sum of the predicted probabilities is 1.0 for each record.

Decile charts are then created for each final cash draw likelihood or average draw amount. All records are sorted, or ranked, by the predicted value. Ten equal sized decile groups are created with 10% of the records in each group. The sum of the actual result and the sum of the predicted result within each decile is calculated. The actual and predicted numbers are then compared for consistency. The objective of a model is to have a

significant spread in predicted values while maintaining a close relationship between the resulting actual and predicted values.

The validation charts for the cash draw models are shown below.

*Figure 13: Model Validation - Likelihood of Cash Draw*

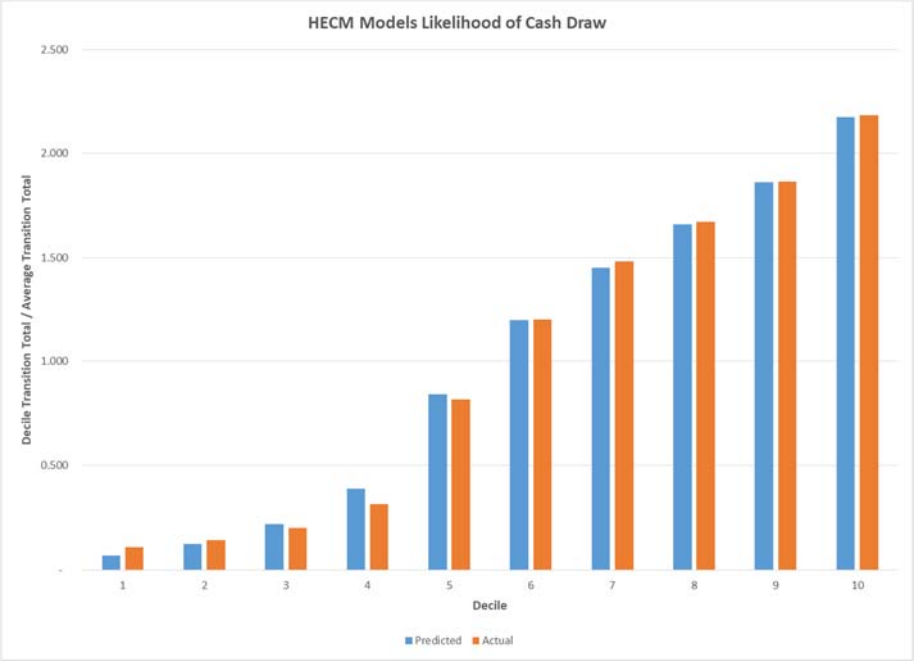


*Figure 14: Model Validation - Likelihood of Full Cash Draw (Quarters 0 – 8)*

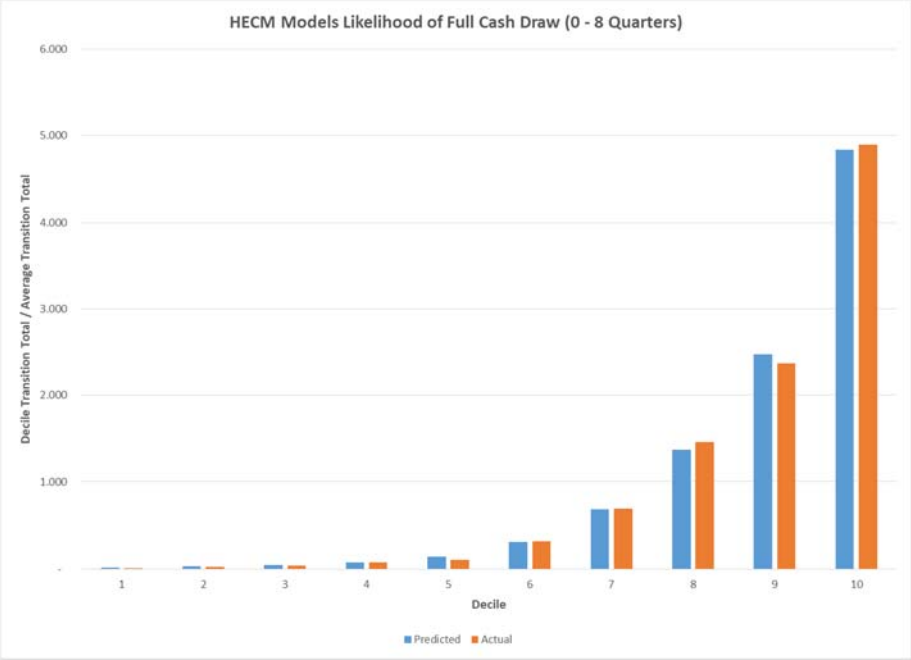



*Figure 15: Model Validation - Likelihood of Full Cash Draw (Quarters 9+)*

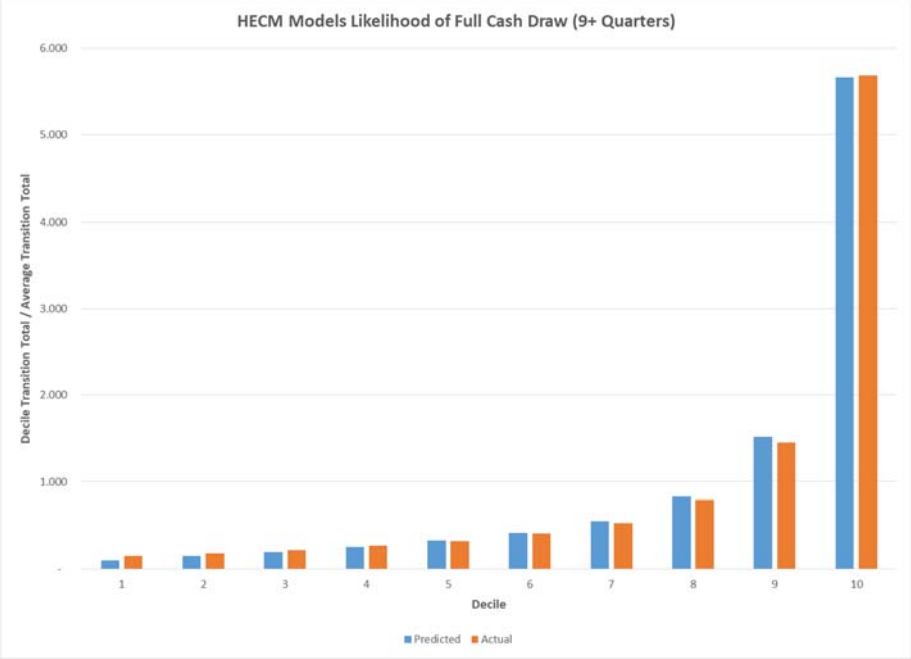
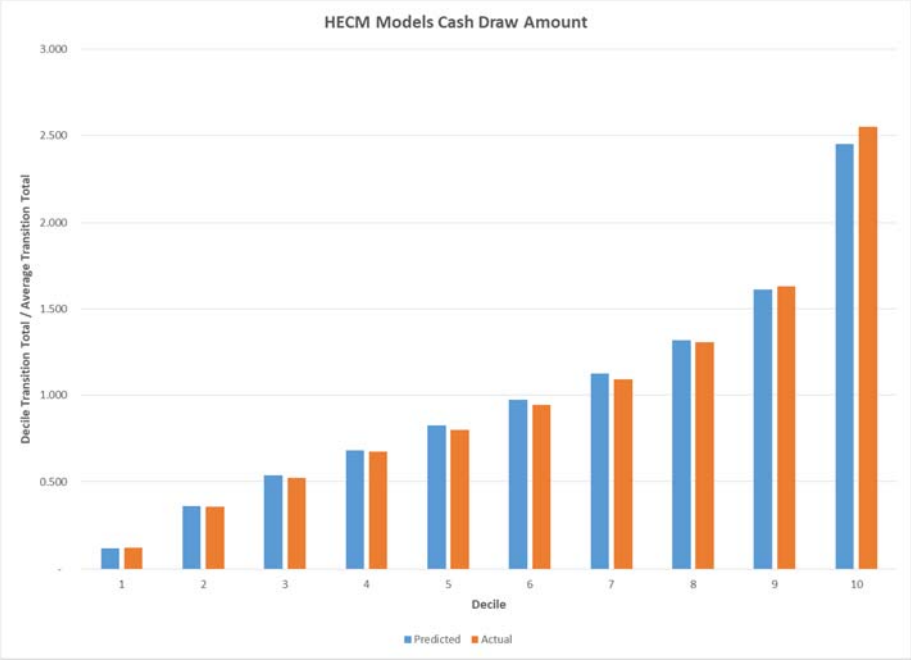
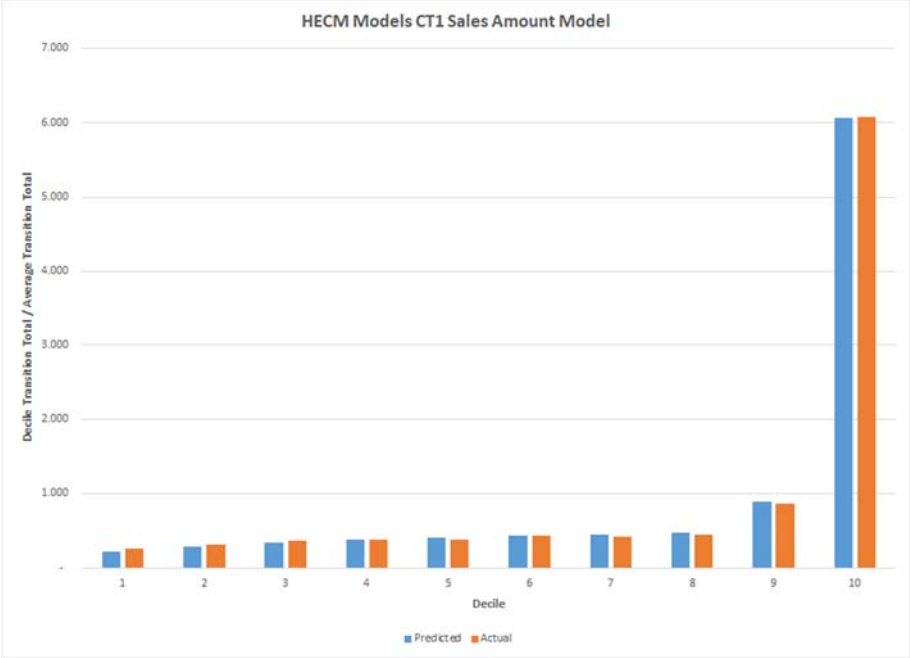


*Figure 16: Model Validation – Cash Draw Amount Model*




The validation chart for the Tax and Insurance Default model is shown below.

*Figure 17: Model Validation – Tax and Insurance Default Model*



# Appendix D: Economic Scenarios

To measure the possible variation in MMIF's Cash Flow NPV on the existing portfolio, we developed a baseline projection using OMB Economic Assumptions and also projections for ten additional deterministic economic scenarios from Moody's. For this analysis, we used the Moody's September 2018 forecast of the U.S. economy. For purposes of our analysis, the components of Moody's forecast include:

- HPI at the MSA, state, regional and national levels
- 1-year CMT rate
- 3-year CMT rate
- 5-year CMT rate
- 10-year CMT rate
- 30-year CMT rate
- Commitment rate on 30-year fixed-rate mortgages
- Unemployment rates at the MSA, state, regional and national levels
- GDP

## Alternative Scenarios

To assess the effect of alternative economic scenarios on the Cash Flow NPV, ten alternative scenarios from Moody's were used. The ten Moody's scenarios are:

- Baseline
- Exceptionally Strong Growth
- Stronger Near-Term Rebound
- Slower Near-Term Growth
- Moderate Recession
- Protracted Slump
- Below-Trend Long-Term Growth
- Stagflation
- Next-Cycle Recession
- Low Oil Price

The Moody's projections provide a range of better than expected economic assumptions and worse than expected economic assumptions. This range of assumptions produces a range of Cash Flow NPV projections.

## Graphical Depiction of the Scenarios

Figure 18 shows the future movements of the HPI under the baseline and the alternative economic scenarios. In the Moody's Baseline scenario, the HPI increases over the entire projection period, and the rate of change is consistently between 2.5% and 3.5%. The mortgage interest rate increases and settles at a long-term average of about 5.9%. The unemployment rate decreases to 3.4% over the next year, and then increases to a long-term average of around 5.0%.

*Figure 18: Paths of the Future National House Price Index in Different Scenarios*

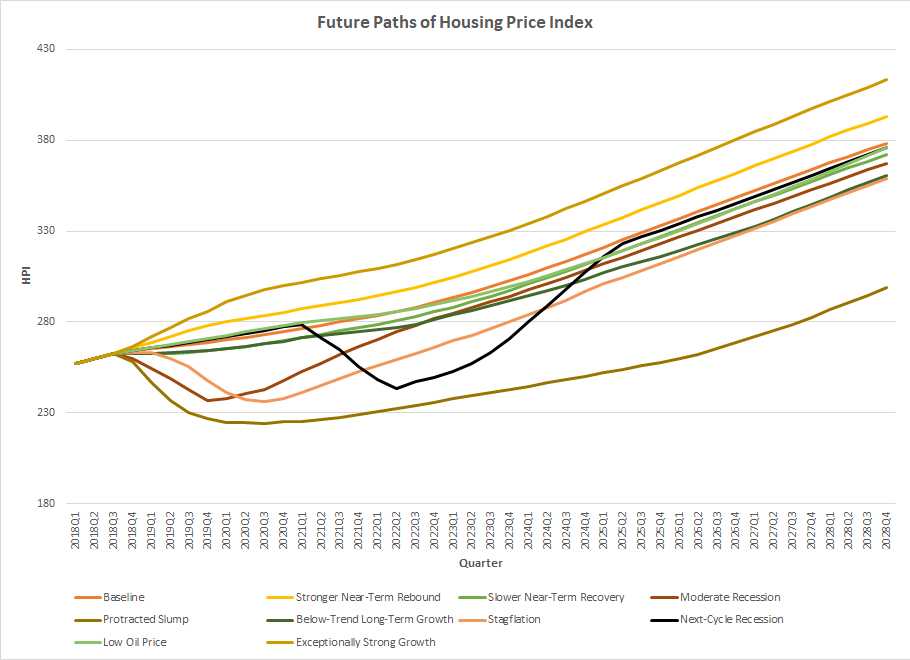



Figure 19 shows the forecasted mortgage rate of 30-year fixed-rate mortgages for the ten Moody's scenarios. Moody's Baseline forecast for the 30-year fixed interest rate shows that the mortgage interest rate increases to just under 5.6% by 2022, holds steady though 2024, then increases to a long-term average rate of around 5.7%. For the Moody's projections, we use the 30-year fixed rate as this represents the majority of the mortgage products sold.

*Figure 19: Paths of the Future Mortgage Rate*

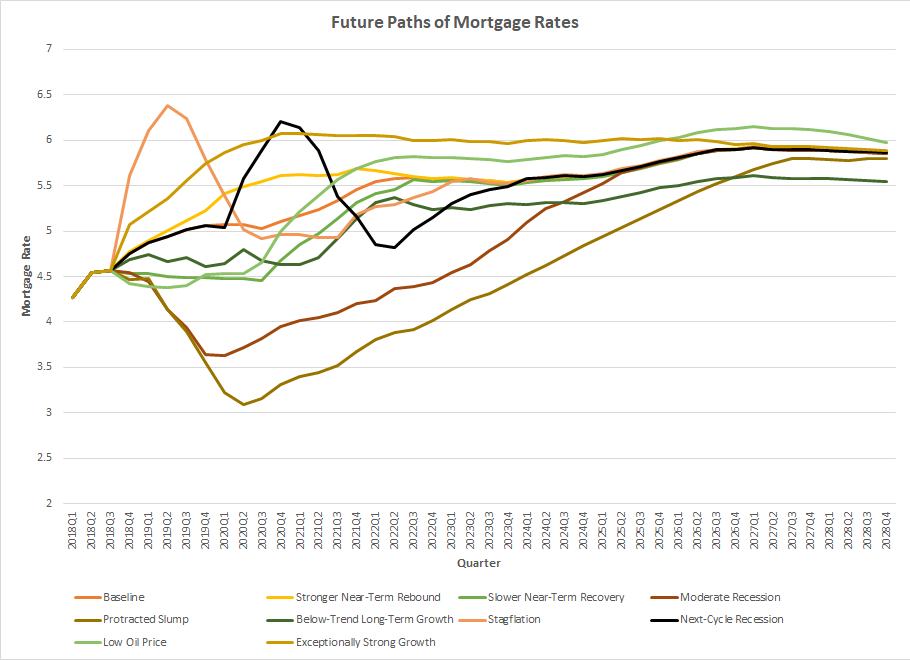
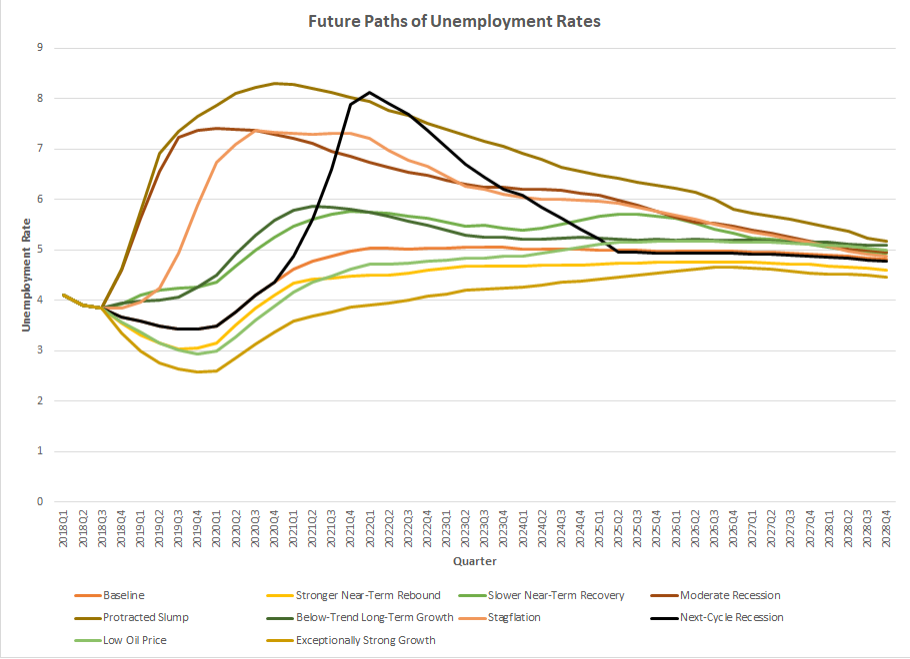



Figure 20 shows the forecasted unemployment rate under alternative economic scenarios. The Moody's Baseline forecast projects that the unemployment rate will decrease to 3.4% in 2019, and then increases to a long-term average of just over 5%.

*Figure 20: Paths of Future National Unemployment Rate*



## Stochastic Simulation

This section describes the stochastic models fitted to generate the economic variables simulations used in the projection of Cash Flow NPV.

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

- 1-Year Treasury Rates
- 3-Month Treasury Rates
- 6-Month Treasury Rates
- 2-Year Treasury Rates
- 3-Year Treasury Rates
- 5-Year Treasury Rates
- 7-Year Treasury Rates
- 10-Year Treasury Rates
- 20-Year Treasury Rates
- 30-Year Treasury Rates
- 30-Year Fixed Rate Mortgage (FRM) Rates
- FHFA National Purchase Only House Price Index (HPI-PO)
- Unemployment Rates
- Gross Domestic Product (GDP)

### Historical Data

**A. Interest Rates**

Figure 21 shows historical interest rates since 1971.

This graph illustrates the variability of interest rates over time and the consistent spread between rates. Shown are the 1-year Treasury rate (tr1y), 10-year Treasury rate (tr10y) and the 30-year fixed rate mortgage rate (mr).

High inflation rates caused by the global oil crisis in the late 1970's was the major factor for the historically high level in early 1980's. The Federal Reserve shifted its monetary policy from managing interest rates to managing the money supply as a way to influence interest rates after this period of time. The 1-year Treasury rate (tr1y) was around 5% in CY 1971 and increased steadily to its peak of 16.31% in CY 1981 Q3. After that, it followed a decreasing trend and reached an all-time low of 0.10% in CY 2014 Q2. Since then rates have started a slow upward trend.

*Figure 21: Historical Interest Rates (%)*

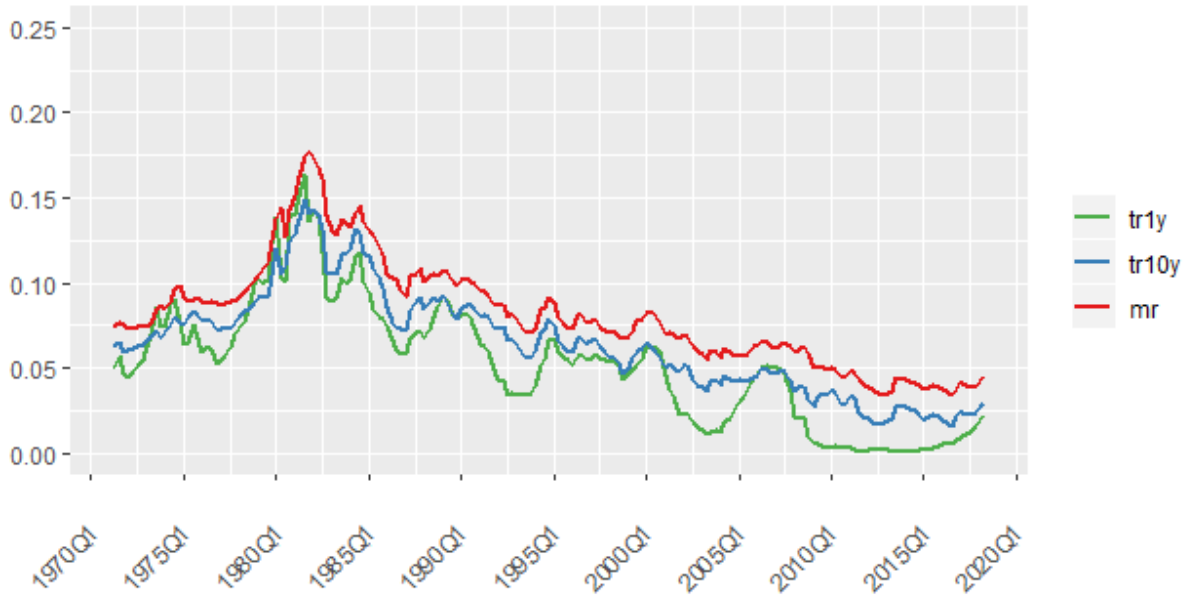
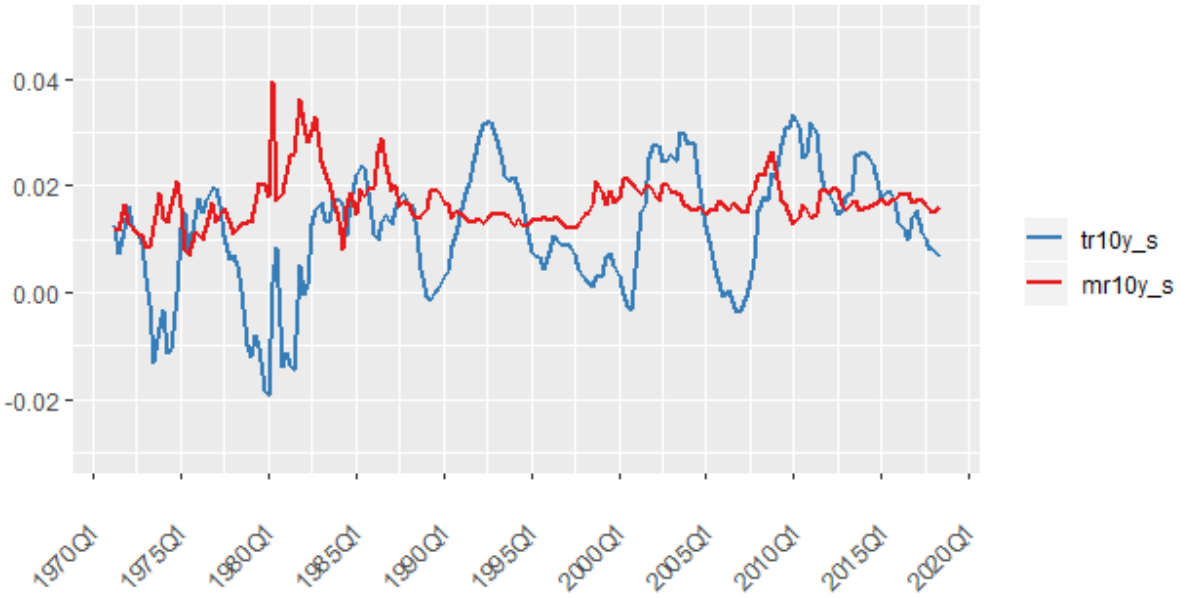



Figure 22 shows historical interest rate spreads, including the spread between 10-year and 1-year Treasury rates (tr10y_s) and the spread between the 30-year mortgage rate and the 10-year Treasury rate (mr10y_s). Both spreads have a mostly positive value with long cycles. Lower, and negative spreads typically correspond with economic downturns, like during the late 70's through early 80's. Also note, the spread of the mortgage rate over the 10-year Treasury rate is always positive, reflecting the premium for credit risk.

*Figure 22: Historical Interest Rate Spreads (%)*




**B. House Price Appreciation Rates**

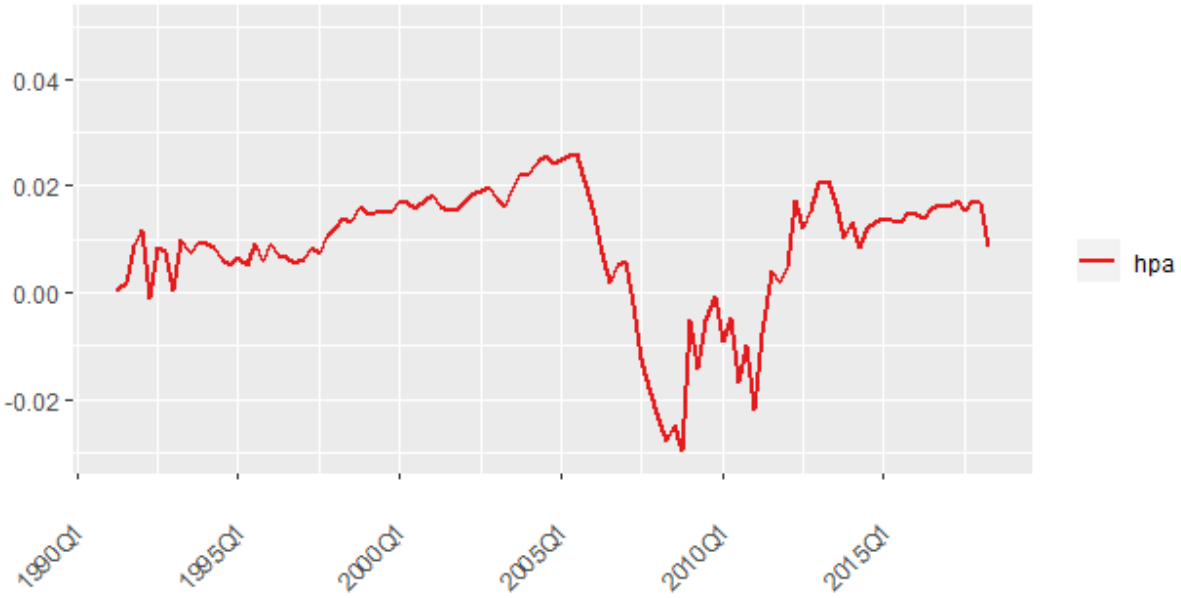
The national house price appreciation rate (HPA) is derived from the FHFA repeat sales house price indexes (HPIs) of purchase-only (PO) transactions. The PO HPI provides a reliable measure of housing market conditions, since it is based on repeat sales at market prices and does not use any appraised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

The HPA series being modeled is defined as:

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

Figure 23 shows the national quarterly HPA from CY 1991 Q1 to CY 2018 Q2. The long-term average quarterly HPA is around 0.87% (3.30% annual rate).

*Figure 23: Historical National HPI and Quarterly HPA*




The HPI increased steadily before 2004, and the quarterly appreciation rate was around 1.14%. Then house prices rose sharply starting in 2004. The average quarterly house price appreciation rate was 1.88% during the subprime mortgage expansion period from 2004 to 2006, and reached its peak of 2.59% in CY 2005 Q2. After 2006, the average growth rate of house price became negative until 2011 when appreciation returns to a positive value. Table 34 shows the quarterly HPA by selected historical time periods.

*Table 34: Average Quarterly HPA by Time Span*

| Period | Average Quarterly HPA |
|---|---|
| 1991 – 2003 | 1.13% |
| 2004 – 2006 | 1.87% |
| 2007 – 2010 | -1.23% |
| 2011 – 2018 | 1.15% |

## Modeling Techniques

The primary modeling techniques used in these simulations include

- Auto Regressive Moving Average (ARMA)
- General Auto Regressive Conditional Heteroscedasticity (GARCH)

ARMA models are typically specified as ARMA(*p,q*) where *p* is the auto regressive component of the series, and *q* is the moving average.

GARCH models are typically specified as GARCH(*p,q)* where *p* is the auto regressive component of $\sigma_t{}^2$, and *q* is the AR component of the error term.

Description and examples of using an ARMA-GARCH model for time series analysis includes Engle and Mezrich (1995).

## 1-Year Treasury Rate

In this section, we present some historical statistics on the 1-year Treasury rate, and then describe the estimation model for the stochastic process, and finally report the parameter estimates and their standard errors.

Table 35 shows the summary statistics of the historical 1-year Treasury rates for two periods, one from 1971 and the other from 1992, as well as the simulated series. We can see that in the last 25 years, interest rates have been much more stable than in the past.

*Table 35: Statistics for the 1-Year Treasury Rates*

| Statistics | Since 1953 | Since 1992 | Simulations |
|---|---|---|---|
| **Mean** | 4.86% | 2.46% | 2.93% |
| **Standard Deviation** | 3.28% | 2.27% | 2.48% |
| **Max** | 16.31% | 6.71% | 17.26% |
| **95- Percentile** | 10.30% | 5.94% | 9.75% |
| **90- Percentile** | 9.02% | 5.65% | 7.18% |
| **50- Percentile** | 4.72% | 2.33% | 2.58% |
| **25-Percentile** | 2.39% | 0.53% | 1.89% |
| **10- Percentile** | 0.52% | 0.16% | 0.93% |
| **5- Percentile** | 0.19% | 0.13% | 0.33% |
| **Min** | 0.10% | 0.10% | 0.01% |

An ARMA(2,4) parameterization was used to model the 1-Year Treasury rate (*r1*) difference from the previous period and estimated it using data from CY 1953 Q1 to CY 2018 Q2. The process takes the following form:

$$r_{1,t} = x_1 r_{1,ar1} + x_2 r_{1,ar2} + x_3 w_{1,ma1} + x_4 w_{1,ma2} + x_5 w_{1,ma3} + x_6 w_{1,ma4} + \sigma_t dZ_1 \qquad (2)$$

Where $Z_1$ is an independent Wiener random process with distribution N(0,.5), and where the variance (σ) of the residual term follows a GARCH(1,1) process:

$$\sigma_t{}^2 = \beta_0 + \beta_1 \varepsilon^2{}_{t-1} + \beta_2 \sigma^2{}_{t-1} \qquad (3)$$

Where ε is the error term, which equals $\sigma_t dZ_1$ from equation (2).

Full information maximum likelihood (FIML) method was used to estimate the parameters in equations (2) and (3). The results are presented in Table 36.

*Table 36: Estimation Results for 1-Year Treasury Rate Model*

| Parameter | Estimate | Std Dev | t-value | prob>t |
|---|---|---|---|---|
| $x_1$ | 0.2585 | 0.3296 | 0.7841 | 0.4330 |
| $x_2$ | -0.1196 | 0.2902 | -0.4120 | 0.6803 |
| $x_3$ | 0.2269 | 0.3088 | 0.7347 | 0.4625 |
| $x_4$ | 0.0256 | 0.1826 | 0.1403 | 0.8884 |
| $x_4$ | 0.2484 | 0.1337 | 1.8576 | 0.0632 |
| $x_5$ | 0.1968 | 0.0789 | 2.4955 | 0.0126 |
| β0 | 0.0000 | 0.0000 | 0.0358 | 0.9714 |
| β1 | 0.3172 | 0.0420 | 7.5521 | 0.0000 |
| β2 | 0.6818 | 0.0370 | 18.4040 | 0.0000 |
| Pearson's GOF | 0.9380 | | | |

The model based on these parameters is used to simulate the 1-year Treasury rates for the forecast period starting in FY 2018 Q3. The model was fit using Akaike Information Criterion (AIC) and Pearson's goodness-of-fit test.

A lower bound of 0.01 percent was applied to the simulated future 1-year Treasury rates to avoid negative rates in the simulation.

## Additional Interest Rate Models

Additional interest rate models were developed. All are transformed as a spread (difference) between the current maturity length and prior. Table 37 describes these spreads and models.

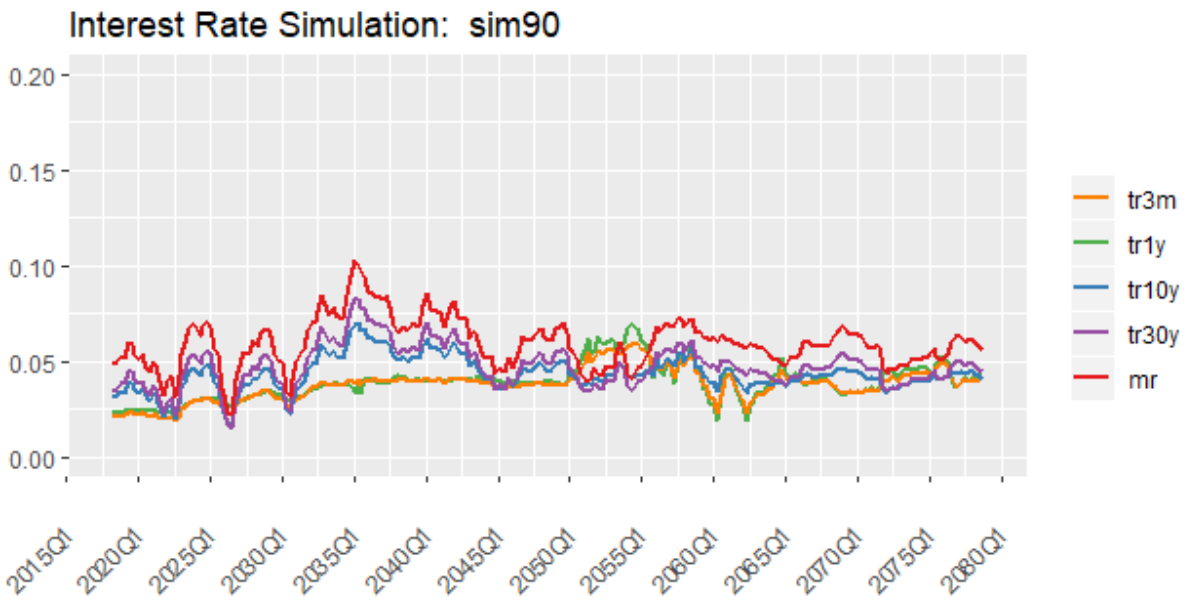
*Table 37: Model Specification for Additional Interest Rates*

| Variable | Variable Transformation | Model Specification | *Notes |
|---|---|---|---|
| 3-month | $S_{3m} = r_{3m} - r_{6m}$ | AR(1)-GARCH(1,1) | |
| 6-month | $S_{6m} = r_{6m} - r_{1y}$ | ARMA(4,2)-GARCH(1,1) | |
| 1-year | $r_{1y}$ | ARMA(2,4)-GARCH(1,1) | *Base Interest Rate |
| 2-year | $S_{2y} = r_{2y} - r_{1y}$ | ARMA(1,2)-ARCH(1) | |
| 3-year | $S_{3y} = r_{3y} - r_{2y}$ | ARMA(2,1)-ARCH(1) | |
| 5-year | $S_{5y} = r_{5y} - r_{2y}$ | ARMA(2,1)-ARCH(1) | |
| 7-year | $S_{7y} = r_{7y} - r_{5y}$ | ARMA(2,1)-ARCH(1) | |
| 10-year | $S_{10y} = r_{10y} - r_{7y}$ | ARMA(2,1)-ARCH(1) | |
| 20-year | $S_{20y} = r_{20y} - r_{10y}$ | AR (2) | *dataset for 1980 forward producing a weaker model |
| 30-year | $S_{30y} = r_{30y} - r_{10y}$ | ARMA(1,1)-GARCH(1,1) | *used 10 year rate for spread |
| 30-year FRM | $S_{mr} = r_{mr} - r_{30y}$ | AR(1)-ARCH(1) | |

All models also used Akaike Information Criterion (AIC) and/or Pearson's goodness-of-fit test to determine the best fitting model.

A lower bound of 0.01 percent was applied to the simulated future Treasury rates to avoid negative rates in the simulation.

*Figure 24: Interest Rate Sample Simulation*




## House Price Appreciation Rate (HPA)

**A. National HPA**

The national HPA series was fit using an ARMA(1,1)-GARCH(1,1). The 1-year, 10-year, and mortgage rates at time *t* and *t-1* were also included as external regressors for a model formula:

$$HPA_t = \mu + x_1 HPA_{ar1} + x_2 w_{1,ma1} + x_3 r_{1,t} + x_4 r_{1,t-1} + x_5 r_{10,t} + x_6 r_{10,t-1} + x_7 mr_t + x_8 mr_{t-1} + \sigma_t dZ_1 \quad (4)$$

Where $Z_1$ is an independent Wiener random process with distribution N(0,1), and where the variance (σ) of the residual term follows a GARCH(1,1) process:

$$\sigma_t{}^2 = \beta_0 + \beta_1 \varepsilon^2{}_{t-1} + \beta_2 \sigma^2{}_{t-1} \quad (5)$$

The model specification and variable inclusions were determined by achieving appropriate coefficient signs and significance, and overall model fit. FIML was used to estimate parameters in equations (4) and (5). The results are shown in Table 38.

*Table 38: Estimation Results for the National HPA Model*

| Parameter | Estimate | Std Dev | t-value | prob>t |
|---|---|---|---|---|
| μ | 0.0252 | 0.0068 | 3.7051 | 0.0002 |
| $x_1$ | 0.9382 | 0.0288 | 32.6179 | 0.0000 |
| $x_2$ | -0.2899 | 0.1044 | -2.7771 | 0.0055 |
| $x_3$ | -0.0740 | 0.0675 | -1.0960 | 0.2731 |
| $x_4$ | -0.1391 | 0.0678 | -2.0525 | 0.0401 |
| $x_5$ | 0.1167 | 0.1928 | 0.6054 | 0.5449 |
| $x_6$ | -0.1933 | 0.1708 | -1.1315 | 0.2578 |
| $x_7$ | -0.1600 | 0.0939 | -1.7031 | 0.0885 |
| $x_8$ | -0.0954 | 0.0865 | -1.1028 | 0.2701 |
| β0 | 0.0000 | 0.0000 | 0.3245 | 0.7456 |
| β1 | 0.4479 | 0.1483 | 3.0207 | 0.0025 |
| β2 | 0.5511 | 0.0956 | 5.7675 | 0.0000 |
| Pearson's GOF | 0.7848 | | | |

We used these parameters to simulate future HPAs from FY 2018 Q3.

**B. 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 ratio of HPAs between the *i*th MSA or State level and the national forecast:

$$Disp_{i,t}^{Base} = HPA_{i,t}^{Base} / HPA_{national,t}^{Base} \quad (6)$$

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

$$HPA_{i,t}^{j} = HPA_{national,t}^{j} * Disp_{i,t}^{Base} \quad (7)$$

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.[4]

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 of the Fund.

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

## Unemployment Rate

**A. National Unemployment Rate**

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

We used quarterly data from CY 1971 to CY 2018 Q2 to estimate the national unemployment rate. The model we adopted was:

$$ue_t = \mu + x_1 ue_{ar1} + x_2 ue_{ar2} + x_3 ue_{ar3} + x_4 r_t + x_5 s_{mr} + \varepsilon_t \quad (8)$$

where $r_t$ is the 1-year Treasury rate,

$s_{mr}$ is the 30-year mortgage rate to 10-year treasury rate spread,

$ue_{ari}$ is the unemployment rate auto regressive component at the $i^{th}$ interval.

The model specification and variable inclusions were determined by achieving appropriate coefficient signs and significance, and overall model fit. FIML was used to estimate parameters in equation (8). The results are shown in Table 39.

*Table 39: Estimation Results for the National Unemployment Rate Model*

| Parameter | Estimate | Std Error |
|---|---|---|
| $\mu$ | 0.0685 | 0.0057 |
| $x_1$ | 1.6273 | 0.0736 |
| $x_2$ | -0.6042 | 0.1346 |
| $x_3$ | -0.0508 | 0.0740 |
| $X_4$ | -0.1395 | 0.0219 |
| $X_5$ | -0.0065 | 0.0406 |

From the simulated interest rates and house prices, we applied the parameters shown in Table 39 to calculate the corresponding national unemployment rate. Based on historical statistics, the national unemployment rate was capped at 20% with a floor at 2%.

**B. Geographic Dispersion**

Following the same logic that we applied to the MSA-level HPA forecasts, we first obtained the dispersion of unemployment rates between the $i^{th}$ MSA or State level and the national level from Moody's July base-case forecast at each time $t$:

$$Disp_{i,t}^{Base} = ue_{i,t}^{Base} / ue_{national,t}^{Base} \quad (9)$$

This dispersion forecast was preserved for all local unemployment rate forecasts under each individual future

economic path. That is, for economic path *j*, the unemployment rate of the *i*th MSA at time *t* was computed as:

$$ue_{i,t}^{j} = ue_{national,t}^{j} * Disp_{i,t}^{Base} \quad (10)$$

For the simulation, we capped the unemployment rate at the local level at 30% with a floor at 1%.

## Gross Domestic Product

In the Gross Domestic Product (GDP) model, the GDP depends on the prior GDP, unemployment, mortgage and Treasury rates.

We used quarterly data from CY 1971 to CY 2018 Q2 to estimate the national unemployment rate. The model tested for integration, so first difference transformations were used prior to estimations. The model adopted was an ARMA(1,2):

$$GDP_t = x_1 GDP_{ar1} + x_2 GDP_{ma1} + x_3 GDP_{ma2} + x_4 r_t + x_5 s_{mr,t} + x_6 ue_t + \varepsilon_t \quad (11)$$

where, $r_t$ is the 1-year Treasury rate,

$s_{mr,t}$ is the 30-year mortgage rate to 10-year treasury rate spread,

$ue_t$ is the unemployment rate,

$GDP_{ar1}$ is the unemployment rate auto regressive component,

$GDP_{mai}$ is the unemployment rate moving average component at the *i*th interval.

The model specification and variable inclusions were determined by achieving appropriate coefficient signs and significance, and overall model fit. FIML was used to estimate parameters in equation (11). The results are shown in Table 40.

*Table 40: Estimation Results for the National Gross Domestic Product Model*

| Parameter | Estimate | Std Error |
|---|---|---|
| $x_1$ | 0.7290 | 0.1242 |
| $x_2$ | -1.3563 | 0.1519 |
| $x_3$ | 0.3858 | 0.1383 |
| $x_4$ | 1223.90 | 760.00 |
| $X_5$ | -1317.81 | 928.72 |
| $X_6$ | -216.00 | 736.72 |

## Simulation Selection/Moody's Baseline

A total of 1000 simulations paths were generated using all of the economic variable models described. This was to create a large sample pool. From this pool a sample was drawn of 100 simulated series.

It was desired that these simulations center around the ten Moody's June 2018 forecasts used within this analysis. Using a least squares method (12) the Moody's forecasts were compared to the simulated paths to sample 10 simulations.

$$score_{v,s} = min(\sum_1^p (vm_t - vs_t)^2) \quad (12)$$

where $vm_t$ is the Moody's forecasted economic variable value at time *t,*

$vs_t$ is the stochastic simulated economic variable forecasted value at time *t,*

*p* is the number of periods compared.

The first 40 periods (10 years) of the series were used for *p*, as the Moody's forecasts converge to a mean value after this time period. Each economic variable (*v*) was scored for each simulation (*s*) and then ranked in a scoring algorithm, and then selecting the 10 best models for each of the 10 Moody's forecasts to provide 100 simulated paths that most closely center on each of these forecasts.

# Appendix E: HECM Cash Flow Analysis

This appendix describes the calculation of the Cash Flow NPV. Future cash flow calculations are based on forecasted variables, such as HPI and interest rates, in addition to individual mortgage characteristics and borrower behavior assumptions. HECM cash flows are discounted according to the latest discount factors published by the OMB.

## General Approach to Mortgage Termination Projections

HECM termination rates are projected for all future policy years for each surviving (active) mortgage. The variables used in the projection are derived from mortgage characteristics and economic forecasts. OMB Economic Assumptions and Moody's March 2018 forecasts of interest and HPI are combined with the mortgage-level data to simulate the projected economic paths and create the necessary forecasted variables. MSA-level forecasts of HPI apply to mortgages in metropolitan areas; otherwise mortgages use the state-level HPI forecasts. House price forecasts are generated simultaneously with various macroeconomic variables including the local unemployment rates.

For each mortgage during future policy years, the derived mortgage variables serve as independent variables to the termination models described in Appendix B. The termination projections by claim type are then calculated to generate the probability of mortgage termination in a policy year by different modes of termination given that it survives to the end of the prior policy year. The HECM cash flow model uses these forecasted termination rates to project the cash flows associated with different termination events. Based on the specific characteristics of the mortgage, the probability of each termination is calculated. Then, a random number between 0 and 1 is generated, and based on this random draw a mortgage transition is determined. The projection process continues for each mortgage until the mortgage ends by termination or claim.

## Cash Flow Components

There are four major components of HECM cash flows:

1. MIP,
2. claims,
3. note holding expenses, and
4. recoveries on notes in inventory (after assignment).

Premiums consist of upfront and annual MIPs, which are inflows to the HECM program. Recoveries are the property recovery amount received by FHA at the time of note termination after assignment, which is the minimum of the mortgage balance and the predicted net sales proceeds at termination. The recovery amount for refinance termination is always the mortgage balance. Claim Type 1 (CT1) payments are cash outflows paid to the lender when the net proceeds of a property sale are insufficient to cover the balance of the mortgage. Assignment claims and note holding payments are additional outflows. Table 41 summarizes the HECM inflows and outflows.

*Table 41: HECM Cash Flows*

| Cash Inflows | Cash Outflows |
|---|---|
| Upfront MIP | Claim Type 1 Payments |
| Annual MIP | Claim Type 2 Payments |
| Recoveries | Note Holding Expenses |

## Mortgage Balance

The UPB is a key input to the cash flow calculations. In general, the UPB at a given time t is calculated as follows:

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

The UPB for each period t consists of the previous mortgage balance plus any new borrower cash draws and accruals. The accruals include interest, annual MIP, and servicing fees. Future borrower draws for borrowers with a line of credit are estimated based on a model of historical cash flow draws as described in Appendix D. Otherwise, mortgages with a tenure plan use the cash draws associated with the tenure of the mortgage.

## Tax & Insurance Defaults

In ML 2011-01, FHA announced that a HECM with tax and insurance (T&I) delinquencies is considered due and payable, and therefore subject to foreclosure if the borrower does not comply with the repayment plan.[5] Through impacts on termination speeds and recovery rates, this ruling was intended to positively impact the economic value of the HECM program by providing an intervention that could reduce potential losses.

There were several major policy changes in fiscal year 2015 that may affect the T&I default experience. In Mortgagee Letter (ML) 2015-09, FHA introduced the requirement and calculation of Life Expectancy Set-Aside (LESA), which is used for the payment of property taxes and hazard and flood insurance premiums. The LESA guidelines became effective on April 27, 2015. With this set-aside, HECM's with LESA will have fewer funds available for withdrawal, but there will be no T&I default before the life expectancy of the borrowers. Since this program has only two years of history and there is no origination data showing information related to LESA, we assume no effect of this LESA guideline due to limited information about mortgages impacted by this guideline. Once more origination data with LESAs become available, the potential performance impact of this policy will be re-evaluated.

For HECM's before assignment, FHA provided additional guidance on due and payable policies and the timing

[5] Mortgagee Letter 2011-01, January 3, 2011 – "Home Equity Conversion Mortgage Property Charge Loss Mitigation."

requirements in ML 2015-10[6] and ML 2015-11[7]. For HECM's after assignment, FHA currently does not foreclose on assigned mortgages that are in T&I default. In order to secure and maintain FHA's position on the lien of an assigned mortgage, FHA advances T&I payments on behalf of the borrower. FHA first advances funds from the borrower's available HECM funds. If no funds are available, FHA advances the tax payment and adds the payment amount to the UPB. These policies affect all existing books and future books.

For unassigned mortgages, if a mortgage goes to into default, the lender may provide a separate mortgage to the borrower to cover the T&I. If this occurs, once a mortgage becomes eligible for assignment, it will not be able to be assigned until the separate mortgage is satisfied.

For assigned mortgages, the T&I payments are treated as note holding expenses, a component of cash outflows, and added to the UPB. The projected T&I payments are not projected separately, but are included in the projection of note holding expenses.

### MIP

Upfront and annual MIP, along with recoveries, are the sources of FHA revenue from the HECM program. Borrowers typically finance the upfront MIP when taking out a HECM mortgage. Similarly, the recurring annual MIP is added to the balance of the mortgage. The upfront MIP is paid to FHA at the time of mortgage closing. It is equal to a stated percentage of the MCA. Typically, the upfront MIP is financed by the HECM lender. The upfront MIP is paid in full to FHA at the mortgage closing, and is a positive cash flow. The annual MIP is calculated as a percentage of the current mortgage balance. Before a mortgage is assigned, the annual MIP is assumed to be advanced by the lender, paid to FHA, and added to the accruing mortgage balance.

### Claims

Claims made by lenders consist of CT1 and Claim Type 2 (CT2).

CT1 enters the HECM cash flows as payments to the lender when a property is sold and the net proceeds from the sale are not sufficient to cover the balance of the mortgage at termination. The CT1 payment for a mortgage that terminates without assignment is expressed as:

*Claim Type 1 Payment = maximum (0, UPB - Net Property Sales Price)*

The net sales price of the property is:

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

The estimated property sale price is developed using models that incorporate the Maintenance Risk Adjustment (MRA). The MRA factors vary by period number and are determined such that the expected CT1 claim severity

[6] Mortgagee Letter 2015-10, April 23, 2015 – "Home Equity Conversion Mortgage (HECM) Due and Payable Policies."
[7] Mortgagee Letter 2015-11, April 23, 2015 – "Loss Mitigation Guidance for Home Equity Conversion Mortgages (HECMs) in Default due to Unpaid Property Charges."

rate after applying the MRA to the projected home appraisal value is equal to the observed CT1 claim severity rate.

Sales expenses are those required to conduct the actual sale, and other expenses are those incurred to manage the property until the sale.

Sales and other expenses are estimated to be 30.3% of the sales price for CT1 claims based on home sale data provided by FHA. For CT2c claims, the sales and other expenses are 24.7%. This is based on data related to the sale of over 6,000 FHA owned properties.

Lenders can assign a mortgage to FHA when the UPB reaches 98% of the MCA. A CT2 occurs when FHA acquires the note resulting in a cash outflow, the acquisition cost, which is the mortgage balance (up to the MCA). The ultimate net losses from CT2 depends on two components: the note holding expenses after assignment and recoveries from assigned notes.

FHA imposes a set of requirements that, if any of them are not met, makes the HECM ineligible for assignment even when UPB reaches 98% of the MCA. We project the probability of assignment based on historical data by the number of quarters the mortgage has been eligible for assignment as follows:

*Table 42: Probability of Mortgage Assignment*

| Number of Quarters Since Eligible for Assignment | Probability of Assignment |
|---|---|
| 1 | 15% |
| 2 | 30% |
| 3 | 15% |
| 4 | 9% |
| 5 | 5% |
| 6 | 3% |
| 7 – 8 | 2% |
| 9+ | 1% |

This results in approximately a 40% probability that the mortgage is assigned within the first two years it becomes eligible, and a small probability it is assigned after the first two years of eligibility.

### Note Holding Expenses After Assignment

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

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

### Recoveries from Assigned Mortgages

At note termination for an assigned mortgage, the HECM is due and payable to FHA. The timing of mortgage terminations after assignment (when UPB reaches 98% of MCA) is projected with the termination model described in Appendix B. The amount of recovery of assigned mortgages at termination, can be expressed as:

$$\text{Recovery Amount} =$$

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

where the net sales price of the property is:

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

Sales expenses are those required to conduct the actual sale, and other expenses are those to manage the property until the sale. Sales expenses plus other expenses are estimated to be 25% based on historical HECM data.

## Net Future Cash Flows

The Cash Flow NPV for the HECM book of business is computed by summing the individual components as they occur over time:

$$Net\ Cash\ Flow_t = Annual\ Premiums_t + Recoveries_t - Claim\ Type\ 1_t - Claim\ Type\ 2_t - Note\ Holding\ Expenses_t$$

## Discount Factors

The discount factors applied were provided by FHA and reflect the most recent Treasury yield curve, which captures the Federal government's cost of capital in raising funds. These factors reflect the capital market's expectation of the consolidated interest risk of U.S. Treasury securities. Our simulations aggregated each future year's cash flows, which are treated as being received at the end of the year.

# Appendix F: Summary of Historical and Projected Claim Rates and Loss Severities

The following incremental annual summaries are shown by cohort for Claim Type 1 and Claim Type 2.

1. **Claim Rate**: number of claims divided by the number of originations for the cohort

2. **Loss Severity**: Net loss paid divided by the MCA for the cohort

**Claim Type 1**
**Incremental Claim Rate**

| Fiscal | **Number of Quarters Since Beginning of FY** | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 4 - 8 | 8 - 12 | 12 - 16 | 16 - 20 | 20 - 24 | 24 - 28 | 28 - 32 | 32 - 36 | 36 - 40 | 40 - 44 | 44 - 48 | 48 - 52 | 52 - 56 | 56 - 60 | 60 - 64 | 64 - 68 | 68 - 72 | 72 - 76 | 76 - 80 | 80 - 84 | 84 - 88 | 88 - 92 | 92 - 96 | 96 - 100 | 100 - 104 | 104 - 108 |
| 1990 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0100 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.5000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1991 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0068 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0769 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1992 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0018 | 0.0066 | 0.0000 | 0.0034 | 0.0000 | 0.0134 | 0.0000 | 0.0147 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.5000 | 0.0000 | 1.0000 |
| 1993 | 0.0000 | 0.0000 | 0.0000 | 0.0008 | 0.0018 | 0.0031 | 0.0012 | 0.0000 | 0.0000 | 0.0029 | 0.0041 | 0.0000 | 0.0000 | 0.0000 | 0.0417 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1250 | 0.1429 | 0.0769 | 0.2222 | 0.0000 | |
| 1994 | 0.0000 | 0.0000 | 0.0000 | 0.0009 | 0.0020 | 0.0030 | 0.0014 | 0.0009 | 0.0080 | 0.0046 | 0.0066 | 0.0000 | 0.0053 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0455 | 0.1500 | 0.0000 | 0.0000 | 0.2000 | 0.0000 | | |
| 1995 | 0.0000 | 0.0000 | 0.0000 | 0.0015 | 0.0018 | 0.0000 | 0.0025 | 0.0053 | 0.0076 | 0.0038 | 0.0018 | 0.0028 | 0.0000 | 0.0000 | 0.0000 | 0.0100 | 0.0000 | 0.0000 | 0.0286 | 0.1017 | 0.0893 | 0.1739 | 0.0667 | | | |
| 1996 | 0.0000 | 0.0006 | 0.0014 | 0.0017 | 0.0010 | 0.0017 | 0.0059 | 0.0024 | 0.0115 | 0.0000 | 0.0043 | 0.0070 | 0.0107 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0333 | 0.0889 | 0.1538 | 0.0714 | 0.2000 | | | | |
| 1997 | 0.0000 | 0.0007 | 0.0016 | 0.0000 | 0.0013 | 0.0038 | 0.0045 | 0.0090 | 0.0007 | 0.0063 | 0.0062 | 0.0111 | 0.0030 | 0.0039 | 0.0425 | 0.0058 | 0.0828 | 0.1016 | 0.1275 | 0.1304 | 0.0182 | | | | | |
| 1998 | 0.0003 | 0.0004 | 0.0002 | 0.0013 | 0.0058 | 0.0067 | 0.0114 | 0.0049 | 0.0178 | 0.0093 | 0.0167 | 0.0046 | 0.0014 | 0.0278 | 0.0297 | 0.0650 | 0.1294 | 0.0963 | 0.1200 | 0.0985 | | | | | | |
| 1999 | 0.0000 | 0.0000 | 0.0003 | 0.0039 | 0.0032 | 0.0063 | 0.0035 | 0.0080 | 0.0104 | 0.0083 | 0.0070 | 0.0075 | 0.0214 | 0.0171 | 0.0571 | 0.1340 | 0.1070 | 0.1690 | 0.0969 | | | | | | | |
| 2000 | 0.0000 | 0.0003 | 0.0019 | 0.0040 | 0.0055 | 0.0016 | 0.0070 | 0.0053 | 0.0115 | 0.0056 | 0.0032 | 0.0250 | 0.0243 | 0.0563 | 0.1171 | 0.0836 | 0.1294 | 0.0831 | | | | | | | | |
| 2001 | 0.0001 | 0.0007 | 0.0026 | 0.0032 | 0.0021 | 0.0058 | 0.0057 | 0.0065 | 0.0029 | 0.0038 | 0.0183 | 0.0170 | 0.0528 | 0.1021 | 0.0802 | 0.0857 | 0.0587 | | | | | | | | | |
| 2002 | 0.0000 | 0.0002 | 0.0013 | 0.0012 | 0.0046 | 0.0045 | 0.0083 | 0.0033 | 0.0020 | 0.0052 | 0.0187 | 0.0515 | 0.0913 | 0.0621 | 0.0966 | 0.0587 | | | | | | | | | | |
| 2003 | 0.0001 | 0.0008 | 0.0010 | 0.0033 | 0.0025 | 0.0053 | 0.0025 | 0.0014 | 0.0033 | 0.0214 | 0.0417 | 0.1023 | 0.0708 | 0.0982 | 0.0788 | | | | | | | | | | | |
| 2004 | 0.0001 | 0.0003 | 0.0019 | 0.0024 | 0.0043 | 0.0023 | 0.0015 | 0.0023 | 0.0182 | 0.0370 | 0.0852 | 0.0639 | 0.0877 | 0.0578 | | | | | | | | | | | | |
| 2005 | 0.0000 | 0.0008 | 0.0015 | 0.0037 | 0.0019 | 0.0015 | 0.0021 | 0.0151 | 0.0366 | 0.0854 | 0.0599 | 0.0746 | 0.0552 | | | | | | | | | | | | | |
| 2006 | 0.0001 | 0.0007 | 0.0023 | 0.0015 | 0.0011 | 0.0021 | 0.0156 | 0.0331 | 0.0920 | 0.0574 | 0.0744 | 0.0541 | | | | | | | | | | | | | | |
| 2007 | 0.0001 | 0.0009 | 0.0012 | 0.0013 | 0.0044 | 0.0164 | 0.0322 | 0.0903 | 0.0620 | 0.0772 | 0.0568 | | | | | | | | | | | | | | | |
| 2008 | 0.0002 | 0.0011 | 0.0017 | 0.0066 | 0.0197 | 0.0265 | 0.0775 | 0.0553 | 0.0645 | 0.0499 | | | | | | | | | | | | | | | | |
| 2009 | 0.0002 | 0.0007 | 0.0053 | 0.0158 | 0.0185 | 0.0575 | 0.0421 | 0.0500 | 0.0443 | 0.0395 | 0.0420 | 0.0413 | 0.0488 | 0.0595 | 0.0722 | 0.0832 | 0.0891 | 0.1051 | 0.1177 | 0.1290 | 0.1285 | 0.1482 | 0.1599 | 0.1738 | 0.1735 | 0.1816 |
| 2010 | 0.0001 | 0.0028 | 0.0097 | 0.0119 | 0.0459 | 0.0378 | 0.0413 | 0.0395 | 0.0454 | 0.0473 | 0.0449 | 0.0515 | 0.0548 | 0.0601 | 0.0770 | 0.0836 | 0.0969 | 0.1044 | 0.1215 | 0.1271 | 0.1425 | 0.1559 | 0.1604 | 0.1857 | 0.2042 | 0.2181 |
| 2011 | 0.0003 | 0.0032 | 0.0057 | 0.0266 | 0.0260 | 0.0306 | 0.0316 | 0.0346 | 0.0413 | 0.0416 | 0.0436 | 0.0490 | 0.0585 | 0.0693 | 0.0807 | 0.0920 | 0.1005 | 0.1093 | 0.1273 | 0.1370 | 0.1546 | 0.1586 | 0.1959 | 0.1812 | 0.1778 | 0.1650 |
| 2012 | 0.0005 | 0.0023 | 0.0143 | 0.0194 | 0.0234 | 0.0259 | 0.0301 | 0.0371 | 0.0375 | 0.0376 | 0.0478 | 0.0551 | 0.0663 | 0.0719 | 0.0789 | 0.0958 | 0.0953 | 0.1122 | 0.1316 | 0.1416 | 0.1387 | 0.1672 | 0.1728 | 0.1873 | 0.2011 | 0.2058 |
| 2013 | 0.0002 | 0.0054 | 0.0104 | 0.0166 | 0.0201 | 0.0230 | 0.0267 | 0.0330 | 0.0364 | 0.0446 | 0.0455 | 0.0569 | 0.0665 | 0.0693 | 0.0779 | 0.0928 | 0.1032 | 0.1192 | 0.1298 | 0.1498 | 0.1420 | 0.1596 | 0.1896 | 0.1873 | 0.1796 | 0.1822 |
| 2014 | 0.0005 | 0.0026 | 0.0057 | 0.0086 | 0.0111 | 0.0157 | 0.0199 | 0.0242 | 0.0246 | 0.0285 | 0.0352 | 0.0421 | 0.0518 | 0.0519 | 0.0704 | 0.0814 | 0.0916 | 0.1008 | 0.1101 | 0.1387 | 0.1385 | 0.1441 | 0.1773 | 0.1923 | 0.2047 | 0.1958 |
| 2015 | 0.0004 | 0.0017 | 0.0039 | 0.0070 | 0.0133 | 0.0184 | 0.0232 | 0.0273 | 0.0273 | 0.0307 | 0.0340 | 0.0411 | 0.0468 | 0.0580 | 0.0707 | 0.0827 | 0.0924 | 0.0942 | 0.1269 | 0.1201 | 0.1500 | 0.1652 | 0.1927 | 0.2034 | 0.1869 | 0.1749 |
| 2016 | 0.0003 | 0.0010 | 0.0030 | 0.0073 | 0.0129 | 0.0198 | 0.0248 | 0.0273 | 0.0317 | 0.0322 | 0.0374 | 0.0431 | 0.0503 | 0.0580 | 0.0737 | 0.0796 | 0.1027 | 0.0898 | 0.1052 | 0.1174 | 0.1451 | 0.1562 | 0.1548 | 0.2013 | 0.1841 | 0.1608 |
| 2017 | 0.0001 | 0.0012 | 0.0045 | 0.0088 | 0.0165 | 0.0227 | 0.0274 | 0.0312 | 0.0319 | 0.0328 | 0.0393 | 0.0483 | 0.0539 | 0.0581 | 0.0675 | 0.0854 | 0.0905 | 0.1050 | 0.1228 | 0.1242 | 0.1471 | 0.1341 | 0.1773 | 0.1930 | 0.2012 | 0.1787 |
| 2018 | 0.0001 | 0.0018 | 0.0043 | 0.0089 | 0.0153 | 0.0216 | 0.0275 | 0.0281 | 0.0324 | 0.0345 | 0.0357 | 0.0399 | 0.0469 | 0.0504 | 0.0574 | 0.0636 | 0.0799 | 0.0858 | 0.1027 | 0.1242 | 0.1273 | 0.1395 | 0.1836 | 0.1837 | 0.2155 | 0.1964 |

**Claim Type 1**
**Incremental Claim Rate**

| Fiscal | **Number of Quarters Since Beginning of FY** | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 108 - 112 | 112 - 116 | 116 - 120 | 120 - 124 | 124 - 128 | 128 - 132 | 132 - 136 | 136 - 140 | 140 - 144 | 144 - 148 | 148 - 152 | 152 - 156 | 156 - 160 | 160 - 164 | 164 - 168 | 168 - 172 | 172 - 176 | 176 - 180 | 180 - 184 | 184 - 188 | 188 - 192 | 192 - 196 | 196 - 200 |
| 1990 | 0.0000 | 0.0000 | | | | | | | | | | | | | | | | | | | | | |
| 1991 | 0.0000 | | | | | | | | | | | | | | | | | | | | | | |
| 1992 | | | | | | | | | | | | | | | | | | | | | | | |
| 1993 | | | | | | | | | | | | | | | | | | | | | | | |
| 1994 | | | | | | | | | | | | | | | | | | | | | | | |
| 1995 | | | | | | | | | | | | | | | | | | | | | | | |
| 1996 | | | | | | | | | | | | | | | | | | | | | | | |
| 1997 | | | | | | | | | | | | | | | | | | | | | | | |
| 1998 | | | | | | | | | | | | | | | | | | | | | | | |
| 1999 | | | | | | | | | | | | | | | | | | | | | | | |
| 2000 | | | | | | | | | | | | | | | | | | | | | | | |
| 2001 | | | | | | | | | | | | | | | | | | | | | | | |
| 2002 | | | | | | | | | | | | | | | | | | | | | | | |
| 2003 | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | | | | | | | | | | | | | | | | | | | | | |
| 2005 | | | | | | | | | | | | | | | | | | | | | | | |
| 2006 | | | | | | | | | | | | | | | | | | | | | | | |
| 2007 | | | | | | | | | | | | | | | | | | | | | | | |
| 2008 | | | | | | | | | | | | | | | | | | | | | | | |
| 2009 | 0.1977 | 0.2368 | 0.2718 | 0.2481 | 0.2570 | 0.2540 | 0.3452 | 0.4615 | 0.1923 | 0.2000 | 0.2143 | 0.4545 | 0.3333 | 0.0000 | 0.5000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2010 | 0.2213 | 0.2044 | 0.2550 | 0.2448 | 0.2843 | 0.2381 | 0.2667 | 0.2414 | 0.3810 | 0.5385 | 0.3333 | 0.0000 | 0.0000 | 0.5000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2011 | 0.2274 | 0.2618 | 0.2474 | 0.2296 | 0.2990 | 0.2500 | 0.2500 | 0.4688 | 0.3333 | 0.4444 | 0.2000 | 0.5000 | 0.0000 | 0.5000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2012 | 0.2190 | 0.1806 | 0.2743 | 0.2377 | 0.1977 | 0.2923 | 0.2727 | 0.3125 | 0.3500 | 0.0833 | 0.2727 | 0.5714 | 0.3333 | 0.5000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2013 | 0.2333 | 0.2043 | 0.1872 | 0.2013 | 0.2411 | 0.2561 | 0.2373 | 0.2143 | 0.2000 | 0.2917 | 0.6875 | 0.2000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2014 | 0.2417 | 0.2083 | 0.2500 | 0.1667 | 0.2113 | 0.3393 | 0.2500 | 0.2692 | 0.2105 | 0.3077 | 0.4444 | 0.2500 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2015 | 0.2206 | 0.2390 | 0.2448 | 0.2396 | 0.2273 | 0.3400 | 0.2258 | 0.2609 | 0.3333 | 0.2000 | 0.1250 | 0.2857 | 0.2500 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2016 | 0.2019 | 0.2146 | 0.2367 | 0.2353 | 0.2381 | 0.2241 | 0.2857 | 0.2692 | 0.2222 | 0.2308 | 0.4444 | 0.0000 | 0.2000 | 0.5000 | 0.0000 | 0.5000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2017 | 0.1948 | 0.2567 | 0.2663 | 0.2381 | 0.2738 | 0.3269 | 0.1613 | 0.4000 | 0.1538 | 0.1818 | 0.2500 | 0.2000 | 0.6667 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2018 | 0.1853 | 0.2695 | 0.1818 | 0.1892 | 0.3019 | 0.3333 | 0.2000 | 0.1667 | 0.1000 | 0.2500 | 0.2500 | 0.6667 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

**Claim Type 2**
**Incremental Claim Rate**

| Fiscal | Number of Quarters Since Beginning of FY | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 4 - 8 | 8 - 12 | 12 - 16 | 16 - 20 | 20 - 24 | 24 - 28 | 28 - 32 | 32 - 36 | 36 - 40 | 40 - 44 | 44 - 48 | 48 - 52 | 52 - 56 | 56 - 60 | 60 - 64 | 64 - 68 | 68 - 72 | 72 - 76 | 76 - 80 | 80 - 84 | 84 - 88 | 88 - 92 | 92 - 96 | 96 - 100 | 100 - 104 | 104 - 108 | 108 - 112 |
| 1990 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0100 | 0.0128 | 0.0303 | 0.0000 | 0.0227 | 0.0588 | 0.0000 | 0.0000 | 0.0000 | 0.1000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1991 | 0.0000 | 0.0000 | 0.0000 | 0.0077 | 0.0044 | 0.0000 | 0.0058 | 0.0000 | 0.0083 | 0.0000 | 0.0290 | 0.1087 | 0.1071 | 0.0769 | 0.2000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1992 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0016 | 0.0074 | 0.0044 | 0.0139 | 0.0068 | 0.0591 | 0.0268 | 0.0776 | 0.0441 | 0.2955 | 0.2500 | 0.0714 | 0.1250 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 1993 | 0.0000 | 0.0000 | 0.0000 | 0.0024 | 0.0036 | 0.0021 | 0.0062 | 0.0137 | 0.0451 | 0.0643 | 0.0826 | 0.0727 | 0.1414 | 0.1216 | 0.1042 | 0.0968 | 0.0357 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | |
| 1994 | 0.0000 | 0.0004 | 0.0004 | 0.0040 | 0.0040 | 0.0071 | 0.0084 | 0.0216 | 0.0378 | 0.0851 | 0.1070 | 0.1595 | 0.2275 | 0.0952 | 0.1324 | 0.1163 | 0.0571 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | |
| 1995 | 0.0000 | 0.0006 | 0.0019 | 0.0004 | 0.0026 | 0.0046 | 0.0106 | 0.0243 | 0.0486 | 0.0590 | 0.1574 | 0.1567 | 0.0625 | 0.0741 | 0.0323 | 0.0000 | 0.0000 | 0.0132 | 0.0429 | 0.0169 | 0.0000 | 0.0217 | 0.0000 | | | | |
| 1996 | 0.0006 | 0.0013 | 0.0014 | 0.0000 | 0.0010 | 0.0067 | 0.0165 | 0.0378 | 0.0628 | 0.1577 | 0.1775 | 0.1154 | 0.1016 | 0.0480 | 0.0833 | 0.0241 | 0.0286 | 0.0167 | 0.0000 | 0.0256 | 0.0000 | 0.0000 | | | | | |
| 1997 | 0.0000 | 0.0000 | 0.0008 | 0.0000 | 0.0026 | 0.0091 | 0.0228 | 0.0454 | 0.1118 | 0.1126 | 0.0888 | 0.0757 | 0.0695 | 0.0388 | 0.0189 | 0.0520 | 0.0552 | 0.0547 | 0.0196 | 0.0000 | 0.0182 | | | | | | |
| 1998 | 0.0005 | 0.0004 | 0.0005 | 0.0013 | 0.0034 | 0.0087 | 0.0182 | 0.0363 | 0.0798 | 0.0638 | 0.0642 | 0.0482 | 0.0497 | 0.0245 | 0.0436 | 0.0580 | 0.0620 | 0.0598 | 0.0300 | 0.0076 | | | | | | | |
| 1999 | 0.0010 | 0.0000 | 0.0013 | 0.0025 | 0.0061 | 0.0118 | 0.0445 | 0.0828 | 0.0702 | 0.0687 | 0.0500 | 0.0428 | 0.0441 | 0.0343 | 0.0554 | 0.0742 | 0.0149 | 0.0282 | 0.0306 | | | | | | | | |
| 2000 | 0.0040 | 0.0005 | 0.0006 | 0.0013 | 0.0032 | 0.0082 | 0.0152 | 0.0197 | 0.0248 | 0.0161 | 0.0259 | 0.0139 | 0.0265 | 0.0388 | 0.0293 | 0.0188 | 0.0235 | 0.0133 | | | | | | | | | |
| 2001 | 0.0091 | 0.0000 | 0.0005 | 0.0011 | 0.0030 | 0.0095 | 0.0182 | 0.0214 | 0.0139 | 0.0158 | 0.0195 | 0.0354 | 0.0392 | 0.0515 | 0.0485 | 0.0376 | 0.0344 | | | | | | | | | | |
| 2002 | 0.0036 | 0.0001 | 0.0006 | 0.0017 | 0.0056 | 0.0131 | 0.0223 | 0.0178 | 0.0257 | 0.0199 | 0.0302 | 0.0508 | 0.0545 | 0.0607 | 0.0480 | 0.0577 | | | | | | | | | | | |
| 2003 | 0.0017 | 0.0003 | 0.0019 | 0.0162 | 0.0332 | 0.0508 | 0.0365 | 0.0535 | 0.0421 | 0.0648 | 0.0864 | 0.1025 | 0.0885 | 0.0760 | 0.0498 | | | | | | | | | | | | |
| 2004 | 0.0003 | 0.0006 | 0.0050 | 0.0116 | 0.0212 | 0.0167 | 0.0246 | 0.0223 | 0.0335 | 0.0528 | 0.0589 | 0.0686 | 0.0731 | 0.0806 | | | | | | | | | | | | | |
| 2005 | 0.0002 | 0.0015 | 0.0050 | 0.0097 | 0.0098 | 0.0150 | 0.0147 | 0.0238 | 0.0411 | 0.0464 | 0.0544 | 0.0673 | 0.0852 | | | | | | | | | | | | | | |
| 2006 | 0.0003 | 0.0011 | 0.0028 | 0.0031 | 0.0049 | 0.0053 | 0.0090 | 0.0169 | 0.0202 | 0.0246 | 0.0309 | 0.0354 | | | | | | | | | | | | | | | |
| 2007 | 0.0000 | 0.0004 | 0.0004 | 0.0006 | 0.0008 | 0.0016 | 0.0037 | 0.0049 | 0.0072 | 0.0092 | 0.0129 | | | | | | | | | | | | | | | | |
| 2008 | 0.0000 | 0.0000 | 0.0003 | 0.0007 | 0.0019 | 0.0030 | 0.0049 | 0.0068 | 0.0074 | 0.0115 | | | | | | | | | | | | | | | | | |
| 2009 | 0.0000 | 0.0002 | 0.0014 | 0.0054 | 0.0082 | 0.0198 | 0.0320 | 0.0324 | 0.0331 | 0.0749 | 0.1200 | 0.1550 | 0.1394 | 0.0968 | 0.0623 | 0.0492 | 0.0434 | 0.0392 | 0.0353 | 0.0374 | 0.0362 | 0.0306 | 0.0310 | 0.0240 | 0.0329 | 0.0313 | 0.0233 |
| 2010 | 0.0003 | 0.0013 | 0.0078 | 0.0170 | 0.0360 | 0.0810 | 0.0979 | 0.1190 | 0.1370 | 0.0979 | 0.0571 | 0.0648 | 0.0760 | 0.0734 | 0.0590 | 0.0477 | 0.0474 | 0.0366 | 0.0355 | 0.0341 | 0.0307 | 0.0323 | 0.0362 | 0.0309 | 0.0254 | 0.0309 | 0.0213 |
| 2011 | 0.0000 | 0.0000 | 0.0004 | 0.0060 | 0.0450 | 0.0929 | 0.1840 | 0.1246 | 0.0797 | 0.0684 | 0.0699 | 0.0743 | 0.0571 | 0.0545 | 0.0468 | 0.0411 | 0.0419 | 0.0419 | 0.0427 | 0.0346 | 0.0318 | 0.0229 | 0.0282 | 0.0143 | 0.0234 | 0.0285 | 0.0310 |
| 2012 | 0.0001 | 0.0001 | 0.0006 | 0.0134 | 0.0473 | 0.1159 | 0.1947 | 0.1219 | 0.0750 | 0.0659 | 0.0699 | 0.0552 | 0.0544 | 0.0482 | 0.0474 | 0.0415 | 0.0444 | 0.0360 | 0.0356 | 0.0306 | 0.0299 | 0.0262 | 0.0274 | 0.0207 | 0.0308 | 0.0266 | 0.0261 |
| 2013 | 0.0000 | 0.0000 | 0.0007 | 0.0090 | 0.0360 | 0.1135 | 0.1733 | 0.1274 | 0.0860 | 0.0772 | 0.0704 | 0.0558 | 0.0503 | 0.0460 | 0.0440 | 0.0458 | 0.0368 | 0.0468 | 0.0358 | 0.0313 | 0.0265 | 0.0369 | 0.0294 | 0.0266 | 0.0167 | 0.0426 | 0.0359 |
| 2014 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0018 | 0.0079 | 0.0290 | 0.0625 | 0.0916 | 0.1183 | 0.1077 | 0.0840 | 0.0818 | 0.0897 | 0.0585 | 0.0521 | 0.0525 | 0.0458 | 0.0413 | 0.0475 | 0.0377 | 0.0440 | 0.0196 | 0.0192 | 0.0388 | 0.0482 | 0.0167 |
| 2015 | 0.0000 | 0.0000 | 0.0001 | 0.0004 | 0.0029 | 0.0091 | 0.0232 | 0.0510 | 0.0900 | 0.1158 | 0.1045 | 0.1021 | 0.0999 | 0.0686 | 0.0581 | 0.0570 | 0.0533 | 0.0495 | 0.0425 | 0.0399 | 0.0262 | 0.0281 | 0.0354 | 0.0401 | 0.0437 | 0.0383 | 0.0214 |
| 2016 | 0.0000 | 0.0000 | 0.0000 | 0.0008 | 0.0047 | 0.0131 | 0.0298 | 0.0597 | 0.0995 | 0.1209 | 0.1054 | 0.0895 | 0.0767 | 0.0680 | 0.0604 | 0.0513 | 0.0507 | 0.0502 | 0.0420 | 0.0279 | 0.0302 | 0.0246 | 0.0227 | 0.0267 | 0.0361 | 0.0226 | 0.0252 |
| 2017 | 0.0000 | 0.0000 | 0.0001 | 0.0017 | 0.0057 | 0.0167 | 0.0359 | 0.0686 | 0.1102 | 0.1228 | 0.0990 | 0.0830 | 0.0736 | 0.0700 | 0.0617 | 0.0618 | 0.0582 | 0.0456 | 0.0379 | 0.0355 | 0.0346 | 0.0347 | 0.0348 | 0.0386 | 0.0263 | 0.0255 | 0.0229 |
| 2018 | 0.0000 | 0.0000 | 0.0000 | 0.0003 | 0.0014 | 0.0041 | 0.0120 | 0.0217 | 0.0403 | 0.0590 | 0.0682 | 0.0628 | 0.0657 | 0.0898 | 0.0972 | 0.0901 | 0.0747 | 0.0612 | 0.0550 | 0.0533 | 0.0366 | 0.0263 | 0.0324 | 0.0271 | 0.0335 | 0.0302 | 0.0388 |

**Claim Type 2**
**Incremental Claim Rate**

| Fiscal | Number of Quarters Since Beginning of FY | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 112 - 116 | 116 - 120 | 120 - 124 | 124 - 128 | 128 - 132 | 132 - 136 | 136 - 140 | 140 - 144 | 144 - 148 | 148 - 152 | 152 - 156 | 156 - 160 | 160 - 164 | 164 - 168 | 168 - 172 | 172 - 176 | 176 - 180 | 180 - 184 | 184 - 188 | 188 - 192 | 192 - 196 | 196 - 200 | Cumulative |
| 1990 | 0.0000 | | | | | | | | | | | | | | | | | | | | | | |
| 1991 | | | | | | | | | | | | | | | | | | | | | | | |
| 1992 | | | | | | | | | | | | | | | | | | | | | | | |
| 1993 | | | | | | | | | | | | | | | | | | | | | | | |
| 1994 | | | | | | | | | | | | | | | | | | | | | | | |
| 1995 | | | | | | | | | | | | | | | | | | | | | | | |
| 1996 | | | | | | | | | | | | | | | | | | | | | | | |
| 1997 | | | | | | | | | | | | | | | | | | | | | | | |
| 1998 | | | | | | | | | | | | | | | | | | | | | | | |
| 1999 | | | | | | | | | | | | | | | | | | | | | | | |
| 2000 | | | | | | | | | | | | | | | | | | | | | | | |
| 2001 | | | | | | | | | | | | | | | | | | | | | | | |
| 2002 | | | | | | | | | | | | | | | | | | | | | | | |
| 2003 | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | | | | | | | | | | | | | | | | | | | | | |
| 2005 | | | | | | | | | | | | | | | | | | | | | | | |
| 2006 | | | | | | | | | | | | | | | | | | | | | | | |
| 2007 | | | | | | | | | | | | | | | | | | | | | | | |
| 2008 | | | | | | | | | | | | | | | | | | | | | | | |
| 2009 | 0.0228 | 0.0324 | 0.0305 | 0.0223 | 0.0238 | 0.0000 | 0.0192 | 0.0385 | 0.0500 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 143.4% |
| 2010 | 0.0328 | 0.0050 | 0.0280 | 0.0098 | 0.0159 | 0.0444 | 0.0000 | 0.0000 | 0.0000 | 0.1667 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 163.7% |
| 2011 | 0.0218 | 0.0155 | 0.0222 | 0.0103 | 0.0156 | 0.0208 | 0.0000 | 0.0667 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 145.9% |
| 2012 | 0.0264 | 0.0057 | 0.0328 | 0.0349 | 0.0154 | 0.0000 | 0.0313 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 143.2% |
| 2013 | 0.0430 | 0.0296 | 0.0336 | 0.0268 | 0.0122 | 0.0339 | 0.0476 | 0.0333 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 156.1% |
| 2014 | 0.0179 | 0.0313 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0769 | 0.0000 | 0.0769 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 140.0% |
| 2015 | 0.0390 | 0.0350 | 0.0521 | 0.0152 | 0.0200 | 0.0000 | 0.0435 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2500 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 165.6% |
| 2016 | 0.0215 | 0.0178 | 0.0168 | 0.0476 | 0.0517 | 0.0476 | 0.0385 | 0.0556 | 0.0769 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 151.3% |
| 2017 | 0.0268 | 0.0380 | 0.0317 | 0.0476 | 0.0000 | 0.0323 | 0.0000 | 0.0000 | 0.0909 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 147.3% |
| 2018 | 0.0299 | 0.0364 | 0.0270 | 0.0377 | 0.0333 | 0.0000 | 0.0833 | 0.1000 | 0.1250 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 155.4% |

**Claim Type 1**
**Incremental Loss Severity**

| Fiscal | Number of Quarters Since Beginning of FY | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 4 - 8 | 8 - 12 | 12 - 16 | 16 - 20 | 20 - 24 | 24 - 28 | 28 - 32 | 32 - 36 | 36 - 40 | 40 - 44 | 44 - 48 | 48 - 52 | 52 - 56 | 56 - 60 | 60 - 64 | 64 - 68 | 68 - 72 | 72 - 76 | 76 - 80 | 80 - 84 | 84 - 88 | 88 - 92 | 92 - 96 | 96 - 100 |
| 1990 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1517 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0405 | 0.0000 | 0.0000 |
| 1991 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1077 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3242 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1992 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2606 | 0.4569 | 0.0000 | 0.1611 | 0.0000 | 0.2234 | 0.0000 | 0.0195 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0082 |
| 1993 | 0.0000 | 0.0000 | 0.0000 | 0.2354 | 0.6656 | 0.2911 | 0.1620 | 0.0000 | 0.0000 | 0.3053 | 0.6475 | 0.0000 | 0.0000 | 0.0000 | 0.7542 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.6340 | 0.9399 | 0.9693 | 1.1676 |
| 1994 | 0.0000 | 0.0000 | 0.0000 | 0.4167 | 0.4419 | 0.2354 | 0.3575 | 0.2686 | 0.3011 | 0.6214 | 0.4637 | 0.0000 | 0.2180 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8233 | 1.1596 | 0.0000 | 0.0000 | 1.1026 | 0.0000 |
| 1995 | 0.0000 | 0.0000 | 0.0000 | 0.2817 | 0.3051 | 0.0000 | 0.1431 | 0.3756 | 0.3557 | 0.4606 | 0.0489 | 0.4217 | 0.0000 | 0.0000 | 0.0000 | 0.8481 | 0.0000 | 0.0000 | 1.1514 | 0.7688 | 1.0271 | 0.7710 | 1.0572 | |
| 1996 | 0.0000 | 0.3029 | 0.1995 | 0.3773 | 0.1479 | 0.3141 | 0.5046 | 0.4558 | 0.3236 | 0.0000 | 0.7466 | 0.2115 | 0.7868 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7308 | 0.6823 | 1.0176 | 0.6823 | 0.8496 | | |
| 1997 | 0.0000 | 0.2166 | 0.1272 | 0.0000 | 0.3536 | 0.2539 | 0.3301 | 0.3755 | 0.4288 | 0.4688 | 0.7384 | 0.6546 | 0.0512 | 0.6099 | 0.5969 | 0.4209 | 0.7276 | 0.8015 | 0.8812 | 0.7519 | 1.0845 | | | |
| 1998 | 0.3783 | 0.1689 | 0.5029 | 0.3286 | 0.2919 | 0.3795 | 0.3853 | 0.3618 | 0.4917 | 0.6281 | 0.7522 | 0.8147 | 0.9900 | 0.7440 | 0.9063 | 0.7483 | 0.8082 | 0.8607 | 0.6843 | 0.8238 | | | | |
| 1999 | 0.0000 | 0.0000 | 0.0572 | 0.2833 | 0.3123 | 0.3314 | 0.4024 | 0.6519 | 0.5482 | 0.5434 | 0.5875 | 0.3443 | 0.6871 | 0.5701 | 0.7204 | 0.7615 | 0.7576 | 0.7142 | 0.6511 | | | | | |
| 2000 | 0.0000 | 0.1720 | 0.2271 | 0.3187 | 0.2681 | 0.4323 | 0.3656 | 0.4935 | 0.6395 | 0.4683 | 0.3868 | 0.5208 | 0.6888 | 0.7342 | 0.6600 | 0.5966 | 0.5696 | 0.6878 | | | | | | |
| 2001 | 0.0695 | 0.3259 | 0.3282 | 0.2414 | 0.3092 | 0.3600 | 0.4838 | 0.4851 | 0.5534 | 0.3280 | 0.5045 | 0.5710 | 0.5698 | 0.6408 | 0.6807 | 0.5962 | 0.5962 | | | | | | | |
| 2002 | 0.0000 | 0.4047 | 0.2648 | 0.2674 | 0.3429 | 0.4822 | 0.5157 | 0.4170 | 0.7384 | 0.7083 | 0.4775 | 0.5830 | 0.5736 | 0.5863 | 0.6049 | 0.5173 | | | | | | | | |
| 2003 | 0.1037 | 0.2376 | 0.2088 | 0.3217 | 0.4766 | 0.5164 | 0.4930 | 0.4832 | 0.4583 | 0.5378 | 0.6109 | 0.6085 | 0.6029 | 0.5831 | 0.5346 | | | | | | | | | |
| 2004 | 0.1013 | 0.2210 | 0.3068 | 0.3897 | 0.4997 | 0.4453 | 0.3626 | 0.5038 | 0.4666 | 0.5430 | 0.5202 | 0.5162 | 0.5100 | 0.4675 | | | | | | | | | | |
| 2005 | 0.2689 | 0.2758 | 0.2881 | 0.4063 | 0.3640 | 0.4144 | 0.5161 | 0.4740 | 0.5382 | 0.4806 | 0.4740 | 0.4620 | 0.4590 | | | | | | | | | | | |
| 2006 | 0.2439 | 0.1933 | 0.3545 | 0.3922 | 0.3591 | 0.4185 | 0.4677 | 0.4829 | 0.4744 | 0.4540 | 0.4353 | 0.4018 | | | | | | | | | | | | |
| 2007 | 0.2091 | 0.2889 | 0.3246 | 0.3802 | 0.4513 | 0.4561 | 0.4788 | 0.4747 | 0.4562 | 0.4400 | 0.3946 | | | | | | | | | | | | | |
| 2008 | 0.2402 | 0.3125 | 0.3896 | 0.4092 | 0.4558 | 0.4631 | 0.4627 | 0.4533 | 0.4243 | 0.4135 | | | | | | | | | | | | | | |
| 2009 | 0.2346 | 0.3045 | 0.3519 | 0.3783 | 0.4017 | 0.4244 | 0.4229 | 0.4191 | 0.4242 | 0.5656 | 0.5516 | 0.5456 | 0.5881 | 0.6402 | 0.6946 | 0.7889 | 0.8740 | 0.9254 | 0.9553 | 0.9787 | 0.9877 | 0.9944 | 0.9978 | 1.0000 |
| 2010 | 0.2131 | 0.2613 | 0.3457 | 0.3576 | 0.3749 | 0.4181 | 0.4374 | 0.4413 | 0.6622 | 0.6411 | 0.6205 | 0.6322 | 0.6754 | 0.7153 | 0.7812 | 0.8349 | 0.9322 | 0.9430 | 0.9710 | 0.9839 | 0.9910 | 0.9958 | 0.9995 | 1.0000 |
| 2011 | 0.1899 | 0.2397 | 0.3052 | 0.3264 | 0.3751 | 0.3834 | 0.4065 | 0.5982 | 0.6050 | 0.5970 | 0.6216 | 0.6272 | 0.6782 | 0.7459 | 0.8003 | 0.8922 | 0.9358 | 0.9603 | 0.9740 | 0.9863 | 0.9945 | 0.9994 | 0.9994 | 1.0000 |
| 2012 | 0.2953 | 0.2553 | 0.2989 | 0.3423 | 0.3767 | 0.4002 | 0.5743 | 0.5898 | 0.5883 | 0.6158 | 0.6458 | 0.6812 | 0.7146 | 0.7988 | 0.8442 | 0.9228 | 0.9752 | 0.9779 | 0.9948 | 0.9967 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 2013 | 0.2601 | 0.2603 | 0.3187 | 0.3441 | 0.3554 | 0.5319 | 0.5379 | 0.5543 | 0.5718 | 0.6263 | 0.6212 | 0.6952 | 0.7330 | 0.7858 | 0.8577 | 0.9267 | 0.9626 | 0.9794 | 0.9897 | 0.9907 | 0.9933 | 0.9960 | 1.0000 | 0.9987 |
| 2014 | 0.2932 | 0.2026 | 0.2694 | 0.2907 | 0.3818 | 0.4151 | 0.4194 | 0.4293 | 0.4611 | 0.4888 | 0.4908 | 0.5222 | 0.5788 | 0.6449 | 0.7662 | 0.7990 | 0.8953 | 0.9586 | 0.9727 | 0.9687 | 0.9878 | 0.9955 | 0.9834 | 0.9941 |
| 2015 | 0.1687 | 0.1946 | 0.2541 | 0.3967 | 0.3882 | 0.4295 | 0.4445 | 0.4646 | 0.4800 | 0.4917 | 0.5155 | 0.5413 | 0.5609 | 0.6134 | 0.7213 | 0.8180 | 0.8656 | 0.9365 | 0.9530 | 0.9659 | 0.9887 | 0.9886 | 0.9969 | 0.9919 |
| 2016 | 0.1636 | 0.1791 | 0.2629 | 0.3451 | 0.3792 | 0.4280 | 0.4413 | 0.4670 | 0.4912 | 0.4946 | 0.5271 | 0.5551 | 0.6064 | 0.6246 | 0.6996 | 0.8228 | 0.8933 | 0.9163 | 0.9502 | 0.9761 | 0.9854 | 0.9846 | 0.9997 | 0.9757 |
| 2017 | 0.1751 | 0.1619 | 0.2825 | 0.3559 | 0.4170 | 0.4609 | 0.4667 | 0.4863 | 0.5148 | 0.5348 | 0.5478 | 0.5803 | 0.6105 | 0.6729 | 0.7496 | 0.8337 | 0.8971 | 0.9445 | 0.9563 | 0.9722 | 0.9921 | 0.9988 | 0.9930 | 0.9985 |
| 2018 | 0.1704 | 0.1612 | 0.2856 | 0.3177 | 0.3734 | 0.3947 | 0.4166 | 0.4226 | 0.4287 | 0.4520 | 0.4228 | 0.4694 | 0.4602 | 0.5353 | 0.5718 | 0.6680 | 0.7334 | 0.8150 | 0.8614 | 0.9155 | 0.9575 | 0.9809 | 0.9899 | 0.9857 |

**Claim Type 1**
**Incremental Loss Severity**

| Fiscal Year | Number of Quarters Since Beginning of FY | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100 - 104 | 104 - 108 | 108 - 112 | 112 - 116 | 116 - 120 | 120 - 124 | 124 - 128 | 128 - 132 | 132 - 136 | 136 - 140 | 140 - 144 | 144 - 148 | 148 - 152 | 152 - 156 | 156 - 160 | 160 - 164 | 164 - 168 | 168 - 172 | 172 - 176 | 176 - 180 | 180 - 184 | 184 - 188 | 188 - 192 | 192 - 196 |
| 1990 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | | | | | | | | | | | | | | | | | | | |
| 1991 | 0.0000 | 0.0000 | 0.0000 | | | | | | | | | | | | | | | | | | | | | |
| 1992 | 0.0000 | 1.9713 | | | | | | | | | | | | | | | | | | | | | | |
| 1993 | 0.0000 | | | | | | | | | | | | | | | | | | | | | | | |
| 1994 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1995 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1996 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1997 | | | | | | | | | | | | | | | | | | | | | | | | |
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| 2001 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2002 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2003 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2004 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2005 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2006 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2007 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2008 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2009 | 0.9991 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2010 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2011 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2012 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2013 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2014 | 0.9983 | 0.9949 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2015 | 0.9980 | 0.9959 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2016 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.9978 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 1.0000 | 1.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2017 | 0.9977 | 1.0000 | 0.9954 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2018 | 0.9888 | 0.9588 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

**Claim Type 2**
**Incremental Loss Severity**

| Fiscal | Number of Quarters Since Beginning of FY | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 4 - 8 | 8 - 12 | 12 - 16 | 16 - 20 | 20 - 24 | 24 - 28 | 28 - 32 | 32 - 36 | 36 - 40 | 40 - 44 | 44 - 48 | 48 - 52 | 52 - 56 | 56 - 60 | 60 - 64 | 64 - 68 | 68 - 72 | 72 - 76 | 76 - 80 | 80 - 84 | 84 - 88 | 88 - 92 | 92 - 96 | 96 - 100 | 100 - 104 |
| 1990 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 1.08 | 1.01 | 0.00 | 0.99 | 1.00 | 0.00 | 0.00 | 0.00 | 0.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1991 | 0.00 | 0.00 | 0.00 | 1.01 | 1.05 | 0.00 | 0.99 | 0.00 | 0.99 | 0.00 | 1.00 | 0.99 | 1.00 | 0.99 | 0.99 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 |
| 1992 | 0.00 | 0.00 | 0.00 | 0.00 | 1.04 | 1.10 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1993 | 0.00 | 0.00 | 0.00 | 1.02 | 1.06 | 1.00 | 0.99 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1994 | 0.00 | 1.00 | 1.01 | 1.05 | 1.03 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.96 | 0.99 | 1.00 | 1.00 | 1.00 | 0.99 | 0.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 1995 | 0.00 | 1.03 | 1.06 | 0.99 | 1.00 | 0.99 | 0.99 | 0.99 | 1.00 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 0.95 | 0.00 | 0.00 | 1.00 | 1.00 | 0.93 | 0.00 | 1.00 | 0.00 | | |
| 1996 | 0.35 | 1.01 | 1.05 | 0.00 | 0.98 | 0.99 | 0.99 | 1.00 | 0.99 | 0.99 | 0.99 | 1.00 | 0.96 | 0.99 | 0.97 | 1.00 | 1.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 | | | |
| 1997 | 0.00 | 0.00 | 1.01 | 0.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 0.99 | 0.97 | 0.99 | 1.00 | 0.99 | 1.00 | 0.99 | 0.00 | 1.00 | | | | |
| 1998 | 0.58 | 0.51 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | | | | | |
| 1999 | 0.81 | 0.00 | 0.99 | 0.99 | 0.99 | 0.98 | 0.99 | 0.99 | 0.99 | 1.00 | 0.99 | 0.99 | 0.99 | 1.00 | 0.99 | 0.99 | 0.99 | 0.98 | 1.00 | | | | | | |
| 2000 | 0.86 | 0.98 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.96 | 1.00 | 1.00 | | | | | | | |
| 2001 | 0.91 | 0.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | | | | | | | | |
| 2002 | 0.71 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | | | | | | | | | |
| 2003 | 0.74 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.98 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | | | | | | | | | | |
| 2004 | 0.68 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.98 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | | | | | | | | | | | |
| 2005 | 0.90 | 0.99 | 0.99 | 0.98 | 0.98 | 0.98 | 0.98 | 0.99 | 0.99 | 0.98 | 0.99 | 0.99 | 0.99 | | | | | | | | | | | | |
| 2006 | 0.99 | 0.99 | 0.99 | 0.98 | 0.99 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | | | | | | | | | | | | | |
| 2007 | 0.99 | 0.99 | 0.98 | 0.97 | 0.98 | 0.99 | 0.99 | 0.98 | 0.97 | 0.99 | 0.99 | | | | | | | | | | | | | | |
| 2008 | 0.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.98 | 0.99 | | | | | | | | | | | | | | | |
| 2009 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2010 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2011 | 0.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2012 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2013 | 0.00 | 0.99 | 0.98 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2014 | 0.00 | 0.50 | 0.99 | 0.88 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2015 | 0.00 | 1.00 | 0.77 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2016 | 0.00 | 0.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2017 | 0.00 | 0.00 | 1.00 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 2018 | 1.00 | 0.00 | 1.00 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

**Claim Type 2**
**Incremental Loss Severity**

| Fiscal Year | Number of Quarters Since Beginning of FY | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 104 - 108 | 108 - 112 | 112 - 116 | 116 - 120 | 120 - 124 | 124 - 128 | 128 - 132 | 132 - 136 | 136 - 140 | 140 - 144 | 144 - 148 | 148 - 152 | 152 - 156 | 156 - 160 | 160 - 164 | 164 - 168 | 168 - 172 | 172 - 176 | 176 - 180 | 180 - 184 | 184 - 188 | 188 - 192 | 192 - 196 |
| 1990 | 0.00 | 0.00 | 0.00 | | | | | | | | | | | | | | | | | | | | |
| 1991 | 0.00 | 0.00 | | | | | | | | | | | | | | | | | | | | | |
| 1992 | 0.00 | | | | | | | | | | | | | | | | | | | | | | |
| 1993 | | | | | | | | | | | | | | | | | | | | | | | |
| 1994 | | | | | | | | | | | | | | | | | | | | | | | |
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| 2006 | | | | | | | | | | | | | | | | | | | | | | | |
| 2007 | | | | | | | | | | | | | | | | | | | | | | | |
| 2008 | | | | | | | | | | | | | | | | | | | | | | | |
| 2009 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2010 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2011 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2012 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |