

Just how good *are* your loss estimates?



Milliman Reserve Variability Modeling



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## Just how good are your loss estimates?

- Do your current tools help you see beyond a traditional deterministic point estimate?
- Can you easily present a distribution of possible outcomes to your management?
- Can your models estimate reserve risk on a one-year time horizon, consistent with Solvency II?
- Do you truly understand the capital required for current or new lines of business?
- Do you have the loss information you need for effective enterprise risk management?

Milliman's Reserve Variability Model toolset offers you a solution to all these issues.



### WHERE YOU ARE NOW

Reserves may be the largest liability on your balance sheet. Yet the one thing you know about that number is that it won't be the exact outcome. You expect that it's a reasonable estimate of the unpaid liability, but what is the likelihood that you are materially over- or under-reserved? You hope the likelihood is low, but do you really know?

If you're like most actuaries, you apply a variety of deterministic methods to arrive at a range of point estimates and a single best estimate. But despite all your work, those estimates provide no statistical information as to whether booked reserves are sufficient. They also don't help you explain the inherent variability to others in management, or to those outside your company.

### ADVANTAGES OF A STOCHASTIC APPROACH

Stochastic models are more informative. They produce a full distribution of possible outcomes and a formal process for estimating confidence intervals around the expected value. They can also consider the volatility of the claim payments for a single line of business, as well as the correlation of losses across various lines. Under Solvency II, this helps you address the solvency capital requirement (SCR) for reserving risk using the claims development result (CDR) for each line of business. Wouldn't you like to develop a truly stochastic view of your outstanding liabilities one, two, or "n" years from now, along with discounting and risk margins?

### Estimated Unpaid

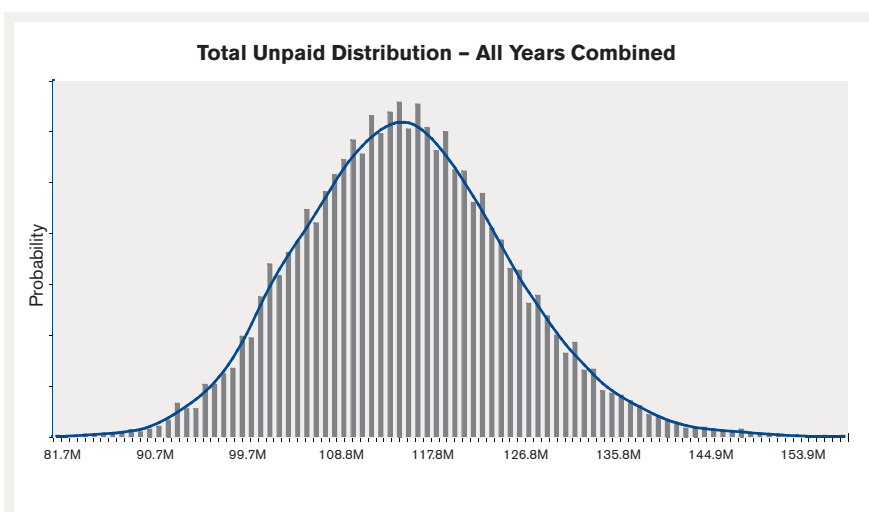
Accident Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0%	75.0%	85.0%	90.0%	95.0%	99.5%	99.9%
2000	23,039	12,654	54.9%	-27,566	72,761	22,768	31,486	36,212	39,374	44,117	53,714	64,079
2001	28,715	12,513	43.6%	-18,264	79,332	28,457	37,034	41,777	44,930	49,851	58,451	68,487
2002	34,416	12,862	37.4%	-16,459	83,151	34,250	42,957	47,893	51,023	55,914	65,134	73,918
2003	41,280	12,968	31.4%	-11,148	92,342	40,938	49,922	54,885	58,025	62,836	72,605	82,751
2004	56,059	13,536	24.1%	3,935	106,483	55,930	65,064	70,057	73,276	79,030	88,384	100,030
2005	91,964	15,371	16.7%	34,016	149,267	91,569	102,341	108,017	112,046	117,937	128,486	141,001
2006	176,320	20,311	11.5%	108,781	248,735	176,010	189,840	197,156	202,591	210,301	225,866	240,316
2007	323,622	25,587	7.9%	235,602	420,070	322,661	341,095	350,541	357,128	366,872	384,982	400,715
2008	508,740	30,132	5.9%	394,211	646,053	508,268	528,906	540,272	548,019	558,848	579,610	602,766
2009	718,250	35,973	5.0%	589,530	839,364	717,029	742,653	756,523	765,814	779,388	802,776	827,651
Total	2,002,404	149,889	7.5%	1,443,934	2,505,219	2,000,758	2,101,612	2,158,691	2,198,273	2,252,151	2,351,735	2,453,647
TVaR						2,122,172	2,194,299	2,237,850	2,268,018	2,313,476	2,394,815	2,477,779
Lognormal TVaR						2,121,720	2,197,357	2,244,085	2,277,820	2,330,618	2,437,696	2,568,793
Gamma TVaR						2,121,905	2,196,000	2,241,271	2,273,727	2,324,155	2,425,089	2,546,331

### MILLIMAN'S RESERVE VARIABILITY MODEL

Our Reserve Variability Model uses a bootstrap simulation approach to provide a realistic distribution of the possible ways your unpaid claims could settle, either on an ultimate or a year-by-year basis. This gives valuable information about your booked reserve levels and the variance around your central estimate. Distribution information is available for each individual reserve segment and for totals of multiple lines factoring in the effects of correlation.

Some of the valuable output includes:

- Multiple approaches for estimating reserve risk on a one-year or ultimate time horizon
- Estimated unpaid amounts at user-specified percentiles
- Estimated ultimate loss ratios, cash flows, and TVaR (Tail Value at Risk) by percentile
- Discounted results based on either a constant rate or a term structure
- Graphical presentation of estimated unpaid claim distributions
- Means, standard errors, and coefficients of variation
- Diagnostic plots to test model assumptions and adjust parameters



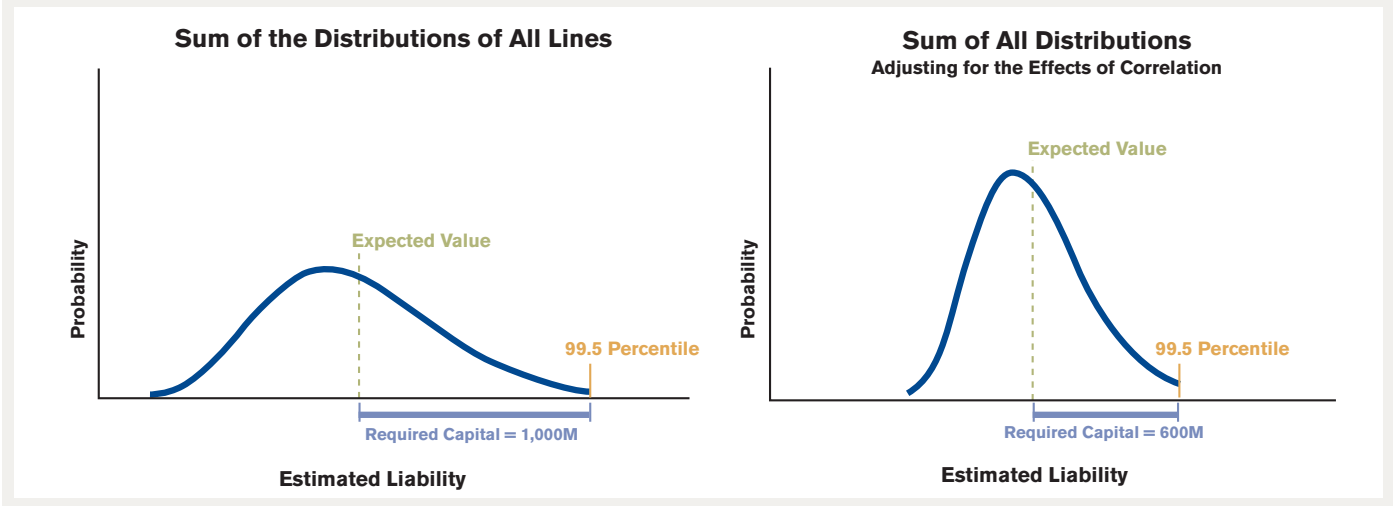
### ESTIMATE A DISTRIBUTION OF YOUR UNPAID CLAIMS

With a full distribution and the statistical information that comes with it, you can now answer many questions that you could never answer with a deterministic best estimate.

- What is the most likely outcome? (Mode)
- At what point is the actual outcome equally likely to be higher or lower than estimated? (Median)
- What is the average of the possible outcomes? (Expected value)
- At what reserve level is there a 0.5% probability of ruin within one year? (Solvency II one-year time horizon risk)
- Does an estimate include parameter, process, and model risk?

### EVALUATE TOTAL CAPITAL REQUIREMENTS

Because your lines of business are at least somewhat independent (less than 100% correlated), the effect of correlation on your required capital will usually be significant. Using the aggregate distributions from the correlated results of our model, you can understand how much capital you *really need* to run your business, rather than relying on less accurate industry rules of thumb.



### Solvency II Reserve Risk Analysis

Line	Reserve Risk (Simulated Values) at One Year						
	Mean Unpaid	99.5%	Implied Capital	Capital / Unpaid	Capital / Premium	Allocated Capital	Capital / Unpaid
BI	463,641	555,763	92,122	19.9%	13.5%	57,235	12.3%
APD	127,967	193,966	65,998	51.6%	3.9%	20,317	15.9%
GL	416,034	563,544	147,510	35.5%	41.7%	134,233	32.3%
Sum	1,007,642	1,313,273	305,630	30.3%	11.2%	211,785	21.0%
Aggregate Results	1,007,642	1,219,427	211,785	21.0%	7.8%		
Correlation Effect			(93,845)	(9.3%)	(3.4%)		

### ALLOCATE CAPITAL

Understanding how to allocate capital is at the heart of many strategic planning decisions. Total capital is a shared asset that can be allocated to different lines or profit centers. But how should it be allocated? You can devise a variety of capital allocation techniques using the output from our model based on relative distributions, correlation coefficients, or both. Having a measure of the relative variability inherent in different reserve segments can allow you to allocate capital based on risk.

**How much capital do you need to run your business? Our approach helps you understand how much and why.**

### Estimated Ultimate Loss Ratios

Accident Year	Mean	Standard Error	Coefficient of									
			Variation	Minimum	Maximum	50.0%	75.0%	85.0%	90.0%	95.0%	99.5%	99.9%
2000	72.5%	2.1%	2.9%	65.6%	80.9%	72.5%	74.0%	74.8%	75.3%	76.1%	77.6%	79.9%
2001	75.1%	2.2%	3.0%	67.8%	83.2%	75.1%	76.6%	77.5%	78.1%	78.9%	80.4%	82.2%
2002	76.7%	2.3%	3.0%	68.7%	85.7%	76.7%	78.2%	79.1%	79.7%	80.5%	82.2%	84.2%
2003	78.6%	2.4%	3.0%	69.8%	89.4%	78.5%	80.2%	81.1%	81.7%	82.6%	84.6%	86.7%
2004	82.9%	2.5%	3.0%	74.1%	94.4%	82.9%	84.6%	85.6%	86.2%	87.2%	89.0%	91.0%
2005	88.8%	2.7%	3.0%	79.1%	99.8%	88.8%	90.6%	91.6%	92.3%	93.4%	95.2%	97.5%
2006	88.8%	2.7%	3.0%	79.6%	99.1%	88.8%	90.6%	91.6%	92.3%	93.3%	95.1%	97.1%
2007	90.6%	2.8%	3.1%	81.2%	100.9%	90.5%	92.5%	93.6%	94.3%	95.3%	97.2%	99.8%
2008	84.9%	2.8%	3.3%	74.8%	94.9%	84.8%	86.8%	87.9%	88.7%	89.7%	91.7%	93.5%
2009	70.4%	2.8%	4.0%	60.8%	80.0%	70.3%	72.3%	73.4%	74.2%	75.3%	77.2%	79.1%
Total	80.9%	1.4%	1.7%	76.3%	85.8%	80.9%	81.8%	82.3%	82.7%	83.2%	84.1%	85.1%

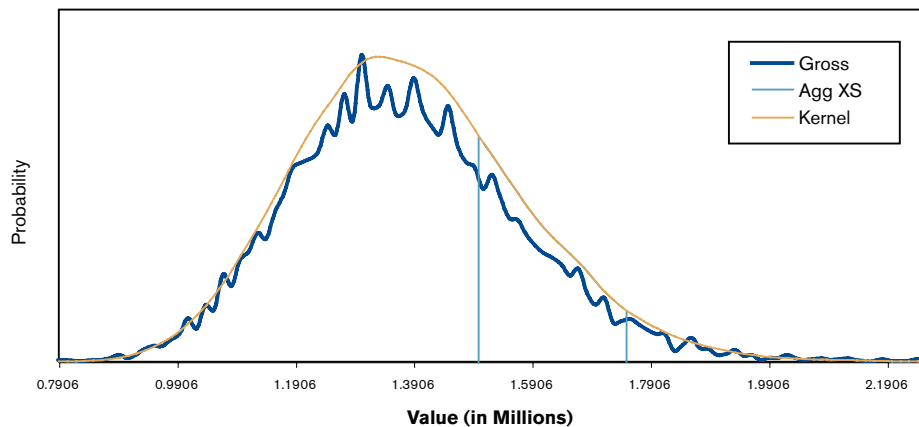
### PRICE YOUR BUSINESS MORE STRATEGICALLY

Once you have estimated your risk-based or economic capital requirements, doesn't it make sense to adjust your expected ROEs based on risk when you price a new line of business? With clear estimates of tail value at risk, you can evaluate adverse scenarios, allocate your capital appropriately, and price your business accordingly.

### REINSURE AT OPTIMAL LEVELS

Evaluate your reinsurance strategies with more clarity. With a much better understanding of the risk profile of a block of business, you can set attachment points, see the effects of different stop-loss levels, and evaluate loss portfolio transfer agreements.

#### Distribution of General Liability Results



Our tools provide the statistical sophistication you expect and need, but are still priced to fit your budget.

### Estimated Cash Flow

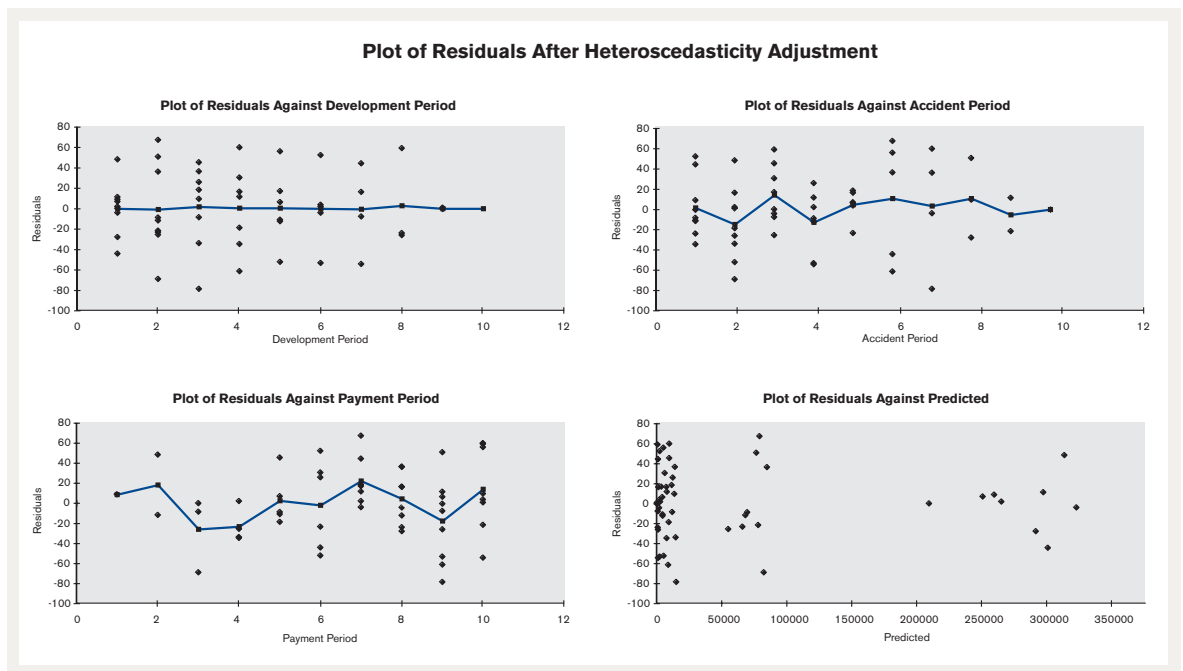
Calendar Period	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0%	75.0%	85.0%	90.0%	95.0%	99.5%	99.9%
2010	739,645	27,432	3.7%	652,226	860,384	739,038	757,937	768,364	775,085	785,810	805,696	824,666
2011	436,812	20,953	4.8%	365,638	522,197	436,388	450,720	458,577	463,957	471,638	487,355	504,070
2012	270,649	16,711	6.2%	213,427	338,642	270,138	281,595	288,017	292,496	298,954	310,850	326,231
2013	168,776	17,291	10.2%	112,232	252,053	168,486	180,345	186,422	190,992	197,569	210,782	222,741
2014	98,157	14,069	14.3%	45,492	156,812	97,986	107,500	112,819	116,363	121,396	131,731	142,640
2015	65,209	13,822	21.2%	11,256	114,214	65,015	74,359	79,606	83,085	88,291	97,838	108,234
2016	48,975	13,821	28.2%	-2,984	99,635	48,787	57,959	63,107	66,849	72,396	82,518	92,645
2017	40,193	14,121	35.1%	-15,045	91,617	39,909	49,679	54,779	58,498	64,119	73,793	83,220
2018	34,506	15,019	43.5%	-20,267	96,891	34,270	44,502	50,159	53,966	59,612	70,603	82,429
2019	29,326	16,051	54.7%	-29,565	87,224	29,179	39,713	46,157	50,146	56,368	68,378	79,023
2020	27,625	15,162	54.9%	-29,107	83,203	27,386	37,530	43,280	47,172	52,771	64,609	74,872
2021	24,248	13,264	54.7%	-27,743	71,907	24,131	32,941	37,941	41,218	46,835	56,625	65,013
2022	18,283	10,118	55.3%	-19,096	58,907	18,062	24,982	28,798	31,384	35,491	42,715	49,537
Total	2,002,404	149,889	7.5%	1,443,934	2,505,219	2,000,758	2,101,612	2,158,691	2,198,273	2,252,151	2,351,735	2,453,647

#### EVALUATE FUTURE INVESTMENT OPPORTUNITIES

You may know what it will cost to start a new line or buy a block from someone else, but do you know if it can ultimately be profitable? Maybe it will, but what's the likelihood? With realistic loss and cash-flow estimates by percentile, you can make more informed strategic decisions.

#### ENTERPRISE RISK MANAGEMENT

As the term *enterprise risk management* implies, many of your management initiatives should be based on a sound evaluation of risk. Understanding capital requirements, pricing implications, optimal reinsurance, and investment options is only the start. Other initiatives that benefit from a solid statistical foundation are mergers and acquisitions, strategic planning, DFA modeling, underwriting cycle management, tax analysis, fair value accounting, and incentive compensation.



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## HOW THE MODEL WORKS

Our Reserve Variability Model tools are based on a bootstrap approach to simulating ultimate results. This approach has been studied and used by statisticians for years. Essentially, the theory goes something like this: given a model of the statistical patterns in the actual historical data, simulate all the myriad ways (well, perhaps 10,000 to 50,000 ways) that the actual loss history might have occurred, and then develop each to ultimate. By summarizing all those simulated results to derive a probability distribution, you can use the model to better understand the statistical nature of the given data set.

We took these theoretical concepts and enhanced them with a number of tools to allow you to build models that more closely reflect the nuances of your particular business.

For each business segment, you can:

- Make statistically based adjustments to the model to provide a better fit to your specific data
- Simulate results based on traditional paid and incurred chain ladder models
- Incorporate both Bornhuetter-Ferguson and Cape Cod models wherever they are more appropriate
- Develop a weighted distribution that blends your judgments about the quality of each model
- Incorporate both stochastic and deterministic results into your final selected *best estimate*

After analyzing individual business segments, for a more realistic look at your overall company-wide risk profile, you can combine the various modeled segments into an aggregate distribution reflecting the effect of correlation and an estimate of overall risk margin.

## BENEFITS OF THE MILLIMAN RESERVE VARIABILITY MODEL

Theoretically, these benefits have been available from similar models for years. So what makes Milliman's solution different?

1. **Easy to use.** It only requires basic triangle data—no information on the underlying distribution is needed. It comes complete with graphics and reports to help you explain your results to others in non-technical terms, and to facilitate sharing the results with other applications.
2. **Based on well-accepted methodologies.** Our toolset uses a bootstrap approach that has been extensively studied in actuarial literature, but has not been widely accessible due to the computing capacity required to use it effectively, until now.
3. **Fast.** Our modeling tools can simulate hundreds of times faster than spreadsheet models that have significantly fewer capabilities, less flexibility, and less reliability.
4. **Flexible.** The model was designed by actuaries and for actuaries. It works with all practical data sets and allows you to easily adjust for exposure issues (e.g., stub periods), outliers, normality, and heteroscedasticity. Most of the assumptions and parameters are transparent, so you can modify them to fit your particular data set.
5. **Reliable.** We have more than 20 years of experience building commercial software specifically for actuaries, which gives you the assurance that the solution is well-designed and professionally tested.
6. **Supported.** We are experienced at using the models ourselves, so we can provide you the support you need, from basic training to a complete peer review of your work and beyond.
7. **Affordable.** Shop and compare. Our tools provide the statistical sophistication you expect and need, but are still priced to fit your budget.

**The Reserve Variability Model can help you gain better insight into the management of your business.**

**As with all our solutions, our goal is not simply to license software, but to provide the tools, training, and understanding you need to get better results for your company.**

**Contact us to see how we can help you easily develop more understandable, more realistic, and more explainable loss estimates.**

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Milliman, whose corporate offices are in Seattle, serves the full spectrum of business, financial, government, and union organizations. Founded in 1947 as Milliman & Robertson, the company has 54 offices in principal cities in the United States and worldwide. Milliman employs more than 2,500 people, including a professional staff of more than 1,300 qualified consultants and actuaries. The firm has consulting practices in employee benefits, healthcare, life insurance/financial services, and property and casualty insurance. For further information visit [milliman.com](http://milliman.com).