# RMBS Performance Profile
*Stochastic Simulation Analysis*

RANGEMARK

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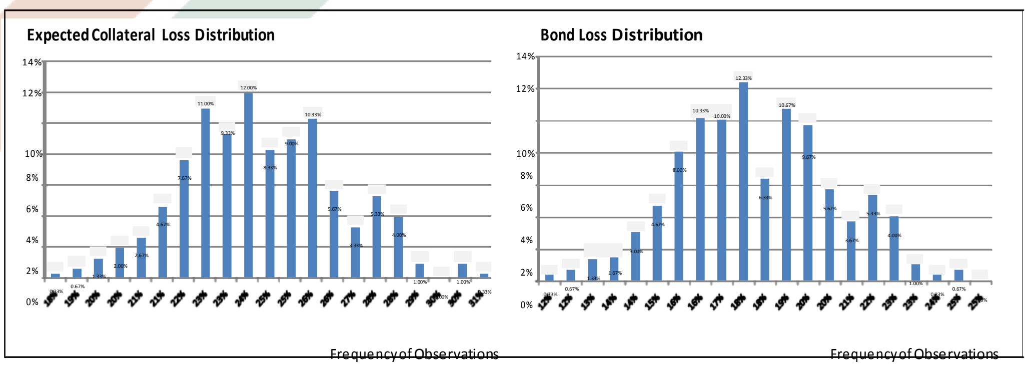
Mortgages and mortgage-backed securities have both embedded credit and prepayment options. Performance and risk are linked to the value such options represent to underlying obligors, and their value is a function of certain macro and regional economic and demographic factors: *key drivers*. Key drivers, such as GDP growth, interest rates, home prices, housing and loan options and affordability affect borrower behavior through their impact on homeowners' employment, income, monthly payments, and obligor-specific current loan-to-value. These factors not only affect the propensity of an obligor to become delinquent or default, but also the level of recovery upon foreclosure.

## RANGEMARK MORTGAGE CREDIT MODEL

The RangeMark Mortgage Credit Model is a discrete choice model that relates loan and borrower properties with key drivers proven to be statistically significant. It is a system of several integrated modules designed to predict highly interrelated: 1) borrower decisions (whole or partial prepayment, continue scheduled payments, cease payments), 2) subsequent lender action, and 3) the timing and amount of proceeds from the liquidation of foreclosed homes. Parameters were determined using Maximum Likelihood estimation. The mathematical relationships describing obligor performance and lender behavior – delinquencies, defaults, severity, prepayments, foreclosure, repossession and loss – are integrated with projections of key economic variables that shape such behavior.

## STOCHASTIC SIMULATION

The Model is also designed to be dynamic. Key drivers are not required to be held constant through time. Moreover, by applying variance and covariance among key drivers, stochastic simulation analysis is possible to derive a full performance profile (probabilistic distribution of cash flow, losses, value or returns) for collateral pools and associated RMBS. This involves selecting a number of random paths to be applied in defining the credit performance distribution-- balancing the trade-off between cost (hardware and processing time) and accuracy – to develop an estimated performance profile that fairly represents the true economics of a subject security. Sample size (number of simulations) sufficiency may differ from deal to deal.




As expressed by the model, collateral pool performance (measured, for example, by cumulative default or cumulative loss) is a random variable with a complicated joint distribution involving stochastic Key driver variables and the probabilistic behavior of individual obligors. Two factors determine the number of scenarios necessary to accurately define the performance profile of collateral pool. The first is the amount of loans in the collateral pool.

The fewer the loans, the greater the potential volatility of aggregate pool outcomes (as diversity is, all else constant, volatility reducing) and consequently more scenarios are needed to obtain a given level of convergence for pool level performance. The second factor is the inherent amount dispersion in the probability distributions shaping the loan level outcomes. The fatter the tail, the greater will be the dispersion in individual outcomes which will impact the volatility of asset pool outcomes. This will result in a need for more simulation passes to achieve a targeted level of convergence. In assessing the simulation run number-accuracy trade-off the challenge rests in defining convergence metrics and developing tools to assess the convergence characteristics of respective pools.

### SAMPLE SIZE STANDARDS

The purpose of setting sample size standards is to ensure a statistical process has *power*, or reliability. All other things equal, a larger sample size produces greater precision in the estimation of a population's properties. Consider the cumulative loss of a collateral pool represented by the random variable X. The variable X will have a distribution D with a first moment (mean) of $\mu_X$ and variance Var(X). We estimate the distribution of X through simulation. We need to have confidence that the sample size selected to generate the estimate of the distribution of X is reliable.

Central Limit Theorem - In valuation, the mean of a loss distribution is of particular interest. This is helpful in managing convergence measurement for two reasons. First, convergence of the mean of a sample to the true mean is likely to be faster than convergence of tail segments. Second, the sampling distribution of a sample mean has a special property. The Central Limit Theorem asserts that as the sample size "n" of independent observations approaches infinity, assuming data comes from a distribution having finite non-zero variance, the sample mean converges in distribution to a normal distribution with a mean equal to the true population mean and a variance equal to Var(X)/n. .

Let $X_1, X_2, \ldots X_n$ be a sequence of random variables. The Variance of the series, Var(X), is the mathematical expectation of the squared difference between the respective individual values $X_i$ in the series and the series mean μ:

$$\mathrm{Var}(X) = E[(X_i - \mu_x)^2]$$

If the random variables are uncorrelated, as would be the case if they are independently drawn from an identical distribution (i.i.d.), the variance of a sum of the random variables is the sum of the variances:

$$\mathrm{Var}(\sum X_i) = \sum \mathrm{Var}(X_i)$$

This equation is known as the Bienayme formula. An important application for the formula occurs in the determination of the variance of the average of a sequence of "n" i.i.d. random variables $X_i$:

$$\mathrm{Var}(\text{Average } X) = \mathrm{Var}((1/n) \sum X_i)) = (1/n^2) \sum \mathrm{Var}(X_i) = (n/n^2)\, \mathrm{Var}(X_i) = (1/n)\, \mathrm{Var}(X_i)$$

So the Variance of the average of a series of uncorrelated numbers is a simple function of the Variance of the sequence itself. Moreover, this variance will decline as the number of elements in the sequence increases.

The (Average $X_i$) is an average of a sample. By the Central Limit Theorem, as long as the series that comprises the sample is drawn *i.i.d.*, the average has an especially important property. If $X_1, X_2, \ldots X_n$ is a finite sum, of i.i.d. random variables with a mean and non-zero variance, as n tends to infinity the sample average converges in distribution to a normal distribution with a mean equal to the true population mean and a variance equal to Var(X)/n.

Convergence Measure for Sample Means – Columbia professor Ward Whitt promulgated a method for assessing sample adequacy.[1] If the object of interest is the mean of a sample and the sample size is reasonably large, the average of a series of random variables $X_i$, Average of X, will be a random variable with an approximately normal distribution centered on the true mean and a variance equal to (1/n) Var($X_i$). The root of that variance is known as the standard error. Because the form of the distribution and its properties are well known, it is easy to establish a confidence interval around the observation of the Average of X. For a confidence level of (1-B), we find the multiple of the standard error that one must go to define a boundary beyond which B/2 proportion of the total distribution lies. This value is denoted as $z_{B/2}$. The (1-B)(100%) confidence interval then is:

$$(\text{Average of X}) - z_{B/2} *((1/n)\ \text{Var}(X_i))^{0.5},\ (\text{Average of X}) + z_{B/2} *((1/n)\ \text{Var}(X_i))^{0.5}$$

Since a normal distribution is symmetric, if we simply double the distance from the average to boundary of the interval on one side of the distribution, the whole size of the interval may be expressed as:

$$2*(z_{B/2} *((1/n)\ \text{Var}(X_i))^{0.5})$$

Whitt proposes a metric called *relative width*. Relative width measures this interval as a proportion of the best linear unbiased estimate of the true mean which is the Average of X:

$$2*(z_{B/2} *((1/n)\ \text{Var}(X_i))^{0.5})/\text{Average of X}$$

It should be noted this measure is an overestimate of possible errors. Since the error will be either an overestimate or an underestimate of the mean but not both at the same time, this overstates the maximum possible error (within the confidence interval) by a factor of 2.

Convergence Tests - The RangeMark Mortgage Credit Model simulates certain variable feeds that are introduced into probability equations of individual obligor behavior. Loan performance is projected based upon the simulations of obligor behavior. Collateral pool performance is the aggregate of loan performance, and can be used to derive the performance profile of associated securities. Distributions of cumulative default and cumulative loss are complicated joint distributions. However, each simulated path is comprised of draws performed independently in each run. Because each simulated outcome is an independent draw from the same distribution, the *average* cumulative default and *average* cumulative loss for each deal is a random variable that is approximately normally distributed.

[1] "Simulation Run Length Planning", 1989 Winter Simulation Conference Proceedings, pp. 106-112.

Using the measures and methods described above, convergence tests were conducted on ten non-agency deals RMBS covering a range of vintages and collateral types as detailed in the Table immediately below:

| Intex Name | Bloomberg Name | Vintage | Collateral Type |
|---|---|---|---|
| ABF02WF2 | ABFC 2002-WF2 | 2002 | Adjustable rate and fixed rate subprime mortgages |
| CBS02CB5 | CBASS 2002-CB5 | 2002 | Fixed rate FHFA insured, VA insured, and conventional res. mortgages |
| CBS06CB6 | CBASS 2006-CB6 | 2006 | ARM and FR non-prime res. 1st and 2nd lien closed end mortgages |
| FFM06F13 | FFML 2006-FF13 | 2006 | ARM and FR subprime 1st lien mortgages or deeds of trust |
| FFML06F3 | FFML 2006-FF3 | 2006 | ARM and FR subprime first lien mortgages |
| MSM053AR | MSM 2005-3AR | 2005 | Alt-A Hybrid ARM res. loans secured by first lien mortgages |
| NCC06002 | NCHET 2006-2 | 2006 | FR second lien subprime mortgages |
| SAS0326A | SASC 2003-26A | 2003 | Alt-A Hybrid ARM first lien mortgages |
| SURF04B4 | SURF 2004-BC4 | 2004 | ARM and FR subprime res. 1st and 2nd lien closed end mortgages |
| SVHE0603 | SVHE 2006-3 | 2006 | ARM and FR subprime res. 1st and 2nd lien closed end mortgages |

The study examined average cumulative default and average cumulative loss estimates at varying sizes of simulation sets. Deal performance characteristics were derived with simulation sets of 100, 200, 300, and 400. The results are reported in Exhibit 1.

Keeping in mind the maximum error within the confidence interval is half the size of the boundary width measure recorded, the respective boundary sizes relative to the associated calculated averages, as measured by relative width, are small. This is especially true when 300 or more simulated paths were run. The one exception to this general description is *SAS 0326A*. This deal's collateral pool is comprised of prime loans with very low cumulative loss projections. The proportional error for this deal is high because it is being compared to a very small average number. The absolute size of the errors is low.
A review of the average cumulative default and average cumulative loss values determined from simulations of varying path size for each of ten respective deals shows the difference between 300 and 400 runs was generally very small. In seven out of the ten deals, the difference in cumulative default rates between projections at 300 runs and projections at 400 runs expressed as a proportion of the 300 path average was less than 5 bps; in 9 out of the 10 deals, the proportionate difference was less than 8 bps. The outlier was an old (2003) prime deal with a small cumulative default rate. The small difference in the estimates between the simulations using 300 and 400 runs respectively was magnified by the small absolute size of the cumulative default rate. Even here, the proportionate difference between the 300 simulation and 400 simulation outcomes was 85 bps. On average, the proportionate difference between cumulative default rate estimates at 300 and 400 runs respectively was less than 12 bps.

In the case of measuring cumulative loss rates, the difference between 300 and 400 runs was also small. In three out of the ten cases, the proportionate difference in cumulative loss estimates between 300 and 400 runs was less than 5 bps; in 8 of the cases, the proportionate difference was no greater than 17 bps. In one case, the proportionate difference was 22 bps. The largest proportionate difference was 29 bps. The average proportionate difference was less than 12 bps.

## EXHIBIT 1

| | Cum Loss stdev | Cum Def stdev | Sample Size | Mean Cum Loss | Mean Cum Default | 95% Confidence Cum Loss | Relative Width Cum Loss | 95% Confidence Cum Default | Relative Width Cum Default |
|---|---|---|---|---|---|---|---|---|---|
| ABF02WF2-SC1 | 0.0160 | 0.0350 | 100 | 11.71% | 27.49% | 0.0063 | 5.34% | 0.0014 | 0.50% |
| ABF02WF2-SC2 | 0.0154 | 0.0371 | 200 | 11.56% | 27.21% | 0.0043 | 3.69% | 0.0007 | 0.27% |
| ABF02WF2-SC3 | 0.0153 | 0.0333 | 300 | 11.66% | 27.34% | 0.0035 | 2.97% | 0.0004 | 0.16% |
| ABF02WF2-SC4 | 0.0145 | 0.0336 | 400 | 11.73% | 27.56% | 0.0028 | 2.42% | 0.0003 | 0.12% |
| CBS02CB5-SC1 | 0.0114 | 0.0248 | 100 | 8.80% | 20.64% | 0.0045 | 5.10% | 0.0010 | 0.47% |
| CBS02CB5-SC2 | 0.0122 | 0.0227 | 200 | 8.85% | 20.78% | 0.0034 | 3.84% | 0.0004 | 0.21% |
| CBS02CB5-SC3 | 0.0126 | 0.0266 | 300 | 8.82% | 20.66% | 0.0029 | 3.24% | 0.0003 | 0.17% |
| CBS02CB5-SC4 | 0.0124 | 0.0258 | 400 | 8.94% | 20.78% | 0.0024 | 2.72% | 0.0003 | 0.12% |
| CBS06CB6-SC1 | 0.0288 | 0.0252 | 100 | 31.00% | 53.06% | 0.0113 | 3.64% | 0.0010 | 0.19% |
| CBS06CB6-SC2 | 0.0312 | 0.0267 | 200 | 31.25% | 53.29% | 0.0086 | 2.77% | 0.0005 | 0.10% |
| CBS06CB6-SC3 | 0.0295 | 0.0249 | 300 | 31.18% | 53.26% | 0.0067 | 2.14% | 0.0003 | 0.06% |
| CBS06CB6-SC4 | 0.0290 | 0.0247 | 400 | 31.30% | 53.31% | 0.0057 | 1.82% | 0.0002 | 0.05% |
| FFM06F13-SC1 | 0.0268 | 0.0222 | 100 | 34.02% | 58.85% | 0.0105 | 3.09% | 0.0009 | 0.15% |
| FFM06F13-SC2 | 0.0278 | 0.0225 | 200 | 34.16% | 58.89% | 0.0077 | 2.25% | 0.0004 | 0.07% |
| FFM06F13-SC3 | 0.0267 | 0.0225 | 300 | 34.16% | 58.93% | 0.0060 | 1.77% | 0.0003 | 0.05% |
| FFM06F13-SC4 | 0.0265 | 0.0222 | 400 | 34.20% | 58.99% | 0.0052 | 1.52% | 0.0002 | 0.04% |
| FFML06F3-SC1 | 0.0312 | 0.0306 | 100 | 29.52% | 53.30% | 0.0122 | 4.14% | 0.0012 | 0.23% |
| FFML06F3-SC2 | 0.0326 | 0.0323 | 200 | 29.87% | 53.65% | 0.0090 | 3.03% | 0.0006 | 0.12% |
| FFML06F3-SC3 | 0.0311 | 0.0304 | 300 | 29.82% | 53.67% | 0.0070 | 2.36% | 0.0004 | 0.07% |
| FFML06F3-SC4 | 0.0304 | 0.0293 | 400 | 29.98% | 53.85% | 0.0060 | 1.99% | 0.0003 | 0.05% |
| MSM053AR-SC1 | 0.0237 | 0.0404 | 100 | 11.10% | 23.50% | 0.0093 | 8.36% | 0.0016 | 0.67% |
| MSM053AR-SC2 | 0.0265 | 0.0443 | 200 | 11.45% | 24.12% | 0.0074 | 6.42% | 0.0009 | 0.36% |
| MSM053AR-SC3 | 0.0257 | 0.0440 | 300 | 11.34% | 23.95% | 0.0058 | 5.13% | 0.0006 | 0.24% |
| MSM053AR-SC4 | 0.0257 | 0.0446 | 400 | 11.43% | 24.16% | 0.0050 | 4.41% | 0.0004 | 0.18% |
| NCC06002-SC1 | 0.0301 | 0.0251 | 100 | 31.75% | 55.06% | 0.0118 | 3.72% | 0.0010 | 0.18% |
| NCC06002-SC2 | 0.0309 | 0.0267 | 200 | 31.92% | 55.12% | 0.0086 | 2.68% | 0.0005 | 0.10% |
| NCC06002-SC3 | 0.0297 | 0.0248 | 300 | 31.91% | 55.21% | 0.0067 | 2.11% | 0.0003 | 0.06% |
| NCC06002-SC4 | 0.0293 | 0.0247 | 400 | 31.99% | 55.25% | 0.0057 | 1.79% | 0.0002 | 0.04% |
| SAS0326A-SC1 | 0.0026 | 0.0109 | 100 | 0.94% | 4.02% | 0.0010 | 10.69% | 0.0004 | 1.06% |
| SAS0326A-SC2 | 0.0031 | 0.0108 | 200 | 0.96% | 4.04% | 0.0009 | 8.88% | 0.0002 | 0.53% |
| SAS0326A-SC3 | 0.0031 | 0.0119 | 300 | 0.97% | 4.12% | 0.0007 | 7.27% | 0.0002 | 0.38% |
| SAS0326A-SC4 | 0.0032 | 0.0120 | 400 | 0.97% | 4.09% | 0.0006 | 6.46% | 0.0001 | 0.29% |
| SURF04B4-SC1 | 0.0117 | 0.0181 | 100 | 15.90% | 31.68% | 0.0046 | 2.88% | 0.0007 | 0.22% |
| SURF04B4-SC2 | 0.0126 | 0.0199 | 200 | 15.87% | 31.60% | 0.0035 | 2.20% | 0.0004 | 0.12% |
| SURF04B4-SC3 | 0.0115 | 0.0193 | 300 | 15.92% | 31.72% | 0.0026 | 1.64% | 0.0003 | 0.08% |
| SURF04B4-SC4 | 0.0108 | 0.0182 | 400 | 15.85% | 31.61% | 0.0021 | 1.34% | 0.0002 | 0.06% |
| SVHE06O3-SC1 | 0.0288 | 0.0272 | 100 | 29.42% | 51.54% | 0.0113 | 3.84% | 0.0011 | 0.21% |
| SVHE06O3-SC2 | 0.0297 | 0.0279 | 200 | 29.58% | 51.68% | 0.0082 | 2.78% | 0.0005 | 0.11% |
| SVHE06O3-SC3 | 0.0292 | 0.0280 | 300 | 29.60% | 51.67% | 0.0066 | 2.23% | 0.0004 | 0.07% |
| SVHE06O3-SC4 | 0.0287 | 0.0272 | 400 | 29.63% | 51.76% | 0.0056 | 1.90% | 0.0003 | 0.05% |

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