

MILLIMAN CLIENT REPORT – DRAFT

NAIC Mortgage Insurer Risk Sensitive Capital Model

Technical Documentation

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Kenneth A Bjurstrom
Principal and Financial Consultant

Jonathan B. Glowacki, FSA, CERA, CSPA, MAAA
Principal and Consulting Actuary

Edem Togbey, ACAS, MAAA
Associate Actuary



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A. Executive Summary

The National Association of Insurance Commissioners engaged Milliman to develop a Mortgage Guaranty Capital Model to support the NAIC Mortgage Guaranty Insurance Working Group's development and implementation of a framework to evaluate the capital levels of mortgage insurance companies. The Mortgage Guaranty Capital Model estimates the amount of capital required for mortgage insurance using a loan-level approach.

The model is a counter-cyclical model that uses a factor based approach to apply a capital factor to each performing active loan as of the evaluation date based on the loans underwriting features and economic environment at the time of loan origination. The table below provides a summary of the model factors:

Model Factor	Description	Level	Value
Base Factor	Base factor applied to all mortgages	N/A	0.55%
FICO Score	Borrower credit score at origination	760-850 740-759 720-739 700-719 680-699 660-679 640-659 620-639 600-619 580-599 560-579 300-599 Missing / Error	1.00 1.35 1.60 1.95 2.40 2.90 3.55 4.40 5.50 6.60 7.60 9.50 5.00
Loan-to-Value Ratio	Loan-to-value ratio at origination	(0, 80] (80, 85] (85, 90] (90, 95] (95, 100] 100+ Missing	1.00 1.45 1.75 2.00 3.05 4.00 2.00
Number of Alternative Risk Factors	Total number of Alternative Risk Factors on the mortgage	0 1 2 3 4+	1.00 1.30 1.65 1.90 2.00
Number of High Risk Factors	Total number of High Risk Factors on the mortgage	0 1 2 3 4	1.00 1.50 2.35 2.95 3.25
Number of Risk Offset Factors	Total number of Risk Offset Factors on the mortgage	0 1 2 3	1.00 0.65 0.50 0.50
Economic Factor	Economic adjustment factor evaluated at origination	Varies by origination year	
Severity Rate	Severity rate, as a percent of original loan amount, applied to mortgage insurance coverage in excess of Standard Coverage	Varies by the Economic Factor	

This document provides the technical documentation for the development of the Mortgage Guaranty Capital Model.

B. Introduction

The National Association of Insurance Commissioners (“NAIC”) is the U.S. standard-setting and regulatory support organization created and governed by the chief insurance regulators from the 50 states, the District of Columbia and five U.S. territories. Through the NAIC, state insurance regulators establish standards and best practices, conduct peer review, and coordinate their regulatory oversight.

The NAIC Mortgage Guaranty Insurance Model Act (#630, or “the Model Act”) establishes the overall regulatory approach adopted by states for monitoring the solvency of mortgage guaranty insurers domiciled in their state. Within the NAIC, the Mortgage Guaranty Insurance Working Group (“Working Group”) is charged with developing changes to the Model Act and other areas of solvency regulation of mortgage guaranty insurers. The Working Group was formed to address solvency and regulatory issues that became apparent during the recent residential housing price collapse, mortgage crisis, and economic downturn.

The NAIC and the Working Group engaged Milliman, Inc. (“Milliman”) to develop a Mortgage Guaranty Capital Model to support the Working Group’s development and implementation of a framework to evaluate the capital levels of mortgage insurance companies. Specifically, Milliman was engaged to:

1. Develop a capital standard framework;
2. Fully document the capital standard framework and operational requirements including (1) mortgage insurer data; (2) model variable segmentation significance testing; and (3) economic data;
3. Verify that the output from the proposed capital standard produces a reasonable capital standard;
4. Recertify mortgage insurer’s loan-level data dictionary; and
5. Assist, review, evaluate and consult on developing an NAIC Model Act "Green Book" reporting requirements, including (1) Survey NAIC Working Group for amended/update existing Yellow Book requirements (State of Domicile's); (2) the development of available historical data in identified "Green Book" format; (3) integrate Annual Statement of Opinion actuarial framework into Statutory Financial Examination framework.

This report provides documentation for the development of the capital model.

C. Data Provided to Milliman

The NAIC and Working Group provided to Milliman data to develop the capital model. The table below provides a summary of the data provided to Milliman:

Table C.1
NAIC Mortgage Insurer Risk Sensitive Capital Model
Summary of Materials Provided to Milliman

Material	Name	Description
Data	Raw Data (423 files)	Loan-level data from each mortgage insurance company that included information on mortgage performance and origination characteristics.
Data	Processed Data (3 files)	Loan-level data after individual company data has been normalized and stacked into performance histories.
Data	Loan-level spec third revision.xlsx	Data request form provided to individual MI's in how to aggregate and report data.

C.1 Description of the Data

The data provided to Milliman contained both raw data from multiple MI companies as well as a processed dataset which normalized the data between the MI companies and stacked the data together in a usable dataset for modeling. Milliman reviewed both the raw data files and processed data files to ensure they could be used for building the capital model. This section describes the data and processes used by Milliman to validate the data.

The companies that provided data for this analysis are: MGIC, Radian, UGC, Genworth, PMI, and CMG. The data includes original mortgage underwriting features and annual performance data for the period 1996 through 2013. Some MI companies provided additional data beyond this performance period; the data used in our analysis is limited to originations between 1996 and 2013 and their associated performance.

Compare Loan-level Data to Statutory Filings

To ensure that the data used to develop the models is consistent with historical MI origination volume, Milliman compared the data used in the modelling process to each MI's 2013 year-end statutory data. The data used to develop this model was provided as of year-end 2013. Insurance in-force ("IIF") and risk in-force ("RIF") were calculated from the raw data (i.e., data provided by the individual mortgage insurance companies) and processed modeling data for comparison. Exhibit C.1.1 provides a summary of this comparison. The exhibit shows insurance and risk in force by policy year as taken from statutory filings (green bars), processed data for estimating the models (yellow bars), and source files from the individual mortgage insurance companies (blue bars). From the exhibit, the data provided by the mortgage insurance companies is consistent with statutory filings, indicating the loan-level data is representative of historical MI volume.

In the exhibit insurance in force is calculated as the total current UPB ("Unpaid Principal Balance") for in-force loans as of report year end 2013. Risk in force is calculated as the total current UPB for in-force loans

as of report year end 2013, multiplied by the MI coverage. Only primary loans (defined as non-pool loans) were included in these calculations to maintain consistency with the statutory data.

“Loan-Level Raw” refers to the raw data that was provided by the MI companies. Milliman performed simple data manipulations to maintain standardization throughout the datasets. Loans from all origination years were included. Observations with errors (such as blank certificate ID numbers) or duplicate loans were excluded from the analysis.

“Loan-Level Full Dynamic” refers to the data that is used to estimate model coefficients after data processing has occurred. Data was removed in this process, which could affect the volume calculations. Specifically, loans with origination year prior to 1975 and performance data from quarters 1, 2 or 3 were removed in this data processing. The analysis was performed on both the raw data and processed data to verify that both the data provided and the final dataset used were representative of the MI’s business.

In addition to reviewing the data in aggregate, Milliman reviewed the data comparisons for each mortgage insurer. The individual MI companies are not shown in order to maintain anonymity on the individual mortgage insurance company data.

Compare MI Data to Industry Data

In addition to the above data check, Milliman assessed the claim and prepayment rates provided in the data used to estimate the models against industry data. Specifically, we compared cumulative claim rates and prepay rates for all primary loans (non-pool loans) originated by each MI company to industry data. Exhibit C.1.2 Pages 1 and 2 provides visual comparisons of cumulative claim and prepay rates, respectively, by FICO and original loan-to-value cohort.

The source of the industry data are datasets published by Fannie Mae and Freddie Mac that contain historical monthly performance on select loans. The data is generally filtered to fixed rate mortgages with a 30-year amortization term and full documentation¹.

In order to maintain consistency with the data used to develop the models, Milliman applied similar filters from the Fannie Mae and Freddie Mac data to the loan-level mortgage insurer data. Specifically, we limited the MI data to primary, 30-year, fixed rate mortgages. The GSE data was limited to performance observations from 1995 to 2013 for 30-year mortgages with MI coverage originating during or after 1975.

Exhibit C.1.2 Page 1 shows that claims rates between the Freddie Mac and Fannie Mae data is generally consistent with the claim rates calculated from the mortgage insurer data. Exhibit C.1.2 Page 2 shows the cumulative prepayment rates in the Freddie Mac and Fannie Mae data is also generally consistent with the prepayment rates calculated from the mortgage insurer data. We note the mortgage insurer data does appear to have slightly more variation in prepayment rates between credit scores relative to the Freddie Mac and Fannie Mae data. Further examination of the differences in the data did not result in any strong conclusions onto the cause for this observation.

Milliman reviewed these exhibits individually for each mortgage insurance company and found the results to be generally consistent across mortgage insurers. The individual MI companies are not shown in order to maintain anonymity of the individual mortgage insurance company data.

¹ http://www.freddiemac.com/research/datasets/sf_loanlevel_dataset.html
<http://www.fanniemae.com/portal/funding-the-market/data/loan-performance-data.html>

Our review concluded the “Loan-Level Full Dynamic” data appears reasonable and consistent with the statutory filings and individual data for use in the model.

C.2 Data Preparation

While the above review concluded the aggregate data was reasonable, there were adjustments made to the data to clean the data or account for multiple termination events. This section describes the process and adjustments that were made to the data for this analysis.

C.2.i Data Preparation Code

All data preparation for this assignment was performed in a single program called “1 – Data Preparation.sas”. This section of the documentation describes the data preparation steps applied to the data for the analysis.

The first step of the data preparation process began with a data file provided to Milliman called “fullmidynamicsampwprob.sas7bdat.” This file is an aggregation of the individual MI data that contains over 360 million observations. Each observation corresponds to the unique combination of a given insured mortgage and its status within a given year. Of the 360 million observations, there are 27 million unique insured mortgages.

To this data, we defined the loan status for each loan using the field “simple_status” in the data. Specifically, loans with a “simple_status” of 1 were defined as performing, 2 as delinquent, and 3 as termination.

Loans with a simple_status of 6 or loans with a final_payment greater than 0 were defined as a claim. Loans with a simple_status of 3, 4, or 5 were defined as a prepayment. For loans with a simple_status of 3, a prepayment was only defined if the monthsleft field was greater than 0.

The following loans were then removed from the analysis:

Description	Number of Observations
Total Observations	27,171,180
Remove records that appear in the origination data but do not have performance data	23,904,723
Remove pool and bulk loans	20,360,186
Remove modified loans	20,164,220
Remove records with multiple terminations	20,062,974

The data was then aggregated into an analysis dataset with one record per loan with the following data fields:

Field	Description
Company	Name of MI company
Origination Year	Origination year of the mortgage
FICO Bucket	FICO cohort for the loan (e.g. 760-850)
LTV Bucket	LTV cohort for the loan (e.g. 90-95)
State	Property state of the mortgage
MI premium rate	Premium rate of the mortgage insurance policy
Interest only indicator	Binary flag if the loan has an interest only feature
Loan Purpose	Loan purpose of the mortgage
Property Type	Property type of the collateral
Occupancy Type	Occupancy type of the borrower
Documentation Type	Documentation type of the mortgage

Loan Term	Original term of the mortgage
Amortization Type	Amortization type of the mortgage
Number of Alternative Risk	Number of alternative risk features
Number of High Risk	Number of high risk features
Number of Risk Offset	Number of low risk features
Removal Indicator	Indicator for removing the loan from the analysis due to the above defined data inconsistencies
Incomplete Record Indicator	Indicator for records without a complete performance history (e.g. originated in 1998 with first performance record in 2004)
Original UPB	Origination mortgage amount
Risk in Force	Original risk for the mortgage calculated as the original UPB times the coverage amount
Claim Amount	Amount of claim paid by the MI, net of recoveries
Performing UPB by year from 1995 through 2013	One column per year of the Performing UPB of the mortgage for each calendar year
Delinquent UPB by year from 1995 through 2013	One column per year of the Delinquent UPB of the mortgage for each calendar year
Performing RIF by year from 1995 through 2013	One column per year of the Performing Risk in Force of the mortgage for each calendar year
Delinquent RIF by year from 1995 through 2013	One column per year of the Delinquent Risk in Force of the mortgage for each calendar year
Claim amount by year from 1995 through 2013	One column per year of the net claim paid each calendar year

The above dataset was used for the entirety of this analysis, with the exception of the severity estimation. For the severity estimates, Milliman relied upon data published by Fannie Mae and Freddie Mac. The dataset can be downloaded at the following links (which also include detailed descriptions of the data):

Fannie Mae: <https://www.fanniemae.com/portal/funding-the-market/data/loan-performance-data.html>

Freddie Mac: http://www.freddiemac.com/research/datasets/sf_loanlevel_dataset.page

C.2.ii Summary Statistics

Exhibit C.2.1 provides summary statistics of the mortgage insurer data. For each data element the exhibits show the original risk by origination year and each variable, the percentage distribution for each origination year, the claim amount, the loss rate (claim amount divided by original risk), and the relativity of the loss rate to the baseline factor. The table below provides a summary of the exhibits.

Exhibit C.2.1	Data Element
Page 1-5	FICO
Page 6-10	Loan-to-Value Ratio
Page 11-15	Amortization Type
Page 16-20	Loan Purpose
Page 21-25	Occupancy Type
Page 26-30	Interest Only Indicator
Page 31-35	Property Type Description
Page 36-40	Documentation Type
Page 41-45	Original Term
Page 46-50	Number of High Risk Features
Page 51-55	Number of Alternative Risk Features
Page 56-60	Number of Risk Offset Factors

D. Mortgage Insurance Capital Theory

This section of the report provides a discussion of the risk profile of mortgage insurance and the theory of an RBC countercyclical capital framework.

D.1 History of Mortgage Insurance²

The current form of the private mortgage insurance industry was developed in the 1950s, but the industry's framework goes back to the late 1800s. To make mortgage loans more marketable to investors, New York State passed legislation authorizing the insuring of mortgages in 1904. Due to an expanding economy and a general growth in property values, mortgage insurance was generally considered a low-risk business. Firms participating in mortgage insurance had minimal regulation and were thinly capitalized. The collapse of real estate values during the Great Depression precipitated the collapse of the entire mortgage insurance industry. Subsequently the State of New York commissioned a study, which recommended among other things, the setting of stringent capital and reserve requirements and the implementation of more sound appraisal, investment and accounting procedures.

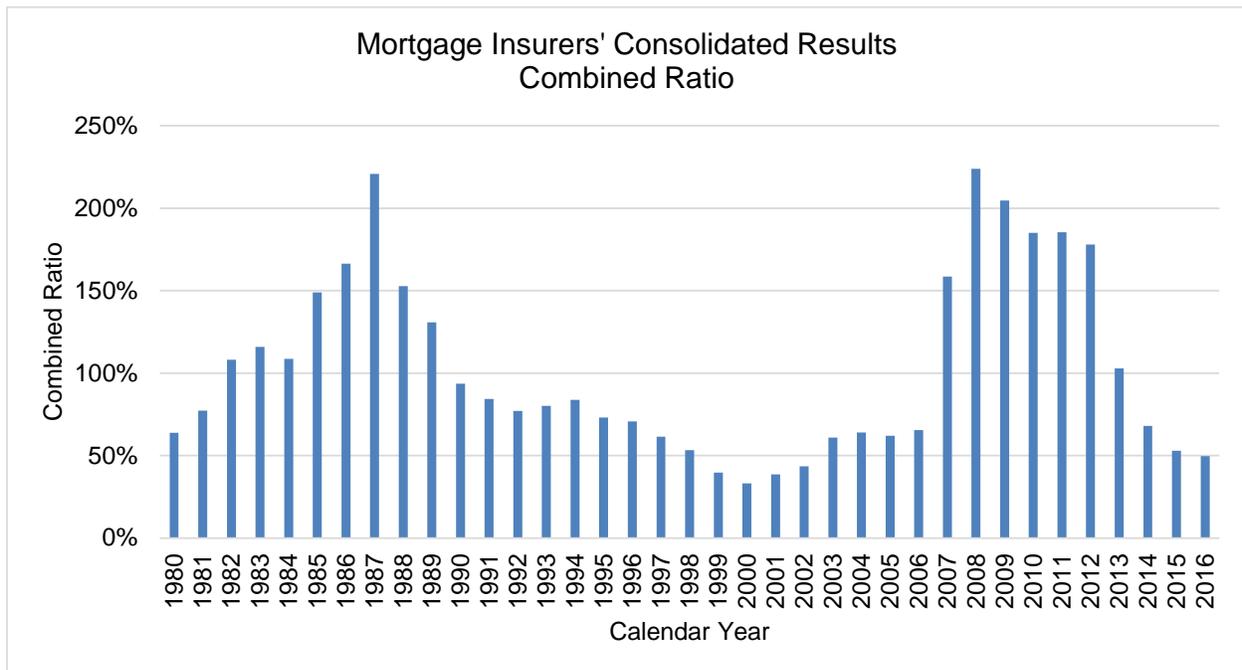
Mortgage insurance was revitalized when various government sponsored guaranty programs were initiated in the 1930s and 40s (Federal Housing Administration's Mutual Mortgage Insurance Fund ["FHA"] and the Veteran Administration's Home Loan Guaranty Program). Private mortgage insurance reestablished itself soon after in the 1950s. During the relatively stable economic period of the 1960s and 70s, the private mortgage industry flourished and expanded to more than a dozen national companies. The early 1980s however brought a period of untested idiosyncratic underwriting, risk management and pricing strategies during a period of double-digit interest rates, inflation and regional recessions. Once again, several private mortgage insurance companies failed and payment obligations were minimally met through regulatory relief, liquidation, acquisition and an industry strategy for replacement mortgage insurance for loans which had been insured by a failed company.

The industry once again attracted investment capital and new entrants in the late 1980s due to historically low interest rates and steady but rising home prices. Mortgage credit risk once again seemed to have minimal risk in the 1990s and early 2000s, and the industry lost market share to competing financial products and government programs which created incentives for homeownership to low and moderate-income households across the banking and insurance markets. The Great Recession followed and once again the private mortgage insurance industry lost several companies due to inadequate capital reserves.

Figure D.1 shows the historical mortgage insurance industry average combined ratio (incurred losses plus expenses divided by earned premium) from 1980 through 2014. The figure highlights the cyclical nature of mortgage insurance described above. Namely, the insurance is characterized as a relatively stable, low risk exposure followed by stark periods of high loss environments.

² References:
 MICA Fact Book
 "History of Mortgage Finance With an Emphasis on Mortgage Insurance", Thomas N. Herzog, Society of Actuaries, 2009
 "Countercyclical Capital Regulation: Should Bank Regulators Use Rules or Discretion?" Federal Reserve Bank of Kansas City Economic Review, Q2 2011

Figure D.1: Historical loss and LAE Ratio for Mortgage Insurers



*Source: MICA Fact Book, SNL

D.2 Countercyclical Capital Regulatory Approach

In response to the resulting financial crisis, the Dodd-Frank Financial Reform and Consumer Protection Act of 2010 mandated changes to the financial markets to require countercyclical capital. The transformation from procyclical capital regulation would require financial institutions to hold higher capital amounts during periods of economic prosperity and therefore dampen excessive growth. A countercyclical structure would also facilitate more responsive capital positions that could absorb future increased losses and sustain mortgage lending during periods of economic stress, as highlighted by the private mortgage insurance industry’s volatile past.

A mortgage insurer’s capital requirement has generally been met by exceeding a minimum capital amount measured by a simple measure of the proportion of risk in force to assets. In 2008 and revised more recently (2015), Fannie Mae and Freddie Mac, of which the mortgage insurance industry is their largest counterparties, enhanced this procyclical capital requirement by adding more granularity to the quantification of risk and the definition of eligible assets through the introduction of the Private Mortgage Insurer Eligibility Requirements (“PMIERS”). The defined *Risk-Based Required Asset Amount* for loans insured are generally determined by factors that are applied to an insurers risk in force. Factors include, but are not limited to, the insured loan’s loan-to-value ratio, original credit score, vintage, modification and delinquency status. The *Risk-Based Required Asset Amount* for an insurer’s portfolio is then compared against the liquid capital investments available to pay claims under a scenario of significant market stress. Although PMIERS certainly provides a more measured risk-based capital requirement and enhances the likelihood of a given mortgage insurers’ solvency during periods of stress it does not mitigate the volatile

insurance market's business cycle amplifications of originating too many policies during periods of excess and the constriction of mortgage originations during periods of stress. The PMIERS requirements are also devoid of the defined specific market stress and solvency conditions that are being imposed on their mortgage insurance counterparties. For example, it is not clear through documentation or published materials what stress environment is assumed in the development of PMIERS.

A rules-based countercyclical mortgage insurance capital regulation approach is designed to address the historical deficiencies caused by the current risk-based procyclical capital regulations. The RBC capital model described in this document would increase required capital ratios in strong economic periods allowing for more potential claim loss absorption during future recessions. The construct would also potentially increase the likelihood that mortgage insurers would continue to prudently originate mortgage insurance policies through the cycle.

E. RBC Capital Model Technical Documentation

This section of the report provides documentation of the RBC capital model approach, including a description of the methodology used to develop the factors.

E.1 RBC Model Framework

The model is a counter-cyclical model that uses a factor based approach to apply a capital factor to each performing active loan as of the evaluation date based on the loan's underwriting features and economic environment at the time of loan origination. The factors are combined together (as described below) to estimate a capital factor for each loan. The capital factor is multiplied by the insurer's risk in force for performing loans only and aggregated to produce a total capital requirement. This capital requirement is offset by a premium credit to produce an aggregate required level of capital. Required capital for delinquent risks are accounted for using the standard RBC process for reserve risk. The diagram below provides a visual of the RBC model framework:



The table below provides a summary of the model factors:

Model Factor	Description	Level	Value
Base Factor	Base factor applied to all mortgages	N/A	0.55%
FICO Score	Borrower credit score at origination	760-850 740-759 720-739 700-719 680-699 660-679 640-659 620-639 600-619 580-599 560-579 300-599 Missing / Error	1.00 1.35 1.60 1.95 2.40 2.90 3.55 4.40 5.50 6.60 7.60 9.50 5.00
Loan-to-Value Ratio	Loan-to-value ratio at origination	(0, 80] (80, 85] (85, 90] (90, 95] (95, 100] 100+ Missing	1.00 1.45 1.75 2.00 3.05 4.00 2.00
Number of Alternative Risk Factors	Total number of Alternative Risk Factors on the mortgage	0 1 2 3 4+	1.00 1.30 1.65 1.90 2.00

Number of High Risk Factors	Total number of High Risk Factors on the mortgage	0	1.00
		1	1.50
		2	2.35
		3	3.95
		4	3.25
Number of Risk Offset Factors	Total number of Risk Offset Factors on the mortgage	0	1.00
		1	0.65
		2	0.50
		3	0.50
Economic Factor	Economic adjustment factor evaluated at origination	Varies by origination year	
Severity Rate	Severity rate, as a percent of original loan amount, applied to mortgage insurance coverage in excess of Standard Coverage	Varies by the Economic Factor	

E.2 RBC Capital Factors

This section of the report describes the development of the RBC capital factors. The RBC capital factors were developed in a three step process:

1. Develop FICO, LTV, and risk factor relativities;
2. Develop economic factor; and
3. Set base rate factor.

E.2.i FICO, LTV and Risk Factor Relativities

The FICO, LTV, and Risk Factor relativities were selected after reviewing three indications of relativities between a base loan and loans with different risk factors. The three relativities are:

1. Empirical odds relativity from the loan-level data;
 - a. The empirical odds relativity is calculated as the ratio of the odds from a given cohort (e.g. FICO range between of 640-659) to the odds from the baseline cohort (e.g. FICO range between 760-850). The odds is calculated as $A / (1-A)$, where A is the ratio of the number of claims to the number of total observations within a given cohort.
2. Rate card price relativity from a representative MI company rate card; and
 - a. This is the simple division of the mortgage insurance premium for a given cohort relative to the premium for the baseline cohort
3. Logistic regression model on the MI's loan-level data.
 - a. A logistic regression was performed on the loan-level data where the removal indicator and the incomplete record indicator were both 0 – that is, the records that were complete without data errors. The regression model is a logistic regression model for loans seasoned at least five years in the data where the dependent variable is a binary indicator of claim or no claim and the claim occurred within the first five years of origination (to control for seasoning). The independent variables are FICO cohort, LTV cohort, number of alternative risk factors, number of high risk factors, number of risk offsets, and an origination year variable to control from economic differences.

The above relativities were reviewed (along with the distribution of observations within the data) and the RBC capital factors were selected from the indications.

Exhibits E.2.1 shows these relativities for FICO score. In the exhibit there are three bar graphs (left axis) and one area chart (right axis). The blue bars on the chart show the odds relativity calculated from the empirical data. The orange lines show the premium relativity from a representative rate card. The grey bar shows the results from the logistic regression model. The back dots on the chart are the selected RBC capital factors. The blue area shows the percent of total observations for each FICO cohort.

Exhibits E.2.2 through E.2.5 show these relativities for the LTV, number of alternative risk, number of high risk factors, and risk offset factors, respectively. Note, a risk offset factor indicates the presence of the factor reduces the overall default risk of the mortgage.

A review of the exhibits shows the selected RBC capital factors are most similar to the logistic regression results. A logistic regression controls for multiple risk factors, while empirical data does not. For example, data indicates borrowers with low credit scores have higher default rates relative to borrowers with high credit scores, all else equal. However, the percent of loans with low credit scores tends to be more prevalent during expansionary periods of the housing market and may have a higher representation in the empirical data during such periods. After a correction, the volume of low credit score loans tends to decline. This could distort claim rate relativities observed through empirical analysis. Regression analysis, by adding an origination year variable, provides one methodology to control for such observations.

MI rate cards provide an indication of how MI companies view the risk, but for business specific reasons, rate cards can be priced competitively or to target specific risks and/or markets. In addition, the information that is published on how insurance companies develop their rates may not be fully transparent. Therefore, while they provide a good benchmark, rate cards were not relied upon fully in setting the relativity factors.

Additionally, for the number of alternative and high risk factors, MI companies typically have adjustment factors for specific underwriting characteristics. Those factors and magnitude can change over time. Instead of identifying specific factors that could require a re-work of the entire RBC capital factor framework, the model includes a number of alternative, high, and offsetting risk factors. Regulators can, in the future, determine which variables should be included as either alternative, high, or offsetting risk factors. Using rate cards, this approach would be difficult to implement.

The table below provides a list of the alternative, high, and offsetting risk factors in the model.

Alternative Risk Factors	High Risk Factors	Risk Offset Factors
Loan purpose other than Purchase	Not full documentation	More than one borrower
Property type other than Single Family Residence	Interest only or other non-fully amortizing loan	Original loan term is less than or equal to 240 months
Greater than 360 month amortization term	Occupancy Type other than Primary	Loan originator is a credit union
Amortization type other than fixed	Back-end DTI above 50	
Back-end DTI greater than 43 and less than or equal to 50		

Loans were categorized into alternative, high, and risk offsets based on the distribution of observations for each risk factor as a percent of total observations, distribution of observations by origination year, distribution of observations by mortgage insurance company, empirical default odds within the data, and a

review of regression coefficients for each variable. For the regression analysis, each variable was labeled as an independent variable in the regression. Variables with an odds ratio at or around 1.50 or higher were classified as high risk variables, variables with an odds ratio between 1.00 and 1.50 were classified as alternative risk variables, and variables with an odds ratio less than 1 were classified as risk offsets. Note, some variables has odds ratios close to 1.50 (e.g. 1.46) and were classified as high risk variables upon review of the distribution of observations and empirical odds ratios. The table below provides the regression variables and risk category for each variable.

Risk Variable Classification and Odds Ratio

Variable	Category	Logistic Odds Ratio	Risk Category
Documentation_Type	Full Doc	1.00	
	Non Full Doc	1.46	High
Interest_Only_Ind	No	1.00	
	Yes	1.50	High
Num_Borrowers	1	1.00	
	GT1	0.61	Offset
Term_240	GT360	1.42	Alternative
	241-360	1.00	
	LE240	0.48	Offset
Loan_Purpose_Desc	Purchase	1.00	
	Cash-Out Refi	1.41	Alternative
	Other	0.58	Alternative
	Rate/Term Refi	1.46	Alternative
	Refi-Property Improvement	0.80	Alternative
	Refi-Use Unknown	1.39	Alternative
Property_Type_Desc	Not Condo	1.00	
	Condo	1.06	Alternative
Occupancy_Type	Primary	1.00	
	Investment	2.16	High
	Secondary	1.46	High
	Unknown	2.58	High
Amort_Type	Fixed	1.00	
	5/1ARM	1.25	Alternative
	< 5/1ARM	1.46	Alternative
	> 5/1ARM	1.11	Alternative
	ARM	1.32	Alternative
	UNKNOWN	2.01	Alternative
Final_DTI_Bucket	LE 43	1.00	
	(43, 50]	1.20	Alternative
	GT 50	1.29	High
	Missing	1.34	
Cred_Union_Flg	Other	1.00	

Credit Union

0.54

Offset

E.2.ii Economic Factor

An important criteria for the RBC capital model is to introduce a countercyclical component to the model framework. The countercyclical component is incorporated into the framework through the economic factor. The economic factor is measured using two economic data series: per capita income and the FHFA conventional and conforming home price index. The model compares the rolling four-year change in income relative to the four-year change in home prices.

Historical data shows when the growth in home prices exceeds the growth in income by a significant margin, there tends to be a correction in house prices that restores the long-term relationship between home prices and per capita income.

The data used for the calculation is performed at the State-level using data that is publicly available. Note, State-level income data is published with a one-year lag. That is, 2018 income data would not be collected and published until 2019. Therefore, there is a one-year lag in the data series. The steps below provide a sample of the calculation for California for origination years 2005 through 2008 using annual data for demonstration purposes. In application of the model, this calculation would be performed using quarterly data series.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Per capita Income	30,641	33,338	34,036	34,185	35,409	37,327	39,296	42,111	43,615	43,843
	4 Year Percentage Change (A)					15.6%	12.0%	15.5%	23.2%	23.2%
Home Price Index	242	273	308	342	385	472	583	642	607	486
	4 Year Percentage Change (B)					59.1%	72.9%	89.3%	87.6%	57.7%
Difference in 4 Year Change Between Home Price Appreciation and Average Household Income Growth (C = B – A)						43.5%	61.0%	73.9%	64.4%	34.5%

The difference in the 4 year change between home price growth and income is applied to an equation to develop the RBC capital factor. The specific equation is:

$$RBC\ Capital\ Factor = \text{Max}(1, \min(20, e^{5x})), \text{ where } x = \text{percentage difference in 4 year change between home price appreciation and per capita growth measured at the State level}$$

Exhibits E.2.6 through E.2.57 provide time series data of the RBC capital factor from 1980 through 2018 for all States as well as a weighted average portfolio using the State distributions in the loan-level data. The exhibits show the economic factor (i.e. difference between home price appreciation and per capita income growth) in the blue line against the left axis and RBC capital factor (“economic factor”) in the orange bars against the right axis. The exhibits demonstrate the volatility of differences between States. For example, Exhibit E.2.6 shows the weighted average for all States. The economic factor ranges from 1.0 to 8.45 for

2006 originations. Exhibit E.2.11 shows the data for California; on this exhibit the economic factor ranges from 1 to 40 (note, the model uses a cap of 20 for the economic factor adjustment while this exhibit does not include the cap), with many observed cycles going back to 1980. Exhibit E.2.12 shows the data for Colorado; on this exhibit the economic factor ranges from 1 to 4.5, with few cycles in the data. Due to these types of observations and to capture regional differences in economic risks and portfolio concentration, the economic factors are calculated and assigned at the State level. Note, these exhibits are calculated using annual data series for demonstration purposes and for readability.

The above equation was estimated by comparing the historical claim odds relativities from the loan-level data against the economic variable at the State level, national level, and using a State weighted average. The loan-level data and claim rates were calculated by origination year for origination years 1995 through 2008. Odds relativities were calculated using 2000 as the baseline year. An exponential curve was fit against the data and parameters were selected upon reviewing State level results and national average results. The parameters Alpha = 1 and Beta = 5 were the final selections.

Empirical odds relativities were also compared to the origination year odds ratios from the logistic regression analysis performed on the loan-level dataset. Note, the odds ratios from the logistic regression would represent a national weighted-average portfolio and would not be State specific.

Exhibit E.2.58 shows a graphical comparison of the empirical odds ratios (Black bar), logistic regression (Green bar), and State-level weighted average exponential fit (Blue bar) on the left axis against the economic variable on the right axis. The exponential fit produces results that are consistent with the empirical data and logistic regression. The exhibit also shows the range of the RBC capital factor ("economic factor") below the chart for varying levels of differences between home price appreciation and average per capita income.

Finally, a minimum floor of 1 was applied to the equation and a maximum value of 20; these values were judgmentally selected after reviewing the distribution of historical data by State and quarter. For some regions, the economic factor exceeded 40 (i.e. in California for 2006Q3 originations); a cap was applied to these instances in order to produce an aggregate annual factor that was consistent with the empirical data and logistic odds ratios when calculated by origination quarter and State and aggregated to a historical weighted-average basis.

E.2.iii Combining the Factors

The above factors are all estimated using a relative odds framework. Therefore, when combining the factors, they must similarly be accounted for as odds ratios. Treating them as odds ratios results in two desirable outcomes:

1. It ensures the capital factor is always between 0 and 1; and
2. It aligns the development of the factors with the implementation.

The specific calculation for combining the RBC capital factors is shown in the formula below.

$$\text{RBC Capital Factor} = \frac{e^b}{1+e^b}, \text{ where } b = \ln\left(\frac{\text{base rate}}{1-\text{base rate}}\right) + \ln(\text{FICO Factor}) + \ln(\text{LTV Factor}) + \ln(\text{alternative risk factor}) + \ln(\text{high risk factor}) + \ln(\text{risk offset factor}) + \ln(\text{economic risk factor})$$

E.2.iv Credit for Future Premium

Mortgage insurance companies typically collect monthly premium for insured policies, and the policies are typically in force until the underlying mortgage refinances or reaches a loan-to-value ratio at or below 78%

through either amortization and/or home price appreciation. Therefore, the RBC capital model should include a recognition of future premium. The RBC capital model accounts for future premium by allowing for an offset against the aggregate capital amount from the above formula. Specifically, the credit for future premium is equal to two years of premium for active insured loans.

The premium credit factors were developed after reviewing historical run-off triangles using the loan-level data. Specifically, run-off triangles were developed from the loan-level data and used to calculate the average life by origination year. The run-off triangles were calculated on performing loans (i.e. not delinquent) only, since delinquent loans, by definition are not paying premium. While the premium may be advanced by servicers, the servicing advances are typically included in the final severity calculation.

Exhibits E.2 Pages 59 through 61 show the results of the analysis. Exhibit E.2 Page 59 shows the run-off triangle for the loan-level data. Exhibit E.2 Page 60 calculates the annual termination rate from one year to the next. On average, the annual termination rate is approximately 25%. Exhibit E.2 Page 61 calculates a weighted average life of each book at 3.84 years. Note, for this calculation, we assume a 25% termination rate for future years to develop the forecast out to ultimate.

Based on a review of the run-off triangles, the credit for future premium factors were selected as two years of credit for loans that are active. Note, the premium credit only applies to performing loans.

E.2.v Base Rate

After the above factors (i.e. FICO, LTV, alternative risk, high risk, risk offset, economic, and premium credit factors) were developed, a base rate was selected for the RBC capital model. The base rate was selected according to the following process³:

1. Using the loan-level data from the MI companies, construct an income statement and balance sheet for each MI company using historical and forecast premium and loss data and the following list of assumptions;
 - a. Assumed investment rate of return of 3%;
 - b. Assume expense ratio of 20% (20% of premium); and
 - c. Assumed federal tax rate of 15%.
2. Apply the RBC capital model to the loan-level population using a base rate that varied from 0.15% up to 0.65%;
3. For each iteration of the base rate and each MI company, determine the number of MI companies whose net capital position (i.e. cumulative cash flows) would be less than the RBC capital model requirement under a run-off scenario (i.e. "entity failure");
4. Perform the above analysis for run-off years 2005 through 2013; and
5. Analyze results and make a base rate selection.

The results from the above analysis were summarized in the following table. The table shows the number of entity failures for varying levels of the base rate by run-off year (note there are six companies total).

³ Note, for this analysis, HARP loans were included in the original loan population. HARP loans were removed from the regression analysis.

Number of Entity Failures by Base Rate and Run-off Year											
Run-off Year	0.15%	0.20%	0.25%	0.30%	0.35%	0.40%	0.45%	0.50%	0.55%	0.60%	0.65%
2005	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0
2007	4	4	4	3	1	1	0	0	0	0	0
2008	5	5	5	5	4	2	1	1	0	0	0
2009	4	4	4	4	4	3	1	1	1	0	0
2010	4	4	4	4	4	4	3	2	2	1	1
2011	2	2	2	2	2	1	1	1	1	0	0
2012	1	1	1	1	1	1	1	1	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0

Based on the above table a base rate of 0.55% was recommended. Note, the base factor may be adjusted upon additional back-testing and analysis.

E.2.vi Severity Adjustment

The above analysis assumes a 100% loss for primary mortgage insurance coverage and was developed using primary coverage data (i.e. pool policies were removed from the analysis). In certain instances, mortgage insurance companies may have exposure to loans with a coverage amounts in excess of standard coverage for mortgage insurance (i.e. “deep cover” mortgage insurance) or the ground-up loss for a pool of mortgages. Therefore, a severity component is required to assess the capital levels of mortgage insurance companies when the coverage amount is in excess of standard coverage.

In the RBC model, the severity rate is calculated at the loan-level as a function of the original loan-to-value ratio of the mortgage and the Economic Factor (discussed in Section E.2.ii of this report). The higher the original loan-to-value ratio of the mortgage, the greater the severity rate. The higher the Economic Factor, the greater the severity rate. The severity rate, expressed as a percentage of the original loan amount, is a linear function of the Economic Factor, and the intercept is set by the original loan-to-value ratio. The equation below describes the calculation of the severity rate.

$$\text{Severity Rate} = \text{Intercept} + \text{Slope} * \text{Economic Factor}$$

The tables below provide the intercept and slope of the function required to calculate the severity rate.

Original loan-to-value Ratio	Intercept	Slope
(0, 10]	0.100	0.02
(10, 20]	0.100	0.02
(20, 30]	0.100	0.02
(30, 40]	0.150	0.02
(40, 50]	0.200	0.02
(50, 60]	0.250	0.02
(60, 70]	0.300	0.02
(70, 80]	0.350	0.02
(80, 85]	0.375	0.02
(85, 90]	0.400	0.02

(90,95]	0.425	0.02
95+	0.450	0.02

As the data from the mortgage insurers does not include ground-up severity, publicly available data from Fannie Mae and Freddie Mac as of June 30, 2018 was used to develop the severity component. The data were normalized between the two entities. The data from Fannie Mae and Freddie Mac includes loan-level information on the unpaid principal balance at the time of a claim, the expenses associated with the claim, delinquent interest paid to the investor for the claim, and net proceeds from the sale of the property. This data was processed to calculate a severity rate for each loan with a loss in the data. The equation below provides the components of severity for this analysis:

$$\text{Severity Rate} = \frac{\text{Unpaid Principal Balance} + \text{Expenses} + \text{Delinquent Interest} - \text{Sale Proceeds}}{\text{Original Unpaid Principal Balance}}$$

The data was processed and summarized by State, origination quarter, and loan-to-value bucket; the severity rate was calculated for each unique combination of the above three variables. Using State and origination quarter, the Economic Factor (discussed previously) was calculated for each State and origination year combination. Exhibit E.2 Page 62 shows select percentiles of the severity rate by loan-to-value cohort. For this exhibit, the data is aggregated by similar values of the Economic Factor.

A linear regression was performed on the data to estimate the relationship between the Economic Factor and the severity rate. The regression produced an R-Square value of between 50% and 60% for loan-to-value ratio cohorts above 40%. The data is volatile and limited for lower loan-to-value ratios. The resulting intercepts were smoothed between loan-to-value cohorts, and a slope of 0.02 was selected for each loan-to-value cohort. Exhibits E.2 Pages 63 through 65 provide a comparison of historical severity rates relative to the regression output severity rates for each loan-to-value cohort. In the charts, the x-axis is the origination year, and the y-axis is the severity rate. The blue bars show the actual severity rate, and the orange lines show the resulting RBC severity rate.

The table below provides an example of how the severity rate will be implemented with the RBC framework. In the table, the column on the left demonstrates how the severity rate would be applied to primary coverage, and the column on the right demonstrates how the severity rate would be applied to pool loans. Note, the intercept in the severity equation is greater than Standard Coverage amounts, so the severity rate would be capped at 100%. For pool loans, the severity rate is applied as a haircut to the RBC Capital Amount.

Illustrative Example of Severity Adjustment		
	Primary Loan	Pool/Structure Loan
A Mortgage Amount	\$300,000	\$300,000
B Coverage (LTV = 96%)	30%	100%
C RBC Capital Factor (Economic Factor = 1.05)	2.34%	2.34%
D RBC Capital Amount = (A x B x C)	\$2,105	\$7,016
E Severity*	47.1%	47.1%
F MI Severity as a Percentage of Coverage = [Min(100%, E / B)]	100%	47%
G RBC Capital Amount (including severity) = (D x F)	\$2,105	\$3,304

*Severity = 0.45 + 0.02 * 1.05 = 0.471

E.3 RBC Factor Testing

The RBC factors were back-tested through the base rate selection process to assess the RBC required capital levels against historical and estimated cumulative cash flows for the mortgage insurance industry. Additional evaluation was performed to test the RBC capital results reasonability to historical data. This section provides a summary of those evaluations.

Book Year Evaluation

Exhibit E.2 Page 66 provides a comparison of the RBC capital requirements against historical and forecast ultimate claims by origination year. The RBC capital requirements are segmented into three components:

1. FICO and LTV capital requirement (orange line on the chart);
2. Underwriting risk factor capital requirement (yellow line on the chart); and
3. Economic capital requirement (green line on the chart).

On the chart, the blue and grey line represent to-date claims (blue) plus ultimate claims (grey). The stacked lines on the chart show the various components of the RBC capital requirement. The visual highlights the largest driver of capital variations is the economic component, which can vary from 0 to several multiples of the other two capital components combined.

Additionally, the exhibit highlights the RBC charge is designed to capture temporal diversification of mortgage insurance companies; that is, some books will require more capital than cumulative claims (e.g. 2003 through 2005) and some books will require less capital than cumulative claims (e.g. 2006 through 2008).

Comparison to 25-to-1 Risk-to-Capital Ratio

Exhibit E.2 Page 67 provides a visual of the historical risk-to-capital ratio calculation using the RBC capital factor (excluding the credit for premium).

The exhibit includes all book years from 1995 through 2013 by development year and calculates the required capital using the RBC factors. The calculation is performed on historical data and aggregated for all mortgage insurance companies that provided data.

F. Qualifications and Limitations; Limited Distribution of Results

F.1 Qualifications and Limitations

The authors and peer reviewers of this analysis are Members of the American Academy of Actuaries, Fellows of the Casualty Actuarial Society and/or have significant expertise in the evaluation of mortgage insurance and reinsurance.

In performing this analysis, Milliman has relied on data evaluated as of December 31, 2013 and other information concerning the data evaluated as of December 31, 2013, provided to Milliman by or on behalf of the National Association of Insurance Commissioners through the date of this report. Note that the assumptions used to create the capital model were derived using data evaluated as of December 31, 2013. Milliman has not audited or verified the data and information provided. If the underlying data or information is inaccurate or incomplete, the results of Milliman's analysis may likewise be inaccurate or incomplete. Except where noted specifically within this report, Milliman is not aware of any relevant events or changes to the data subsequent to Milliman's analysis that would materially impact the results of the analysis.

In performing this evaluation, Milliman has assumed that the NAIC and the Mortgage Insurance Working Group (a) used its best efforts to supply accurate and complete data and (b) did not knowingly provide any inaccurate data. Milliman performed a limited review of the data used directly in Milliman's analysis for reasonableness and consistency and has not found material defects in the data. If there are material defects in the data, it is possible that they would be uncovered by a detailed, systematic review and comparison of the data to search for data values that are questionable or relationships that are materially inconsistent. Such a review was beyond the scope of Milliman's assignment.

The analysis and any conclusions provided in Milliman's deliverables are based on data provided to Milliman by third-party sources. Milliman does not warrant the accuracy or completeness of any third-party data, and Milliman disclaims any and all liability in connection with such third-party data. Any errors in the data provided may affect the results of Milliman's analysis. Milliman shall not be liable for the results of its analysis to the extent errors are contained in third-party data sources.

Any analysis of unpaid claims or study of future operating results involves estimates of future contingencies. While Milliman's analysis represents Milliman's best professional judgment arrived at after careful analysis of the available information, it is important to note that a significant degree of variation from future projections is not only possible but is, in fact, probable. The sources of this variation are numerous, and include, but are not limited to: future national or regional economic conditions, mortgage prepayment speeds, and legislative changes affecting the mortgage market.

Differences between the model projections and actual amounts depend on the extent to which future experience conforms to the assumptions made for this analysis. It is certain that actual experience will not conform exactly to the assumptions used in the capital model. Actual amounts will differ from projected amounts to the extent that actual experience is better or worse than expected.

The uncertainty associated with this capital model is also magnified by the nature of mortgage insurance. Mortgage insurance results are sensitive to economic factors such as unemployment, housing market conditions, interest rate levels and so on. Past experience may not be indicative of future conditions. A loan underwritten in a given year is generally insured over several calendar years. Therefore, adverse economic conditions in a given calendar year could affect results not only for the current underwriting year but also for prior underwriting years. Future economic developments that give rise to additional

delinquencies and losses will impact ultimate losses, and unprecedented changes and stresses in the market add to uncertainty.

Any reader of this report must possess a certain level of expertise in areas relevant to this analysis to appreciate the significance of the assumptions and the impact of these assumptions on the illustrated results. The reader should be advised by, among other experts, actuaries or other professionals competent in the area of actuarial projections of the type in this report, so as to properly interpret the projection results.

F.2 Disclosures

Actuarial Standards require Milliman to disclose the following:

Purpose

The purpose of this assignment is to produce a proposed capital model framework for mortgage insurance companies to the NAIC Mortgage Guaranty Insurance Working Group.

Constraints

There have been no constraints on this project (such as time, availability of data, or access to staff) that materially impacted our ability to provide this analysis.

F.3 Limited Distribution of Results

Milliman's work has been prepared solely for the internal use of the NAIC. No portion of Milliman's work may be provided to any other party without Milliman's prior written consent. Milliman does not intend to benefit or create a legal duty to any third party recipient of its work. Milliman's work may not be filed with the SEC or other securities regulatory bodies. In addition, references to Milliman or its estimates in communications with third parties are not authorized. Should the NAIC make reference to the engagement of an independent actuary (without specifically identifying Milliman) in any SEC filing, the SEC may require disclosure of the name of the actuary. Such disclosure is prohibited without Milliman's prior written consent.

Milliman's consent to release its work product to any third party may be conditioned on the third party signing a Third Party Release Agreement, subject to the following exceptions:

- (a) The NAIC may provide a copy of Milliman's work to its auditor to be used solely for audit purposes. In the event the audit reveals any error or inaccuracy in the data underlying Milliman's work, Milliman requests the auditor or The NAIC notify Milliman as soon as possible.
- (b) The NAIC may provide a copy of Milliman's work to governmental entities, as required by law.
- (c) The NAIC may provide a copy of Milliman's work to its legal advisors, provided they agree not to use Milliman's work for any purpose other than to provide services to The NAIC and agrees not to distribute the work to any other person or entity.

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Any reader of this report agrees that they shall not use Milliman's name, trademarks or service marks, or refer to Milliman directly or indirectly in any third party communication without Milliman's prior written consent for each such use or release, which consent shall be given in Milliman's sole discretion.

G. Closing

If you have any questions with regard to this analysis or would like to have us consider additional information, please do not hesitate to contact us.

Respectfully submitted,

Kenneth A. Bjurstrom
Principal and Financial Consultant

Jonathan Glowacki, FSA, CERA, MAAA
Consulting Actuary

Edem Togbey, ACAS, MAAA
Associate Actuary

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