Estimating Unpaid Claim Liabilities for Mortgage Insurance

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Abstract
This paper will provide practical guidance for the actuary estimating loss reserves for mortgage insurance exposures. It includes a brief background on the mortgage insurance product, the accounting considerations for mortgage insurance, and introduces a practical deterministic approach for estimating unpaid claim liabilities for mortgage insurance.

Keywords. Mortgage insurance; reserving.

1. INTRODUCTION

At the depths of the housing market downturn and the recent "Great Recession," mortgage insurance (MI) companies suffered elevated incurred losses and a sustained period of unprofitability. The nearly simultaneous deterioration of several macroeconomic factors – declining home values, increasing unemployment levels, the tightening availability of credit, and a significant backlog of properties awaiting foreclosure – resulted in diminished usefulness of traditional actuarial chain-ladder techniques for estimating unpaid claim liabilities for mortgage insurers.

The development of alternatives to the traditional chain-ladder framework is critical in estimating unpaid claim liabilities for MI. While some actuarial literature address the topic, the methods presented often utilize stochastic (e.g., regression) modeling; these stochastic models can be difficult to understand without having a basic framework to understand the MI loss process.

1.1 Objective

The objective of this paper is to provide the practicing actuary with:

- Sufficient background on the MI product to understand the special requirements for estimating unpaid claim liabilities for MI;
- An overview of the accounting considerations for mortgage insurers to understand the motivation for specialized approaches to estimating MI unpaid claim liabilities; and
- A practical deterministic framework for estimating MI unpaid claim liabilities.

1.2 Outline

The remainder of the paper proceeds as follows: Section 2 provides a primer on mortgage insurance exposure and a brief introduction to the MI accounting framework; Section 3 provides a

deterministic framework for estimating MI unpaid claim liabilities.

2. BACKGROUND

2.1 Development of the MI Industry

The mortgage insurance industry developed as a mechanism to spread mortgage default risk from a mortgage lending institution to a separate, unrelated party (the mortgage insurer) as part of a broader initiative to promote home ownership and provide stability to the real estate and banking industry. The industry's roots can be traced to the Great Depression and the National Housing Act of 1934, which aimed to stabilize the banking system through the creation of the Federal Housing Administration (the FHA). The FHA "provides mortgage insurance on loans made by FHA-approved lenders throughout the United States and its territories." [1]

In the 1950s, the first privately owned enterprise to compete directly with the FHA was formed when Wisconsin passed legislation that paved the way for the formation of Mortgage Guaranty Insurance Corporation. Private mortgage insurance began significant growth in the 1970s with the passage of federal legislation allowing the Government Sponsored Entities (GSEs) Fannie Mae and Freddie Mac to buy and securitize loans where the loan value divided by the home value (loan to value, or LTV) exceeded 80% provided that those loans were covered by mortgage insurance. The interplay of mortgage lenders, GSEs and private mortgage insurers that developed during the 1970s has continued into the current day, with mortgage insurers playing a critical role in collateralizing loans to the point that they comply with GSE purchasing and securitization guidelines.

2.2 MI Product Background

Several key features of MI policies include:

- MI policies are issued at the time that the mortgage is issued and can either be paid by the borrower (most common) or lender (less common).
- Premiums are paid on either a monthly (most common) or single up-front (less common) basis. The premium associated with monthly pay policies is typically paid along with the monthly mortgage payment.
- The collected monthly premiums are generally recognized as income in the period in which they are collected (that is, the monthly premiums are written and earned at the same time) meaning that there is typically a very small (or no) unearned premium reserve

associated with monthly paid MI policies. There is an unearned premium reserve associated with upfront premium policies, which is amortized over the life of the MI contract as losses associated with the contract are expected to emerge.

- MI coverage is typically expressed as a percentage of a loan's unpaid principal balance ("UPB"). These coverage percentages vary from loan to loan, but a typical average coverage percentage is around 25%[1].
- MI policies provide lenders coverage for a portion of the UPB stipulated in the contract. In addition, the MI policy generally reimburses the coverage beneficiary for loss interest payments and certain foreclosure-related expenses.
- Unlike typical Property and Casualty insurance policies – generally in force for one year and have defined termination dates – MI policies often generate premiums and losses for a number of years and there is uncertainty with regard to how long the policies will remain in force. The MI policy holder may exit the insured population for a number of reasons, including defaulting on the mortgage (i.e., becoming a claim), refinancing the loan, or paying down the principal on the loan to the point that the loan no longer requires MI[2].
- MI losses are highly correlated with macroeconomic factors such as home price inflation and unemployment. As was highly evident in 2007-2011, MI company results were adversely affected by a steep drop in home prices followed by rising levels of unemployment. Not surprisingly, the states with the sharpest decreases in home prices – CA, FL and NV – were significant drivers of adverse loss experience for the MI industry.
- As explained further below, MI loss reserves are recorded at the time when a borrower is "delinquent" in paying their mortgage; this results in an unusual accounting construct where premium earning and loss accrual are not matched. In other words, premium revenue generated for MI policies is recognized (i.e., earned) prior to the associated losses

[1] The coverage percentage is a function of LTV and often of GSE purchasing / securitization guidelines. If a borrower puts a 10% down payment on a home, leaving a 90% LTV, and the GSE requires a 68% LTV – a typical Freddie Mac requirement – to purchase the loan, then the MI provides coverage for 24.4% = 1 - .68 / .90 ≈ 25%.

[2] Typically, private MI policies are cancelled when borrowers pay enough principal such that the LTV ratio drops below 78%.

being recognized[3].

- For a cohort of MI policies issued during a year, the premium revenue generated by the policies is the greatest during the first year and then decreases over the next ten years as policies are cancelled. The delinquencies that give rise to the recording of MI loss reserves tend to rise through fourth or fifth year after loan origination; after peaking, losses tend to decrease as policies are cancelled.

2.3 Accounting for Mortgage Insurance Losses

As described above, the accounting framework for MI results in a departure of one of the common objectives of accounting: revenue and expense matching. For typical, single-year P&C insurance products, both revenue (premium) and expense (claim costs) are recognized uniformly through the year the policy is effective[4]. For monthly-pay MI policies, premium is generally earned on a monthly basis, while losses on MI policies are not recognized until the borrower stops paying his monthly mortgage payment and the lender or loan servicer notifies the MI company that the borrower is delinquent[5].

Since MI loss reserves are not established until the MI company is made aware that a borrower is delinquent in paying their loan, MI Companies typically do not establish a provision for "pure" IBNR, i.e., IBNR for claims that have occurred but that haven't yet been reported to the Company. IBNR is typically only established to the extent that on a monthly basis, there are lags in information reported from the lender to the MI company[6].

Because information reported from the lender to the MI company is usually provided on a timely basis, the IBNR provision is a small portion of the overall loss reserve balance. The majority of the loss reserve is made up of unpaid claim estimates for loans where the borrower has been identified as being delinquent in his loan payment. This paper will focus on preparing unpaid claim estimates

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[3] Contrast this with a normal P&C insurance contract, such as an auto insurance policy. For an auto insurance policy, premium revenue is recognized uniformly over the one year contract period and losses generally occur and are recognized evenly over the life of the contract. For auto insurance policies, there is a matching of premium (revenue) and loss (expense).

[4] This description is generally accurate, although there are exceptions such as property catastrophe cover where premium and loss might not be recognized uniformly.

[5] Although not included in the scope of this paper, MI Companies must also examine whether a premium deficiency exists. A premium deficiency reserve should be established by a MI company when the sum of future incurred losses and policy expenses exceed future premium revenue.

[6] Recently, some MI Companies have added an additional component to the IBNR provision accounting for the potential reinstatement of claim denials or policy rescissions, although those items are beyond the scope of this paper.

for known delinquent loans.

2.4 Terminology and Organization of Data

Before providing a framework for estimating MI unpaid claim liabilities, it is important to introduce several additional terms as well as to lay out the key characteristics used to organize the data.

2.4.1 Terminology

Although the terminology below is not necessarily universal, it is used throughout the remainder of this paper and practitioners familiar with MI will understand it.

- Outstanding delinquency: A loan reported to the MI company when the borrower has fallen two mortgage payments behind (note, there is some variance about when a loan is identified as delinquent in the MI industry, here we are assuming the MI company has set the definition as be borrower being behind two or more payments).
- Delinquency report quarter: The quarter in which a MI is first notified that a borrower is two or more payments behind. (As noted in 2.4.2 below, a loan can become delinquent multiple times over its life; therefore, a single loan can appear in several delinquency report quarters.)
- Cured delinquency: A previously delinquent loan where the borrower has made previous missed payments and is no longer considered delinquent.
- Submitted claim: A delinquent loan where the borrower has not made mortgage payments, the lending institution has foreclosed on the subject property, and a claim has been submitted to the MI company.
- Risk in force ("RIF"): This is the exposure to loss faced by MI Companies. The RIF is calculated by multiplying the MI's coverage percentage by the loan's UPB. As noted above, in addition to the coverage percentage multiplied by the UPB, the MI company may also be required to pay lost interest and certain foreclosure expenses; for this reason, the ratio of claim payments to RIF may be greater than 100%.

2.4.2 Data organization

As in any actuarial analysis, data organization is a critical component of the analysis and must be carefully considered prior to the actuary preparing the reserve analysis. For purposes of the method described in Section 3, the data is organized by delinquency report quarter, with quarterly evaluations of the data (actuaries will be familiar with the "triangular" arrangement of the data used in the analysis)[7].

The actuary must consider how best to segment the data for use in the methods described in Section 3. Although the factors that drive MI claim behavior differ from those that P&C actuaries typically encounter when determining the optimal data segmentation for use in preparing unpaid claim estimates, the primary goal of the actuary remains the same: select the data segmentation that gives the optimal balance of homogeneity and credibility. The actuary may consider the following items (among others) when selecting appropriate data segmentation[8]:

- Foreclosure laws: Each state has its own set of laws governing the foreclosure process. These state-specific laws can generate significant differences in the length of time between delinquency notification and the foreclosure and eventual MI claims.
- Unemployment: The level of unemployment can have a significant impact on the likelihood that delinquent borrowers transition to foreclosure and ultimately become MI claims. A severe downturn in employment in a single area may have a dramatic impact on claims experience and should be considered by the actuary in developing MI unpaid claim estimates.
- Creditworthiness of borrowers: The creditworthiness of borrowers can be a significant predictor in determining borrower behavior. FICO score[9] or distinguishing between Prime and Subprime loans in developing estimates can result in better data stratification.
- Home price appreciation or depreciation: As evidenced by the housing market bubble and subsequent home price deflation of 2005-2008, borrower behavior can be significantly

[7] As described previously, some loans may become delinquent and cure numerous times before rolling to a claim. In the MI framework described in this paper, each new delinquency notification is treated as a separate event. Therefore, a single loan could appear in our reported delinquent loan population in several report quarters.
[8] For a more thorough discussion of data segmentation, please see reference [2] at the end of this paper.
[9] FICO is a common credit scoring mechanism developed originally by the Fair Isaac Corporation. The FICO score is a numerical representation of the credit worthiness of a borrower based on the evaluation of five key pieces of information [3].

impacted by home price appreciation or depreciation. During the height of the housing market bubble around 2005, MI claim experience was very favorable and relatively few reported delinquencies resulted in claims. After the bubble began deflating in 2006 and 2007, cure rates dropped significantly as "underwater" borrowers (i.e., those who owed more principal on their loan than the house's market value) were often unable to sell their home if they were unable to pay their mortgage, and in some cases made a conscious decision to walk away from their mortgage and home. The significant downturn in home prices and decreases in cure rates resulted in elevated MI claims.

During the recent housing market downturn, MI Companies observed elevated MI claim submissions from states that had significant increases in home prices prior to the housing market downturn followed by significantly elevated unemployment levels resulting from the subsequent recession. For this reason, during the last market downturn, it was beneficial to separately analyze California, Florida, and Nevada; these states were particularly hard hit by the combination of a significant housing market collapse and elevated unemployment and displayed similar claim characteristics.

3. DETERMINISTIC FRAMEWORK FOR MI

As described in the previous section, MI claim payments arise from loans that the loan servicer reports as delinquent. Because the MI accounting framework described in this paper has very little "pure" IBNR, we do not need to estimate unreported claims, rather we need to project the probability that a delinquent loan will become a claim (or conversely, that the delinquent loan will cure). The MI claims process and accounting framework gives rise to the fundamental relationship we will utilize to develop our deterministic framework:

Estimated Unpaid Claims = N x F x S, where

- N is the number of reported delinquent loans;
- F is the probability that a delinquent loan will ultimately result in a foreclosure, triggering a claim (also referred to as the "claim rate"); and
- S is the (average) amount or severity of each claim.

In the formula above, N is an amount that is known with certainty. Methods for estimating F and S are described in the sections below and the methodology is outlined in the Appendix file,

which is available on the CAS website.

3.1 Estimating the Claim Rate

To estimate the claim rate, we utilize triangular claim development methods that will be familiar to actuaries. The key to utilizing claim development methods is to recognize several important aspects of the MI claims process:

- As described above, the data utilized will be organized by the quarter in which the delinquent loan first becomes an outstanding delinquency; organizing data in this way means that we do not need to include a provision for IBNR claims in our analysis beyond the potential for delinquencies in transit. The number of loans reported in a quarter will be a certain, fixed number.
- The number of remaining outstanding delinquent loans in subsequent evaluation quarters will decrease to zero as loans resolve (cure or become a claim) over time. Further, at some future date, all reported delinquent loans must either cure or become a claim.

3.1.1 Claim Rate Methodology

Developing the claim rate using the methodology described in this paper is a three step process:

1. First, we evaluate the decline in outstanding delinquencies over time as these resolve by either curing or becoming claims by reviewing an outstanding delinquency decay pattern ("decay pattern"). The decay pattern is developed by calculating ratios of delinquent loans at each evaluation period, i+1, divided by the delinquent loans at the preceding evaluation period, i. The triangle of outstanding delinquent loans compiled based on the delinquent loan data is completed by selecting a decay factor for each evaluation period and then applying the selected decay factor at each period to the outstanding delinquent loans observed (or projected) at the end of the prior evaluation period. Performing these calculations allows the actuary to estimate the number of delinquent loans that remain open at each future period and also to estimate the number of delinquent loans that resolve during each future period.

   As an example, on Exhibit 3-4 of the Appendix file, there are 1,037 loans reported delinquent during the third quarter of 2012 that remain outstanding at the end of the third quarter of 2012 (note, some loans that are reported delinquent during the third

quarter will cure or become claims by then end of the quarter). One quarter later, 249 of these loans have either cured or become claims leaving 788 delinquent loans at the end of the fourth quarter of 2012. We calculate the delinquent loan decay rate as 788 / 1,037 = 76%. We can use this calculated decay ratio to project that 823 loans will remain outstanding as of March 31, 2013 from the cohort of 1,083 loans delinquent loans reported during the fourth quarter of 2012 (823 = 1,083 * 76%). Performing similar calculations across all evaluation ages and delinquency periods allows us to project future outstanding delinquent loans and develop the item labeled "RESULT 3-4".

It is important to note that, in the provided exhibits, the selected decay rate is based on the latest period observation to make the discussion in this text easier to follow. In practice, it may be more appropriate to select longer (perhaps 4) period averages to smooth out seasonality that is often present in mortgage insurance data.

2. The second step of the procedure involves projecting period to period claims and cured delinquencies given the projected number of resolved claims calculated in item (1). In order to prepare these estimates, we review the historical delinquent loan data set to determine the number of the delinquent loans that resulted in a claim or cured delinquency each quarter from the total population of delinquent loans that resolved during the quarter.

   Continuing the example above, for the delinquent loans reported during the fourth quarter of 2012, we have projected that 260 loans will resolve (260 = 1,083 – 823). The next step of the procedure requires that we estimate the portion of the 260 resolved loans that cure and the portion that become claims.

   Again, we can utilize the data from prior delinquency report periods to guide our selection of the conditional claim and cure probabilities (the condition being that the delinquent loans have resolved during the evaluation period). For delinquent loans reported during the third quarter of 2012, we note that 249 loans resolved between September 30, 2012 and December 31, 2012; the 249 resolution consisted of 225 cured delinquencies (= 483 – 258) and 24 claims (= 25 – 1). We can utilize this data to calculate the number of projected cured delinquencies and the number of claims for the cohort of delinquent loans reported during the fourth quarter of 2012 as follows:

   - Projected cured delinquencies = 260 * 225 / 249 = 235 projected incremental

cures;

- Projected claims = 260 * 24 / 249 = 25 projected incremental claims.

Adding the number of previous cures and claims yields the cumulative number of cures and claims at subsequent evaluation dates. Performing similar calculations across the entire triangle allows us to project the ultimate number of cured delinquent loans and claims. Result 3-3 and Result 3-2 of the corresponding exhibits of the Appendix outline these calculations.

3. Although the example in the Appendix does not require it, the actuary should perform a check to ensure that the sum of the projected cured delinquent loans plus the projected claims is equal to the number of initial reported delinquent loans (again, all loans must either cure or become a claim). Exhibit 3 – 1 shows an example of formulas that can be used to rebalance the projected cures and claims in order to match the initial reported delinquent loans.

Exhibit 3 – 1 presents the results of our claim count analysis. Over the projection period, we estimate that approximately 35% of all reported delinquencies will result in claims and 65% of delinquent loans will cure.

It is important to point out that the data set in this example is simplified in several ways: the resolution process occurs relatively quickly (over a period of 8 quarters); there is a relatively smooth relationship over time – the likelihood that a loan will become a claim increases over the data observation period; and the decay and conditional claim rates are relatively stable over time. With real data, the relationships may not be as obvious and the projections would not be as straightforward.

3.1.2 Benefits and limitations of the claim rate methodology

The claim rate methodology should have an appeal for actuaries since the triangular arrangement of the data is familiar to all actuaries and the mechanics of the model are intuitive and straightforward. The methodology is also appealing because in many ways it is easier to describe and demonstrate to a non-actuarial audience than methods that require an understanding of statistical concepts (e.g., regression). Such statistical based methods are often referred to as "black box" methods because the inputs and outputs of the model are easy to describe, but the actual model mechanics are difficult to describe and demonstrate; the model described above does not have this limitation.

The key limitations of the deterministic framework are:

- Using aggregate data does not allow the actuary to explicitly determine the factors that are most correlated with claim behavior. Using regression methods may allow the actuary to determine that unemployment is the most important factor in determining delinquent loan behavior and other factors (e.g., borrower credit score) are less important. Although the actuary can visually inspect the data to see which factors appear to be most critical, statistical data analytics and regression models can allow the actuary to more quickly determine the parameters most closely associated with claim behavior.
- The model does not allow for explicit sensitivity testing of the results to changes in key macroeconomic factors. For example, if the MI company is concerned about the effect of an increase in unemployment on the Company's estimates, the effect cannot be explicitly incorporated into the framework. Conversely, regression models can be developed that utilize unemployment as an explanatory variable, which allows the actuary to quickly develop alternative estimates assuming different future unemployment paths.

3.1.3 Additional observations regarding the delinquency count data

Although the data presented in the example is simulated, it does share many similarities with real mortgage insurance data. Several of the more critical caveats regarding this sample data set are outlined below:

- Delinquencies are much more likely to cure at early maturities than at late maturities. Conversely, the likelihood that a delinquent loan will become claims increases the longer the loan stays delinquent.

  Very few delinquent loans become claims at early maturities limiting the usefulness of claim data at early maturities. For this reason, it is important to monitor the cured delinquency data in addition to the claim data. A significant decrease in the number of cured delinquencies at early maturities can be a signal that results are deteriorating. For example, at the beginning of the housing market collapse of the last decade, not only did the number of delinquent loans increase dramatically, but the number of cured delinquencies at early maturities fell substantially, which was an early indicator that there were significant issues emerging in the housing sector. Monitoring the behavior of claims and cured delinquencies (particularly at early maturities) may give the actuary performing the analysis an early indication that results are deteriorating significantly.

- A limitation of organizing the data in the way this paper describes is that the data does not explicitly capture the number of payments borrowers may miss. Suppose Borrower A misses a mortgage payment one month but then begins paying his mortgage again the following month; Borrower B loses his job, misses a mortgage payment and, due to economic hardship, is unlikely to ever make a mortgage payment again. While the second borrower is certainly more likely to result in an MI claim than the first, both borrowers will appear in the same evaluation points of the outstanding delinquency triangle.

  Given this limitation, it is important that the actuary recognize that the way this paper organizes data may mask some important underlying dynamics – some borrowers fall behind and will never catch up, and some borrowers fall behind for a short time but will continue making loan payments. The actuary should consider examining the data in more detail in order to understand not just how long loans have been delinquent but also how many payments the borrowers have missed and in particular, whether any shifts in the historical data set have occurred.

- It is possible that the actuary examining real data would face a situation where the delinquent loan population was not entirely resolved at the end of the projection period; when facing a lack of data regarding behavior of older loans, the actuary might consider aggregating the data for "late stage" delinquent loans, observing their claim behavior, and selecting a tail claim rate for all loans classified as late stage delinquencies.

- Sometimes after foreclosure and claim submission, the insurance policy giving rise to the claim may be reviewed by the MI company's claims adjusters to confirm that the original loan conformed to the Company's underwriting guidelines and that the proper documentation supporting the claim submission was provided. If it is determined that the original policy did not meet the MI company's underwriting standards, then the original MI policy might be rescinded (cancelled) with a return of the collected policy premium[10]. If a claim is submitted without the proper documentation supporting the submitted claims, then the claim may be denied. Policy rescissions and claim denials need to be considered in the evaluation process either through frequency or severity based on

[10] Generally, MI policies are not underwritten by the MI company at the time the policy is issued. Rather, MI Companies give lending institutions underwriting guidelines that they are required to follow. At the time of claim submission, MI Companies generally have the right to review the original loan documentation in order to ensure the loan conformed to the MI company underwriting guidelines.

historical pattern. Historically, rescissions and denials were not significant, although they have been significant through the housing market downturn.

3.2 Estimating Claim Severity

Estimating severity for MI claims is generally more straightforward and often more predictable than estimating claim behavior. The exposure to loss from individual claim submissions is simply a combination of

a) RIF;

b) a provision for lost interest payment and certain foreclosure expenses; and

c) "Subrogation" in cases where the foreclosed property is sold for a profit, which benefits the MI company.

Item (a) can be derived directly from the outstanding delinquent loan population since the MI company has information regarding the risk associated with delinquent loans. Items (b) and (c) can be estimated by examining the ratio of claim payments to the RIF on submitted claims. For example, if the actuary examines the loss data and determines that on average, $1 of RIF translates into $1.05 of paid loss, then the actuary can estimate the size of future claim payments by multiplying the average RIF on outstanding delinquencies by 1.05.

This method for estimating severity has a key advantage in its simplicity; however it can also have limitations to the extent that the underlying claim dynamics are shifting over time. For example, if the actuary chooses to organize the data used in the analysis by credit score, the data segmentation might mask the fact that a larger portion of recent claim emergence is arising from geographies with higher average cost. More importantly, if claims are more likely to arise from loans with higher than average RIF, then using average RIF on outstanding delinquent loans might understate future claim severity. The actuary should investigate whether the average paid claim has increased or decreased over the observation period and whether the geographic distribution of paid claims has shifted over time.

Exhibit 2 of the Appendix outlines an example of the severity method above. Exhibit 2-2 displays the ratio of observed paid losses to RIF on submitted claims arranged by calendar quarter. Based on the historical data in Exhibit 2-2, we can estimate that for every $1 of RIF, the MI company has paid $1.049 of claims. Exhibit 2-1 shows the calculation of the selected severity, which is developed by multiplying the average RIF on outstanding delinquencies by 1.049. Exhibit 2-2 also

provides a calculation of the average severity on ultimate claims by weighting together the estimated claim severity on outstanding delinquencies with the observed average paid claims on previously submitted claims.

3.3 Unpaid Claim Estimate

The unpaid claim estimate is calculated by multiplying the outstanding claim estimates described in section 3.1 by the severity estimates described in section 3.2. The unpaid claim estimate prepared using our sample data set is shown in Exhibit 1 of the Appendix.

4. CONCLUSIONS

The actuary who prepares unpaid claims estimates for MI must understand the unique accounting for MI losses, given that there is typically very little provision for "pure" IBNR claims and that losses are recorded only when the MI company receives notification of a loan delinquency. Although the accounting for MI differs from traditional P&C insurance products, deterministic triangular methods commonly used to develop estimates for P&C products can help actuaries project delinquent loan behavior. After the actuary has a strong grasp of MI data, accounting model and claim behavior, more complex regression or generalized linear model procedure (for example, see reference [4] below) can be utilized to further refine and enhance MI unpaid claim estimates.

Acknowledgment

The author would like to thank Marc Oberholtzer, Eric Trowbridge, Lynne Bloom, Vladimir Shander and Ernest Wilson for their valuable comments, suggestions and edits to this paper. The author would also like to thank Andrew Harder for his assistance in preparing the Supplementary Material available on the CAS website.

Supplementary Material

The Appendix to this paper is available electronically at the CAS website at http://www.casact.org/pubs/forum/13fforum/. The dataset provided within the Appendix was simulated using constraints generally consistent with the author's knowledge of MI claim behavior.

5. REFERENCES

[1] http://portal.hud.gov/hudportal/HUD?src=/program_offices/housing/fhahistory
[2] Havlicek, Tanya, and Kyle Mrotek, "Data Organization and Analysis in Mortgage Insurance: The Implication of Dynamic Risk Characteristics", *Casualty Actuarial Society Forum*, Winter 2008, 71-89.
[3] http://credit.about.com/od/df/g/ficoscore.htm
[4] Taylor, Greg and Peter Mulquiney, "Modeling Mortgage Insurance as a Multistate Process", Variance 1:1, 2007, pp. 81-102.

Abbreviations and notations

GSE, government sponsored entity
IBNR, incurred but not reported
LTV, loan to value ratio
MI, mortgage insurance
RIF, risk in force
UPB, unpaid principal balance

Biography of the Author

David Kaye is a Director at PwC in Philadelphia, PA. He has a B.S. in Mathematics and a B.S. in Statistics from the Pennsylvania State University. He is a Fellow of the CAS and a Member of the American Academy of Actuaries. David participates on the CAS examination committee and the Committee on Professionalism Education.

Estimated Ultimate Loss and Unpaid Claim Estimate

Exhibit 1

Delq Report Date Year-Qtr	(1) Submitted Claims (A)	(2) Actual Paid Losses (A)	(3) Reported Severity (2)/(1)	(4) Ultimate Claims (B)	(5) Outstanding Claims (4)-(1)	(6) Indicated Ultimate Severity (C)	(7) Severity on Outstanding Claims (9)/(5)	(8) Ultimate Loss (4)*(6)	(9) Indicated Unpaid Claim Estimate (8)-(2)
2011-1	476	20,390,362	42,837	476	0	42,837	0	20,390,362	0
2011-2	454	18,888,106	41,604	462	8	41,609	41,933	19,223,571	335,466
2011-3	389	16,533,738	42,503	412	23	42,493	42,314	17,500,913	967,175
2011-4	381	16,079,727	42,204	467	86	42,150	41,911	19,669,762	3,590,034
2012-1	200	8,445,125	42,226	440	240	43,232	44,072	19,005,409	10,560,284
2012-2	89	3,729,843	41,908	417	328	42,699	42,914	17,801,705	14,071,862
2012-3	25	1,059,885	42,395	424	399	44,140	44,249	18,711,208	17,651,323
2012-4	1	42,932	42,932	443	442	43,045	43,045	19,054,559	19,011,627
Total	2,015	85,169,718	42,268	3,540	1,525	42,761	43,413	151,357,488	66,187,770

Notes
(A) Data provided by the MI Company
(B) From Exhibit 3, Page 1
(C) From Exhibit 2, Page 1

Selected Ultimate Severity

Exhibit 2
Sheet 1

Delq Report Date Year-Qtr	(1) Open Delqs (A)	(2) RIF on Delqs (A)	(3) Average RIF on Open Delqs (2)/(1)*1000	(4) Paid to RIF Ratio (C)	(5) Projected Avg. Paid on Open Delqs (3)*(4)	(6) Outstanding Claims (B)	(7) Estimated Paid on Future Claims (000s) (5)*(6)/1000	(8) Actual Paid Loss (000s) (A)	(9) Indicated Ult. Loss (000s) (7)+(8)	(10) Ultimate Claims (B)	(11) Indicated Ultimate Severity (9)/(10)*1000
2011-1	0	0	0	104.9%	0	0	0	20,390,362	20,390,362	476	42,837
2011-2	8	319,864	39,983,000	104.9%	41,933,201	8	335,466	18,888,106	19,223,571	462	41,609
2011-3	25	1,008,650	40,346,000	104.9%	42,313,907	23	967,175	16,533,738	17,500,913	412	42,493
2011-4	103	4,116,086	39,962,000	104.9%	41,911,177	86	3,590,034	16,079,727	19,669,762	467	42,150
2012-1	328	13,783,216	42,022,000	104.9%	44,071,655	240	10,560,284	8,445,125	19,005,409	440	43,232
2012-2	536	21,932,048	40,918,000	104.9%	42,913,807	328	14,071,862	3,729,843	17,801,705	417	42,699
2012-3	788	33,246,508	42,191,000	104.9%	44,248,898	399	17,651,323	1,059,885	18,711,208	424	44,140
2012-4	1,083	44,449,569	41,043,000	104.9%	43,044,904	442	19,011,627	42,932	19,054,559	443	43,045
Total	2,871	118,855,941	41,398,795			1,525	66,187,770	85,169,718	151,357,488	3,540	42,761

Notes
(A) Data provided by the MI Company
(B) From Exhibit 3, Summary
(C) From Exhibit 2, Page 2

Selected Paid to RIF Ratio

Exhibit 2
Sheet 2

Delq Report Date Year-Qtr	(1) Paid Loss (000s) (A)	(2) RIF on Submitted Claims (000s) (A)	(3) Paid Loss per RIF on Submitted Claims (1)/(2)	(4) 4 Qtr. Weighted Average
2011-1	20,390,362	19,577,880	104.2%	
2011-2	18,888,106	17,942,534	105.3%	
2011-3	16,533,738	15,580,228	106.1%	
2011-4	16,079,727	15,372,588	104.6%	104.99%
2012-1	8,445,125	8,125,000	103.9%	105.13%
2012-2	3,729,843	3,556,974	104.9%	105.05%
2012-3	1,059,885	1,012,500	104.7%	104.44%
2012-4	42,932	40,997	104.7%	104.26%
Total	85,169,718	81,208,701	104.9%	
	Selected Future Paid to RIF Ratio		104.9%	

Notes
(A) Data provided by the MI Company

Claim Summary

Exhibit 3
Summary

Delq Report Date Year-Qtr	(1) Reported Delqs (A)	(2) Reported Cured Delqs (A)	(3) Submitted Claims (A)	(4) Outstanding Delqs (A)	(5) Ultimate Claims (B)	(6) Outstanding Claims (5)-(3)	(7) Outstanding Claims to O/s Delqs (6)/(4)	(8) Estimated Claims to Reptd Delqs (5)/(1)
2011-1	1,335	859	476	0	476	0		35.66%
2011-2	1,309	847	454	8	462	8	100.00%	35.29%
2011-3	1,222	808	389	25	412	23	91.43%	33.70%
2011-4	1,357	873	381	103	467	86	83.16%	34.39%
2012-1	1,213	685	200	328	440	240	73.05%	36.24%
2012-2	1,216	591	89	536	417	328	61.18%	34.29%
2012-3	1,296	483	25	788	424	399	50.62%	32.71%
2012-4	1,337	253	1	1,083	443	442	40.78%	33.11%
Total	10,285	5,399	2,015	2,871	3,540	1,525	53.10%	34.42%

Notes
(A) Data provided by the MI Company
(B) From Exhibit 3, Sheet 1

Projected Claims
Data organized by delinquency report date and evaluation quarter

Exhibit 3
Sheet 1

Delq Report Date Year-Qtr	(1) Indicated Cured Delqs (A)	(2) Indicated Claims (B)	(3) Indicated Reported Delqs (1)+(2)	(4) Initial Projected Claims to Reported (2)/(3)	(5) Actual Reported Delqs (C)	(6) Additional Delqs (5)-(3)	(7) Additional Cured Delqs [1-(4)]*(6)	(8) Additional Claims (4)*(6)	(9) Indicated Cured Delqs (1)+(7)	(10) Indicated Ultimate Claims (2)+(8)
2011-1	859	476	1,335	35.66%	1,335	0	0	0	859	476
2011-2	847	462	1,309	35.29%	1,309	0	0	0	847	462
2011-3	810	412	1,222	33.70%	1,222	0	0	0	810	412
2011-4	890	467	1,357	34.39%	1,357	0	0	0	890	467
2012-1	773	440	1,213	36.24%	1,213	0	0	0	773	440
2012-2	799	417	1,216	34.29%	1,216	0	0	0	799	417
2012-3	872	424	1,296	32.71%	1,296	0	0	0	872	424
2012-4	894	443	1,337	33.11%	1,337	0	0	0	894	443
Total	6,745	3,540	10,285	34.42%	10,285	0	0	0	6,745	3,540

Notes
(A) From Exhibit 3, Sheet 3
(B) From Exhibit 3, Sheet 2
(C) Data provided by the MI Company

Projected Claims
Data organized by delinquency report date and evaluation quarter

Exhibit 3
Sheet 2

Submitted Claims

	1	2	3	4	5	6	7	8
2011-1	1	20	93	230	366	439	467	476
2011-2	0	20	83	218	353	430	454	
2011-3	0	18	89	218	342	389		
2011-4	1	25	95	238	381			
2012-1	0	16	75	200				
2012-2	0	18	89					
2012-3	1	25						
2012-4	1							

Incremental Claim Rate (Incremental Submitted Claims / Prior O/s Delinquent Loans)

	2/1	3/2	4/3	5/4	6/5	7/6	8/7
2011-1	1.78%	8.33%	21.71%	41.46%	55.73%	68.29%	100.00%
2011-2	1.91%	7.52%	22.09%	41.67%	59.23%	68.57%	
2011-3	1.87%	8.98%	23.63%	47.33%	55.95%		
2011-4	2.18%	8.06%	22.88%	45.69%			
2012-1	1.67%	7.42%	20.97%				
2012-2	1.87%	9.01%					
2012-3	2.31%						
2012-4							
4 Qtr Avg.	2.01%	8.37%	22.39%	44.04%	N/a	N/a	N/a
Latest point	2.31%	9.01%	20.97%	45.69%	55.95%	68.57%	100.00%
Selected	2.31%	9.01%	20.97%	45.69%	55.95%	68.57%	100.00%

RESULT 3-2: Actual and Projected Claims (Bold is Projected)

	1	2	3	4	5	6	7	8	Ultimate
2011-1	1	20	93	230	366	439	467	476	**476**
2011-2	0	20	83	218	353	430	454	**462**	**462**
2011-3	0	18	89	218	342	389	**406**	**412**	**412**
2011-4	1	25	95	238	381	**439**	**460**	**467**	**467**
2012-1	0	16	75	200	**350**	**410**	**432**	**440**	**440**
2012-2	0	18	89	**201**	**336**	**390**	**410**	**417**	**417**
2012-3	1	25	**96**	**208**	**343**	**397**	**417**	**424**	**424**
2012-4	1	**26**	**100**	**218**	**358**	**415**	**436**	**443**	**443**

Projected Cured Delinquent Loans
Data organized by delinquency report date and evaluation quarter

Exhibit 3
Sheet 3

Cured delinquent loans

	1	2	3	4	5	6	7	8
2011-1	266	439	611	777	838	855	859	859
2011-2	262	451	615	767	826	844	847	
2011-3	257	413	587	742	796	808		
2011-4	257	464	637	806	873			
2012-1	255	402	542	685				
2012-2	255	410	591					
2012-3	258	483						
2012-4	253							

Incremental Cured Rate (Incremental Cured delinquent loans / Prior O/s delinquent loans)

	2/1	3/2	4/3	5/4	6/5	7/6	8/7
2011-1	16.20%	19.63%	26.31%	18.60%	12.98%	9.76%	0.00%
2011-2	18.05%	19.57%	24.88%	18.21%	13.85%	8.57%	
2011-3	16.17%	22.00%	28.39%	20.61%	14.29%		
2011-4	18.84%	19.93%	27.04%	21.41%			
2012-1	15.34%	17.61%	23.99%				
2012-2	16.13%	22.97%					
2012-3	21.70%						
2012-4							
4 Qtr Avg.	18.00%	20.63%	26.07%	19.71%	N/a	N/a	N/a
Latest point	21.70%	22.97%	23.99%	21.41%	14.29%	8.57%	0.00%
Selected	21.70%	22.97%	23.99%	21.41%	14.29%	8.57%	0.00%

RESULT 3-3: Actual and Projected Cured delinquent loans (Bold is Projected)

	1	2	3	4	5	6	7	8	Ultimate
2011-1	266	439	611	777	838	855	859	859	**859**
2011-2	262	451	615	767	826	844	847	**847**	**847**
2011-3	257	413	587	742	796	808	**810**	**810**	**810**
2011-4	257	464	637	806	873	**888**	**890**	**890**	**890**
2012-1	255	402	542	685	**755**	**771**	**773**	**773**	**773**
2012-2	255	410	591	**720**	**783**	**797**	**799**	**799**	**799**
2012-3	258	483	**664**	**793**	**856**	**870**	**872**	**872**	**872**
2012-4	253	**488**	**677**	**811**	**877**	**892**	**894**	**894**	**894**

Projected Outstanding Delinquent Loans — Exhibit 3
Data organized by delinquency report date and evaluation quarter — Sheet 4

Outstanding Delinquent Loans

	1	2	3	4	5	6	7	8
2011-1	1,068	876	631	328	131	41	9	0
2011-2	1,047	838	611	324	130	35	8	
2011-3	965	791	546	262	84	25		
2011-4	1,099	868	625	313	103			
2012-1	958	795	596	328				
2012-2	961	788	536					
2012-3	1,037	788						
2012-4	1,083							

Outstanding Delinquent Loan Decay Rate

	2/1	3/2	4/3	5/4	6/5	7/6	8/7
2011-1	82.02%	72.03%	51.98%	39.94%	31.30%	21.95%	0.00%
2011-2	80.04%	72.91%	53.03%	40.12%	26.92%	22.86%	
2011-3	81.97%	69.03%	47.99%	32.06%	29.76%		
2011-4	78.98%	72.00%	50.08%	32.91%			
2012-1	82.99%	74.97%	55.03%				
2012-2	82.00%	68.02%					
2012-3	75.99%						
2012-4							
4 Qtr Avg.	79.99%	71.01%	51.53%	36.26%	N/a	N/a	N/a
Latest point	75.99%	68.02%	55.03%	32.91%	29.76%	22.86%	0.00%
Selected	75.99%	68.02%	55.03%	32.91%	29.76%	22.86%	0.00%

RESULT 3-4: Actual and Projected Outstanding Delinquent Loans

	1	2	3	4	5	6	7	8
2011-1	1,068	876	631	328	131	41	9	0
2011-2	1,047	838	611	324	130	35	8	0
2011-3	965	791	546	262	84	25	6	0
2011-4	1,099	868	625	313	103	31	7	0
2012-1	958	795	596	328	108	32	7	0
2012-2	961	788	536	295	97	29	7	0
2012-3	1,037	788	536	295	97	29	7	0
2012-4	1,083	823	560	308	101	30	7	0

O/s RIF

	2011-1	2011-2	2011-3	2011-4	2012-1	2012-2	2012-3	2012-4	Latest Diagonal
2011-1	42,524,556	34,043,112	25,307,517	13,366,000	5,321,875	1,634,055	361,746	0	0
2011-2	43,013,901	32,878,930	23,910,874	12,961,296	5,178,160	1,412,110	319,864		319,864
2011-3	40,010,830	31,768,142	21,973,770	10,886,362	3,430,392	1,008,650			1,008,650
2011-4	43,743,497	35,023,800	26,166,875	12,471,485	4,116,086				4,116,086
2012-1	39,893,994	33,002,835	24,679,168	13,783,216					13,783,216
2012-2	39,293,368	31,551,520	21,932,048						21,932,048
2012-3	43,442,004	33,246,508							33,246,508
2012-4	44,449,569								44,449,569

RIF on Claims

	2011-1	2011-2	2011-3	2011-4	2012-1	2012-2	2012-3	2012-4	Latest Diagonal
2011-1	39,327	776,400	3,711,444	9,113,290	14,832,150	17,109,586	18,306,867	19,577,880	19,577,880
2011-2	0	823,920	3,311,202	8,649,368	14,271,084	16,868,900	17,942,534		17,942,534
2011-3	0	724,230	3,499,035	8,835,104	13,882,122	15,580,228			15,580,228
2011-4	39,365	1,034,275	3,763,995	9,797,508	15,372,588				15,372,588
2012-1	0	636,288	3,143,025	8,125,000					8,125,000
2012-2	0	759,060	3,556,974						3,556,974
2012-3	41,013	1,012,500							1,012,500
2012-4	40,997								40,997

Paid

	2011-1	2011-2	2011-3	2011-4	2012-1	2012-2	2012-3	2012-4	Latest Diagonal
2011-1	40,900	807,223	3,857,304	9,633,659	15,677,583	17,852,142	19,192,919	20,390,362	20,390,362
2011-2	0	860,832	3,479,080	8,987,558	14,910,429	17,661,738	18,888,106		18,888,106
2011-3	0	753,706	3,647,044	9,179,673	14,544,299	16,533,738			16,533,738
2011-4	41,176	1,081,438	3,981,930	10,404,953	16,079,727				16,079,727
2012-1	0	673,638	3,279,118	8,445,125					8,445,125
2012-2	0	792,231	3,729,843						3,729,843
2012-3	42,621	1,059,885							1,059,885
2012-4	42,932								42,932

Outstanding Delinquent Loans

	2011-1	2011-2	2011-3	2011-4	2012-1	2012-2	2012-3	2012-4	Latest Diagonal
2011-1	1,068	876	631	328	131	41	9	0	0
2011-2	1,047	838	611	324	130	35	8		8
2011-3	965	791	546	262	84	25			25
2011-4	1,099	868	625	313	103				103
2012-1	958	795	596	328					328
2012-2	961	788	536						536
2012-3	1,037	788							788
2012-4	1,083								1,083

Submitted Claims

	2011-1	2011-2	2011-3	2011-4	2012-1	2012-2	2012-3	2012-4	Latest Diagonal
2011-1	1	20	93	230	366	439	467	476	476
2011-2	0	20	83	218	353	430	454		454
2011-3	0	18	89	218	342	389			389
2011-4	1	25	95	238	381				381
2012-1	0	16	75	200					200
2012-2	0	18	89						89
2012-3	1	25							25
2012-4	1								1

Reported Delinquent Loans

	2011-1	2011-2	2011-3	2011-4	2012-1	2012-2	2012-3	2012-4
2011-1	**1,335**	1,335	1,335	1,335	1,335	1,335	1,335	1,335
2011-2	**1,309**	1,309	1,309	1,309	1,309	1,309	1,309	1,309
2011-3	**1,222**	1,222	1,222	1,222	1,222	1,222	1,222	1,222
2011-4	**1,357**	1,357	1,357	1,357	1,357	1,357	1,357	1,357
2012-1	**1,213**	1,213	1,213	1,213	1,213	1,213	1,213	1,213
2012-2	**1,216**	1,216	1,216	1,216	1,216	1,216	1,216	1,216
2012-3	**1,296**	1,296	1,296	1,296	1,296	1,296	1,296	1,296
2012-4	**1,337**	1,337	1,337	1,337	1,337	1,337	1,337	1,337

Cured Delinquent Loans

	2011-1	2011-2	2011-3	2011-4	2012-1	2012-2	2012-3	2012-4	Latest Diagonal
2011-1	266	439	611	777	838	855	859	859	859
2011-2	262	451	615	767	826	844	847		847
2011-3	257	413	587	742	796	808			808
2011-4	257	464	637	806	873				873
2012-1	255	402	542	685					685
2012-2	255	410	591						591
2012-3	258	483							483
2012-4	253								253