Use of Simulation Models in Pricing Health Insurance and Reinsurance Risk

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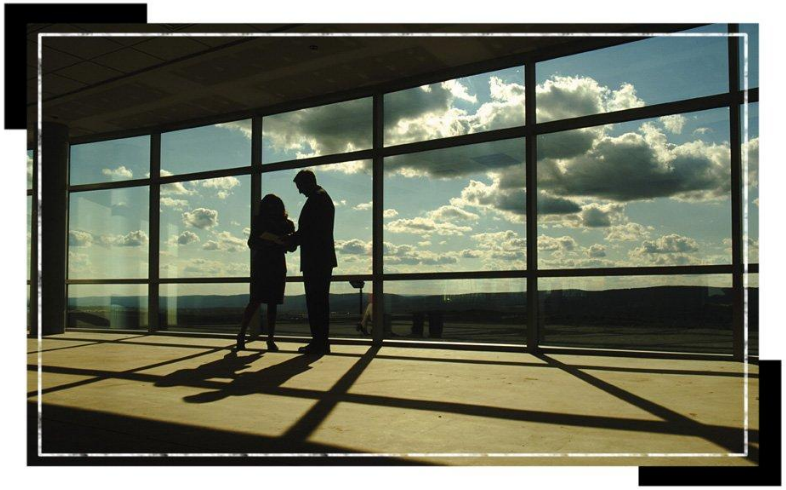

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Use of Simulation Models in Pricing Health Insurance and Reinsurance Risk

- Health insurance pricing intro
- Why simulation modeling?
- Setting up the models
- Case Study 1: Excess Loss Reinsurance
- Case Study 2: Employer Stop Loss Insurance
- Summary / Questions

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Health Insurance Pricing Intro

- We are trying to predict the total cost to the risk taker (e.g. health plan, employer, reinsurer) per covered life, per year
  - How many units of service will be utilized?
  - What will be the cost per unit of service?
  - What mix of services will be utilized?
  - How will utilization and cost vary by demographic category?
- We base our prediction on an analysis of past experience
  - Ideally millions of lives exposed per year analyzed
  - Similar type of risk (Medicare, Medicaid, Commercial)
  - Typically 5% of the population uses 50% of the resources

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Health Insurance Pricing Intro

- In reality the risk is carved up among different risk-takers with different characteristics
  - The covered employee or subscriber (e.g. copays, deductibles, non-covered services)
  - The health plan or self-insured employer (what we typically think of as "health insurance")
  - One or more reinsurers (may cover a share of the total risk, or only claims exceeding some threshold, or both)
- Each risk taker must quantify the expected cost and the variability unique to their share of the risk
  - Claim frequency
  - Claim size

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Why Simulation Modeling?

- Given certain data points, “first dollar” healthcare costs are fairly predictable
  - Scope of services to be covered
  - Rates of payment to healthcare providers
  - Size and demographic characteristics of covered population
  - Historical data on population cost and utilization

- BUT when we start carving up the risk there is tremendous variability *within risk cells*
  - By claim amount (i.e. “large” or “excess loss” claims)
  - By disease state, treatment protocol, etc.

- Reinsurers quantify this variability in order to assure that their premium and capital levels are adequate

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Why Simulation Modeling?

- Look at the relationships among group size, annual claim dollar limits, and the variability in annual claim costs

- This table shows the *coefficient of variation* in claim costs (ratio of the standard deviation to the mean)

Covered	upper limit on annual claims for any one covered life										
Lives	$15,000	$25,000	$50,000	$75,000	$100,000	$125,000	$150,000	$175,000	$200,000	$500,000	no limit
50	23.2%	27.7%	30.9%	38.4%	40.9%	48.2%	44.6%	51.4%	48.5%	50.4%	54.4%
100	17.2%	17.0%	23.0%	25.3%	27.7%	29.0%	35.4%	36.2%	32.2%	36.3%	40.6%
250	10.0%	10.9%	15.2%	15.6%	16.0%	16.4%	20.5%	22.1%	19.3%	28.4%	27.9%
500	8.1%	8.3%	9.5%	11.3%	11.9%	13.5%	13.6%	15.1%	14.0%	19.2%	20.6%
750	6.0%	6.5%	7.9%	9.2%	10.4%	12.2%	11.1%	12.6%	11.6%	14.6%	16.8%
1,000	5.3%	5.8%	6.3%	7.5%	9.0%	10.4%	9.0%	10.5%	10.9%	12.3%	15.3%
1,500	4.2%	4.9%	5.4%	6.2%	7.4%	8.4%	7.3%	8.2%	9.4%	9.9%	11.7%
2,000	3.7%	4.4%	4.8%	5.5%	6.3%	6.8%	6.0%	7.5%	8.4%	8.7%	10.0%
3,000	3.1%	3.5%	4.0%	4.7%	5.0%	5.1%	4.6%	5.6%	6.6%	7.0%	8.7%
4,000	2.9%	3.0%	3.4%	4.1%	4.5%	4.1%	3.9%	4.9%	5.4%	5.6%	7.0%
5,000	2.5%	2.7%	3.2%	3.7%	3.7%	3.7%	3.9%	4.7%	4.8%	5.2%	6.3%

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Why Simulation Modeling?

Example of variability in cost and utilization for diabetics

Data for members with a diabetic diagnosis

Two year period ending July 2007

Class	Members	% of Total Members	# ER Visits	# Office Visits	# Admits	ALOS	Average Diseases per Member	Average Cost per Member	Risk Index	Adjusted Risk Index
7	46	0.6%	3.9	35.0	4.5	20.9	5.3	$422,829	96.65	154.13
6	166	2.3%	3.6	34.0	2.9	9.4	4.7	$148,281	64.34	107.73
5	374	5.2%	1.8	25.7	1.6	7.1	4.0	$67,774	40.92	73.23
4	1,183	16.5%	1.3	21.1	0.8	4.2	3.2	$30,107	24.43	48.25
3	1,548	21.6%	0.8	14.9	0.3	3.8	2.5	$14,342	15.61	33.64
2	1,592	22.2%	0.5	10.9	0.1	4.7	2.2	$7,304	11.56	26.58
1	2,263	31.6%	0.2	6.6	0.1	4.1	1.8	$2,300	7.37	19.78
	7,172	100.0%	0.8	13.6	0.4	4.6	2.5	$20,087	16.53	34.66

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Why Simulation Modeling?

- The risks we are modeling do not have a single distribution with observable parameters
  - In reality they are a “convolution” – a complex aggregation of distributions
  - So the parameters – *especially the variability* – are difficult or impossible to determine without simulation

- For example, consider the risk for total population claims greater than $100,000 . . .
  - How many ways are there to accumulate $100,000 in claims for a group?
  - 4 claims at $25,000? 100 claims at $1,000? 1 claim at $100,000?
  - The combinations are almost infinite . . . and this is only one risk cell!

- We solve this problem via simulation by generating an empirical (experience-based) distribution of the risk and then exploring the variability of the modeled risk
  - More on this in the case studies . . .

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Setting Up the Simulation Model

- Our goal is to create a mathematical model of the *range of financial results* to the risk-taker(s)

- This is best accomplished through simulation
  - Remember we have a convolution of distributions that cannot be easily represented mathematically
  - Need the variability in results as well as the expected value
  - Provides a means to test the impact of specific model parameters (e.g. coverage terms, pricing assumptions)
  - Capital and surplus targets can be expressed with respect to various percentiles in the distribution of results (e.g. "funding to the 97.5th percentile")

- Requires appropriate stochastic modeling software: @Risk

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Setting Up the Simulation Model: Key Steps

- Describe the anticipated block of business via a series of mathematical models and assumptions (a "model office" approach)

- Using historical data and "manual rates" where necessary, develop realistic empirical distributions of loss results, identifying key risk factors

- Replace the expected value of each key risk factor with a statistical distribution that describes the mean and variability associated with the risk

- Each input distribution will be sampled to arrive at a projection of total loss costs

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Setting Up the Simulation Model: Special Considerations

- Process risk vs. parameter risk
  - Process risk reflects the inherent variability in empirical data which is quantified via the selected distributions and risk factors
  - Parameter risk reflects the possibility that the pricing assumptions and underwriting practices fundamentally misrepresent the actual risk as experience emerges
  - Need to model the impact of both!
  - A simple example: replace the mean of the loss distribution with another distribution
- Model efficiency – look for ways to minimize inputs
- Number of simulations
  - Required number will depend on the degree of variability in results
  - Want enough so that results are not significantly different when the process is repeated

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Case Study #1: Excess Loss ("XOL") Reinsurance

- Definitions
  - Generally refers to total claim dollars for one individual in excess of some large annual dollar amount (e.g. $100K, $500K, $1M, etc.)
  - The "tail" of the healthcare claim distribution ⟹ variability
  - Even large health plans may lay off some or all of this risk
    - Substantial variability implies substantial capital and surplus requirements
    - Part of overall enterprise risk management strategy
  - Variability can only be reduced by aggregating large numbers of covered lives ⟹ This is the role of the Reinsurer
- Client was a regional health plan looking to restructure the reinsurance of its XOL risk

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Case Study #1: Purpose Of Building the Model

- To understand risks assumed by the new reinsurance entity by simulating large claim experience
- To evaluate the impact of different reinsurance structures on capital needs and long term stability
- To evaluate changes in enterprise risk capital relative to changes in required Risk Based Capital
  - There may be tradeoffs: e.g., big change in enterprise risk capital versus change in RBC with a particular structure
  - May get more risk stability but at the expense of proportionately more RBC
- To develop a net premium target for reinsurer negotiations
- To develop a framework to provide assistance to potential reinsurers

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Case Study #1: Stochastic Modeling Basic Steps

- Build a framework for the business to be modeled (simple "model office" structure)
- Develop representative claims distributions for each model office cell
  - e.g., service type, product type, client size, geography
- Consider parameter risk
  - A function of the size of the covered population
- Build a stochastic model using @Risk
- Run sets of simulations under various scenarios
  - Simulating large claim frequency and conditional claim amounts
- Run tests on the stability of the simulation results
  - Did we run enough scenarios?

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Case Study #1: Empirical Data

- Obtained detailed claims and eligibility data for three most recent calendar years
- Data were analyzed by service type, risk type, and client size
- Developed claim continuance tables or distributions
- Distributions specify claim frequency and average claim size in 59 different size bands ($0 claims up to $1 million plus)

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Case Study #1

Sample Claim Distributions

claim size band	average claim size	frequency of having annual claims in the given band: inpatient hospital	outpatient hospital	total hospital	physician	total all categories
nonclaimant	$0	0.950399	0.717809	0.699279	0.220507	0.191002
0-100	$50	0.000068	0.071336	0.067842	0.115684	0.096911
100-200	$150	0.000190	0.041629	0.038513	0.117807	0.095338
200-300	$250	0.000063	0.021690	0.019469	0.080555	0.065361
300-400	$350	0.000127	0.014709	0.013048	0.057464	0.050519
400-500	$450	0.000118	0.013602	0.012222	0.042218	0.040571
500-600	$550	0.000811	0.011257	0.010838	0.032361	0.031312
600-700	$650	0.000260	0.010160	0.009260	0.025546	0.026823
700-800	$750	0.000087	0.007954	0.007193	0.022470	0.023066
800-900	$850	0.000327	0.006930	0.006343	0.018495	0.019801
900-1000	$950	0.001151	0.006298	0.006388	0.016384	0.018139
1000-1250	$1,125	0.002687	0.012286	0.013095	0.033506	0.038973
1250-1500	$1,375	0.000842	0.009035	0.008417	0.026909	0.030235
1500-1750	$1,625	0.001044	0.007182	0.006780	0.020954	0.025865
1750-2000	$1,875	0.001390	0.005641	0.005869	0.017564	0.020652
2000-2500	$2,250	0.002323	0.008015	0.009059	0.028516	0.034270
2500-3000	$2,750	0.002444	0.006704	0.007638	0.020987	0.024875
3000-3500	$3,250	0.002719	0.005014	0.006567	0.016729	0.018828
3500-4000	$3,750	0.002466	0.003124	0.004727	0.013025	0.015211
4000-4500	$4,250	0.002422	0.002297	0.003944	0.009685	0.012781
4500-5000	$4,750	0.002934	0.002049	0.003778	0.008026	0.011728
5000-6000	$5,500	0.003518	0.003300	0.006287	0.012347	0.017304
6000-7000	$6,500	0.002310	0.002138	0.004259	0.009224	0.013363
7000-8000	$7,500	0.001481	0.001864	0.003305	0.006131	0.010461
8000-9000	$8,500	0.001270	0.001224	0.002295	0.004359	0.007943
9000-10000	$9,500	0.001059	0.001001	0.001859	0.003585	0.006691
10000-12500	$11,250	0.003573	0.001824	0.004582	0.005501	0.011343
12500-15000	$13,750	0.002665	0.000857	0.003664	0.003174	0.008095
15000-17500	$16,250	0.001304	0.000765	0.002324	0.002457	0.005760
17500-20000	$18,750	0.001398	0.000537	0.001884	0.001608	0.004516
20000-25000	$22,500	0.001481	0.000573	0.002437	0.001949	0.005815
25000-30000	$27,500	0.000821	0.000268	0.001273	0.001332	0.003961
30000-35000	$32,500	0.000816	0.000210	0.001067	0.000784	0.002425
35000-40000	$37,500	0.000568	0.000159	0.000756	0.000599	0.001963
40000-45000	$42,500	0.000394	0.000077	0.000435	0.000334	0.001376
45000-50000	$47,500	0.000302	0.000122	0.000505	0.000276	0.000908
50000-60000	$55,000	0.000600	0.000154	0.000742	0.000337	0.001395
60000-70000	$65,000	0.000330	0.000094	0.000504	0.000307	0.001069
70000-80000	$75,000	0.000210	0.000033	0.000315	0.000101	0.000731
80000-90000	$85,000	0.000220	0.000010	0.000233	0.000053	0.000590
90000-100000	$95,000	0.000120	0.000013	0.000144	0.000057	0.000404
100000-125000	$112,500	0.000178	0.000035	0.000231	0.000045	0.000655
125000-150000	$137,500	0.000154	0.000022	0.000241	0.000029	0.000248
150000-175000	$162,500	0.000104	0.000000	0.000084	0.000010	0.000216
175000-200000	$187,500	0.000031	0.000000	0.000054	0.000010	0.000127
200000-225000	$212,500	0.000059	0.000000	0.000049	0.000000	0.000077
225000-250000	$237,500	0.000027	0.000000	0.000039	0.000000	0.000073
250000-275000	$262,500	0.000017	0.000000	0.000027	0.000000	0.000039
275000-300000	$287,500	0.000010	0.000000	0.000006	0.000000	0.000023
300000-350000	$325,000	0.000023	0.000000	0.000039	0.000000	0.000053
350000-400000	$375,000	0.000041	0.000000	0.000041	0.000000	0.000026
400000-450000	$425,000	0.000019	0.000000	0.000009	0.000000	0.000026
450000-500000	$475,000	0.000010	0.000000	0.000019	0.000000	0.000015
500000-600000	$550,000	0.000003	0.000000	0.000003	0.000000	0.000006
600000-700000	$650,000	0.000006	0.000000	0.000006	0.000000	0.000013
700000-800000	$750,000	0.000005	0.000000	0.000005	0.000000	0.000009
800000-900000	$850,000	0.000003	0.000000	0.000003	0.000000	0.000006
900000-1000000	$950,000	0.000002	0.000000	0.000002	0.000000	0.000003
1000000+	$1,095,572	0.000000	0.000000	0.000000	0.000000	0.000010

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Case Study #1: Detailed Modeling Approach

- Model claims over and under XOL threshold separately
  - This is the convolution of distributions problem to be solved via simulation
- Focus is on simulating XOL or large claim experience
  - Use a Poisson distribution to model large claim frequency
  - Expected value of the Poisson is defined by the claim distributions built from the empirical data
  - Large claim size (given the occurrence of a large claim) is generated from these same distributions
  - Use a conditional distribution for efficiency (only need to model claim amounts in excess of the XOL threshold)
- Fit a normal distribution to claims under the XOL threshold so we can simulate total population claim costs
  - Expected value is again defined by the claim distribution
  - Variance is a function of 1) population size; and 2) the XOL threshold
  - Understand how reinsurance impacts the risk that is retained by the health plan
- Run 10,000 trials for each simulation

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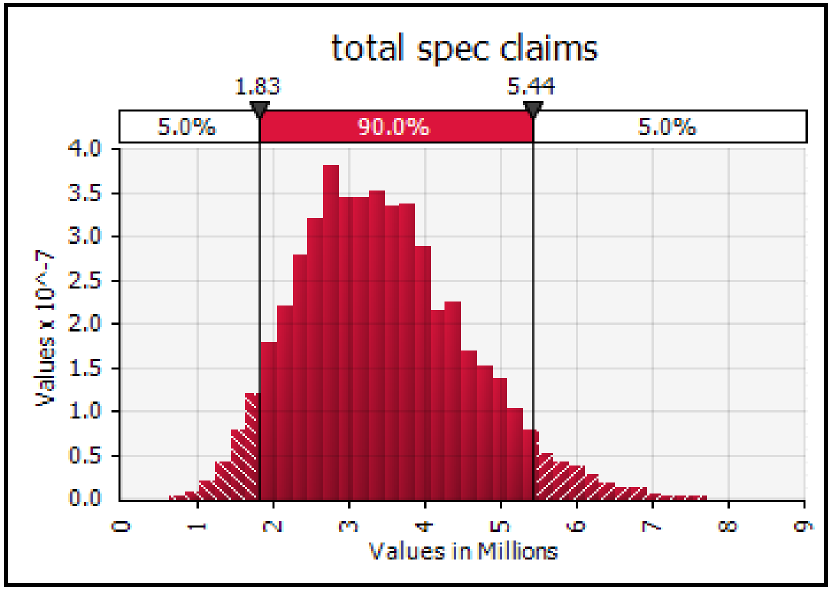
Case Study #1: @RISK Sample Output for a $150,000 Limit with 35,000 Lives



Simulation Summary Information	
Workbook Name	distributions_model.xls
Number of Simulations	1
Number of Iterations	10000
Number of Inputs	252
Number of Outputs	3
Sampling Type	Monte Carlo
Simulation Start Time	9/22/08 10:23:16
Simulation Duration	00:00:44
Random # Generator	Mersenne Twister
Random Seed	128362817

Summary Statistics for total spec claims			
Statistics		**Percentile**	
Minimum	$433,830	**5%**	$1,828,971
Maximum	$8,547,406	**10%**	$2,102,149
Mean	$3,448,711	**15%**	$2,317,444
Std Dev	$1,104,909	**20%**	$2,492,141
Variance	1.22082E+12	**25%**	$2,647,087
Skewness	0.497811821	**30%**	$2,782,563
Kurtosis	3.132339054	**35%**	$2,919,826
Median	$3,349,348	**40%**	$3,059,680
Mode	$2,714,632	**45%**	$3,205,125
Left X	$1,828,971	**50%**	$3,349,348
Left P	5%	**55%**	$3,490,381
Right X	$5,437,534	**60%**	$3,642,509
Right P	95%	**65%**	$3,793,436
Diff X	$3,608,563	**70%**	$3,948,887
Diff P	90%	**75%**	$4,132,487
#Errors	0	**80%**	$4,364,669
Filter Min	Off	**85%**	$4,610,239
Filter Max	Off	**90%**	$4,950,569
#Filtered	0	**95%**	$5,437,534

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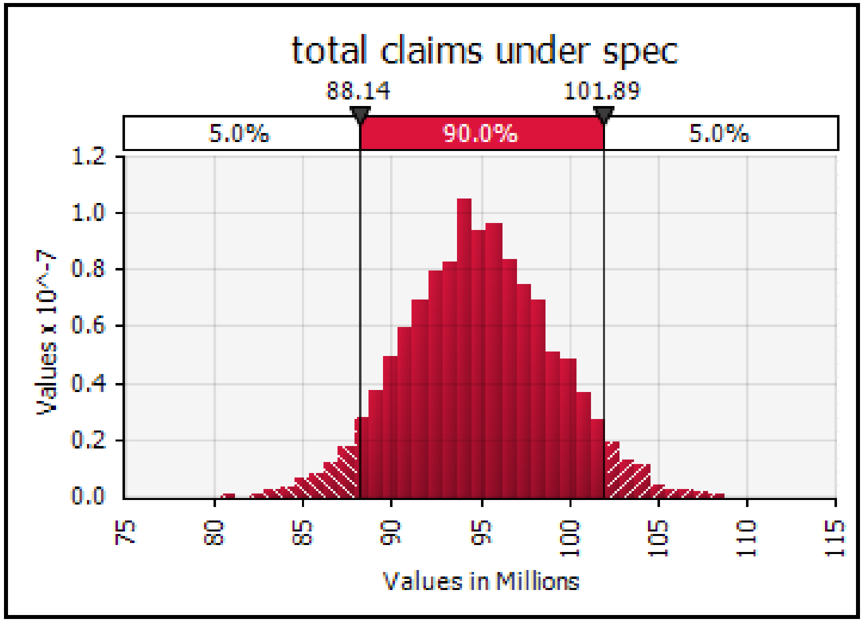

Summary Statistics for total claims under spec			
Statistics		**Percentile**	
Minimum	$78,683,807	**5%**	$88,137,036
Maximum	$112,103,382	**10%**	$89,591,209
Mean	$94,930,767	**15%**	$90,546,483
Std Dev	$4,197,245	**20%**	$91,387,094
Variance	1.76169E+13	**25%**	$92,084,074
Skewness	0.021650898	**30%**	$92,717,995
Kurtosis	3.009773192	**35%**	$93,340,481
Median	$94,860,472	**40%**	$93,902,175
Mode	$94,134,298	**45%**	$94,371,466
Left X	$88,137,036	**50%**	$94,860,472
Left P	5%	**55%**	$95,404,077
Right X	$101,894,226	**60%**	$95,931,694
Right P	95%	**65%**	$96,502,803
Diff X	$13,757,190	**70%**	$97,088,713
Diff P	90%	**75%**	$97,772,748
#Errors	0	**80%**	$98,449,413
Filter Min	Off	**85%**	$99,316,437
Filter Max	Off	**90%**	$100,382,383
#Filtered	0	**95%**	$101,894,226

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Simulation Duration	00:00:44
Random # Generator	Mersenne Twister
Random Seed	128362817

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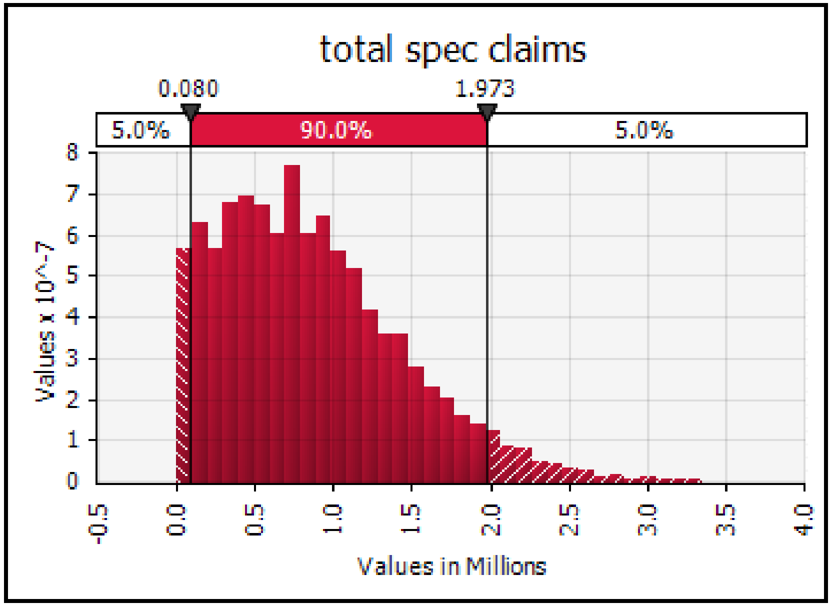
Case Study #1: @RISK Sample Output for a $400,000 Limit with 35,000 Lives



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Number of Iterations	10000
Number of Inputs	252
Number of Outputs	3
Sampling Type	Monte Carlo
Simulation Start Time	9/30/08 12:51:10
Simulation Duration	00:00:56
Random # Generator	Mersenne Twister
Random Seed	2056025269

Summary Statistics for total spec claims			
Statistics		**Percentile**	
Minimum	$0	**5%**	$79,580
Maximum	$3,946,844	**10%**	$170,953
Mean	$864,320	**15%**	$264,100
Std Dev	$585,579	**20%**	$331,391
Variance	3.42903E+11	**25%**	$401,501
Skewness	0.839407704	**30%**	$475,729
Kurtosis	3.664581806	**35%**	$560,129
Median	$774,228	**40%**	$632,050
Mode	$0	**45%**	$704,504
Left X	$79,580	**50%**	$774,228
Left P	5%	**55%**	$851,501
Right X	$1,972,535	**60%**	$945,572
Right P	95%	**65%**	$1,019,800
Diff X	$1,892,954	**70%**	$1,101,501
Diff P	90%	**75%**	$1,209,671
#Errors	0	**80%**	$1,335,052
Filter Min	Off	**85%**	$1,476,653
Filter Max	Off	**90%**	$1,672,068
#Filtered	0	**95%**	$1,972,535

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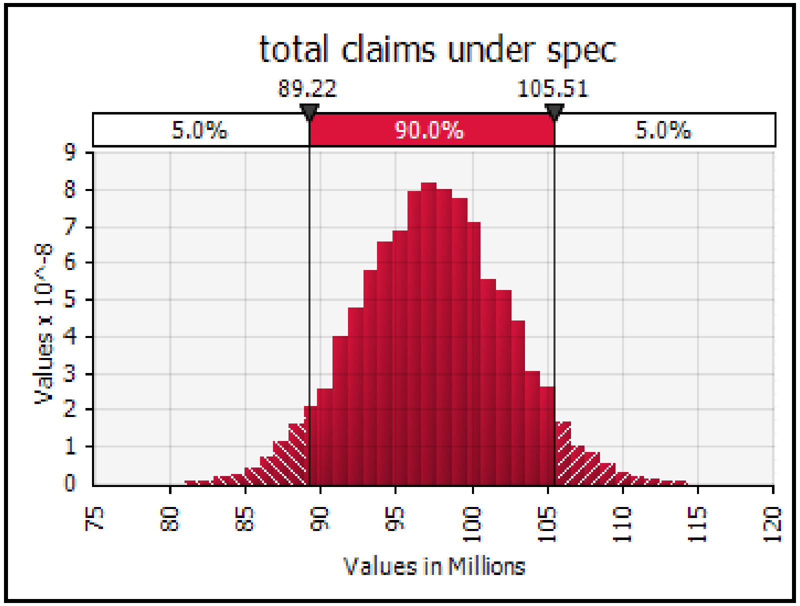

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Simulation Start Time	9/30/08 12:51:10
Simulation Duration	00:00:56
Random # Generator	Mersenne Twister
Random Seed	2056025269

Summary Statistics for total claims under spec			
Statistics		**Percentile**	
Minimum	$78,046,818	**5%**	$89,220,184
Maximum	$117,443,849	**10%**	$91,185,897
Mean	$97,449,004	**15%**	$92,260,402
Std Dev	$4,943,285	**20%**	$93,274,789
Variance	2.44361E+13	**25%**	$94,090,670
Skewness	-0.016172513	**30%**	$94,843,034
Kurtosis	2.979466945	**35%**	$95,575,101
Median	$97,444,286	**40%**	$96,242,341
Mode	$97,295,398	**45%**	$96,855,440
Left X	$89,220,184	**50%**	$97,444,286
Left P	5%	**55%**	$98,088,169
Right X	$105,507,237	**60%**	$98,713,995
Right P	95%	**65%**	$99,339,628
Diff X	$16,287,052	**70%**	$100,071,667
Diff P	90%	**75%**	$100,744,103
#Errors	0	**80%**	$101,654,737
Filter Min	Off	**85%**	$102,619,887
Filter Max	Off	**90%**	$103,779,162
#Filtered	0	**95%**	$105,507,237

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Case Study #1: Sample Results and Implications

		XOL limit $150,000	XOL limit $200,000	XOL limit $300,000	XOL limit $400,000	XOL limit $150,000 capped at $400,000
Claims over the XOL limit						
	Mean	$3,448,711	$2,433,703	$1,407,004	$862,065	$2,597,991
	Standard Deviation	$1,104,909	$970,433	$759,320	$590,973	$678,717
	Coefficient of Variation	32.0%	39.9%	54.0%	68.6%	26.1%
	75th percentile	$4,132,487	$3,033,870	$1,859,419	$1,209,671	$3,036,001
	85th percentile	$4,610,239	$3,443,046	$2,191,721	$1,467,330	$3,306,082
	95th percentile	$5,437,534	$4,183,948	$2,793,596	$1,965,372	$3,766,205
	Minimum	$433,830	$181,726	$0	$0	$612,969
	Maximum	$8,547,406	$7,941,955	$5,569,368	$4,110,943	$5,454,084
Claims below the XOL limit						
	Mean	$94,930,767	$95,958,424	$96,968,427	$97,587,025	$94,893,764
	Standard Deviation	$4,197,245	$4,558,732	$4,782,731	$4,914,901	$4,254,639
	Coefficient of Variation	4.4%	4.8%	4.9%	5.0%	4.5%
	75th percentile	$97,772,748	$99,022,670	$100,199,718	$100,865,265	$97,758,682
	85th percentile	$99,316,437	$100,667,285	$101,918,752	$102,628,136	$99,266,819
	95th percentile	$101,894,226	$103,455,799	$104,874,648	$105,650,456	$101,921,531
	Minimum	$78,683,807	$78,951,060	$80,178,166	$81,250,558	$79,000,934
	Maximum	$112,103,382	$112,041,432	$116,600,400	$118,820,811	$111,131,916
modeling is based upon 3 years historical data and assumes 35,000 covered lives						

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Case Study #2: Employer Stop Loss Insurance

- Definitions
  - Many employers (nearly all large employers) “self-fund” the healthcare benefits for their employees
  - But they limit their risk exposure by purchasing Employer Stop Loss Insurance
  - Specific Stop Loss – covers the risk that any <u>one individual’s claims</u> exceed a given $$ threshold (the “Specific Deductible”) in one year
  - Aggregate Stop Loss – covers the risk that <u>total claims for the group</u> exceed a given $$ threshold (the “Aggregate Attachment Point”) in one year

- Client was an underwriter of Employer Stop Loss Insurance looking to participate in the risk by forming a Captive Reinsurer

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Case Study #2: Purpose Of Building the Model

- Remember our “convolution” problem - a complex aggregation of distributions
  - Risks are intertwined because aggregate risk depends on the specific deductible size
  - We also have a portfolio of groups with different sizes and specific deductibles, and thus different risk distributions
  - Simulation is the only way to quantify the risks and understand the inter-relationships
- Determine capital and surplus requirements which are defined based on outcome likelihoods
- Regulatory requirements
- Provides a benchmark for monitoring performance going forward

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Case Study #2: Empirical Data

- Data elements specific to the covered employer groups
  - Range of group sizes and demographics
  - Range of specific deductibles
  - Aggregate as well as specific risk? (not all groups have both)
  - Rate model parameters
  - Historical results including variability across the above factors
- Certain "environmental" or less technical factors
  - Plans for business volume and growth
  - Regulatory environment / requirements
  - Expenses
- Developed customized claim continuance tables or distributions
- Distributions specify claim frequency and average claim size in 198 different size bands ($0 claims up to $2.5 million plus)

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Case Study #2:
Employer Stop Loss Insurance

Sample of customized (empirical) claim distribution used in simulation

distribution cell	claim size range	claim frequency	average claim size
1	non-claimant	0.201823	$0
2	>0-100	0.037605	$53
3	100-200	0.043446	$150
4	200-300	0.038102	$249
5	300-400	0.033471	$349
6	400-500	0.030051	$449
7	500-600	0.026787	$548
8	600-700	0.024324	$648
9	700-800	0.022083	$748
10	800-900	0.020319	$848
11	900-1000	0.018718	$948
12	1000-1100	0.017265	$1,047
13	1100-1200	0.016062	$1,147
14	1200-1300	0.014899	$1,247
15	1300-1400	0.013983	$1,347
16	1400-1500	0.013069	$1,447
*	*	*	*
*	*	*	*
*	*	*	*

distribution cell	claim size range	claim frequency	average claim size
91	24000-25000	0.002340	$24,483
92	25000-26000	0.002127	$25,473
93	26000-27000	0.001987	$26,474
94	27000-28000	0.001852	$27,483
95	28000-29000	0.001705	$28,462
96	29000-30000	0.001553	$29,473
97	30000-32500	0.003470	$31,179
98	32500-35000	0.002812	$33,692
99	35000-37500	0.002468	$36,201
100	37500-40000	0.002061	$38,699
101	40000-42500	0.001799	$41,217
102	42500-45000	0.001579	$43,705
103	45000-47500	0.001304	$46,170
104	47500-50000	0.001222	$48,674
105	50000-52500	0.001068	$51,191
106	52500-55000	0.000967	$53,716
*	*	*	*
*	*	*	*
*	*	*	*

distribution cell	claim size range	claim frequency	average claim size
183	1250000-1300000	0.000004	$1,271,040
184	1300000-1350000	0.000002	$1,331,602
185	1350000-1400000	0.000003	$1,376,906
186	1400000-1450000	0.000003	$1,427,281
187	1450000-1500000	0.000003	$1,474,188
188	1500000-1600000	0.000003	$1,542,129
189	1600000-1700000	0.000002	$1,651,998
190	1700000-1800000	0.000003	$1,763,366
191	1800000-1900000	0.000002	$1,853,297
192	1900000-2000000	0.000001	$1,948,248
193	2000000-2100000	0.000002	$2,054,121
194	2100000-2200000	0.000001	$2,161,123
195	2200000-2300000	0.000000	$2,266,564
196	2300000-2400000	0.000001	$2,313,825
197	2400000-2500000	0.000001	$2,439,469
198	>2500000	0.000003	$3,546,305

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Case Study #2: Detailed Modeling Approach

- Model office approach simulates Specific and Aggregate claims *separately for each group* (considers size and specific deductible)

- Specific Stop Loss modeling (individual claims)
  - Use a Poisson distribution to model large claim <u>frequency</u>
  - Expected value of the Poisson is defined by the claim distributions built from the empirical data
  - Large claim <u>size</u> (given the occurrence of a large claim) is generated from these same distributions
  - Use a conditional distribution for efficiency (only need to model claim amounts in excess of the specific deductible)

- Aggregate Stop Loss modeling (group claims)
  - Fit a normal distribution to claims under the specific deductible
  - Expected value is again defined by the claim distribution
  - The Aggregate Attachment Point is defined with respect to this expected value (e.g. 125%)
  - You have an Aggregate claim whenever simulated claims exceed the Attachment Point
  - Variance is a function of 1) population size; and 2) the specific deductible

- Run 10,000 trials for each simulation

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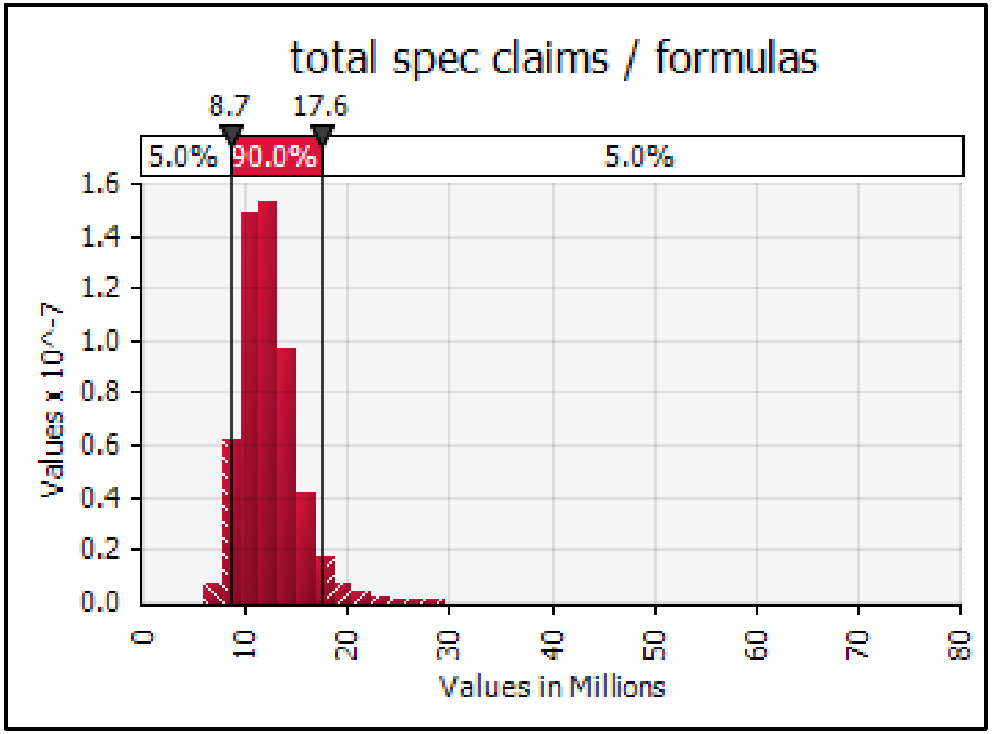
Case Study #2: @Risk Sample Output for Specific Stop Loss



Summary Statistics for total spec claims / formula			
Statistics		**Percentile**	
Minimum	$5,939,536	**5%**	$8,682,237
Maximum	$79,158,970	**10%**	$9,302,049
Mean	$12,496,243	**15%**	$9,789,260
Std Dev	$3,259,370	**20%**	$10,177,709
Variance	1.06235E+13	**25%**	$10,510,568
Skewness	3.463568093	**30%**	$10,823,809
Kurtosis	38.48036088	**35%**	$11,117,011
Median	$12,035,122	**40%**	$11,428,281
Mode	$12,059,220	**45%**	$11,740,217
Left X	$8,682,237	**50%**	$12,035,122
Left P	5%	**55%**	$12,331,343
Right X	$17,577,595	**60%**	$12,655,016
Right P	95%	**65%**	$13,022,898
Diff X	$8,895,358	**70%**	$13,412,477
Diff P	90%	**75%**	$13,821,204
#Errors	0	**80%**	$14,293,867
Filter Min	Off	**85%**	$14,948,585
Filter Max	Off	**90%**	$15,922,062
#Filtered	0	**95%**	$17,577,595

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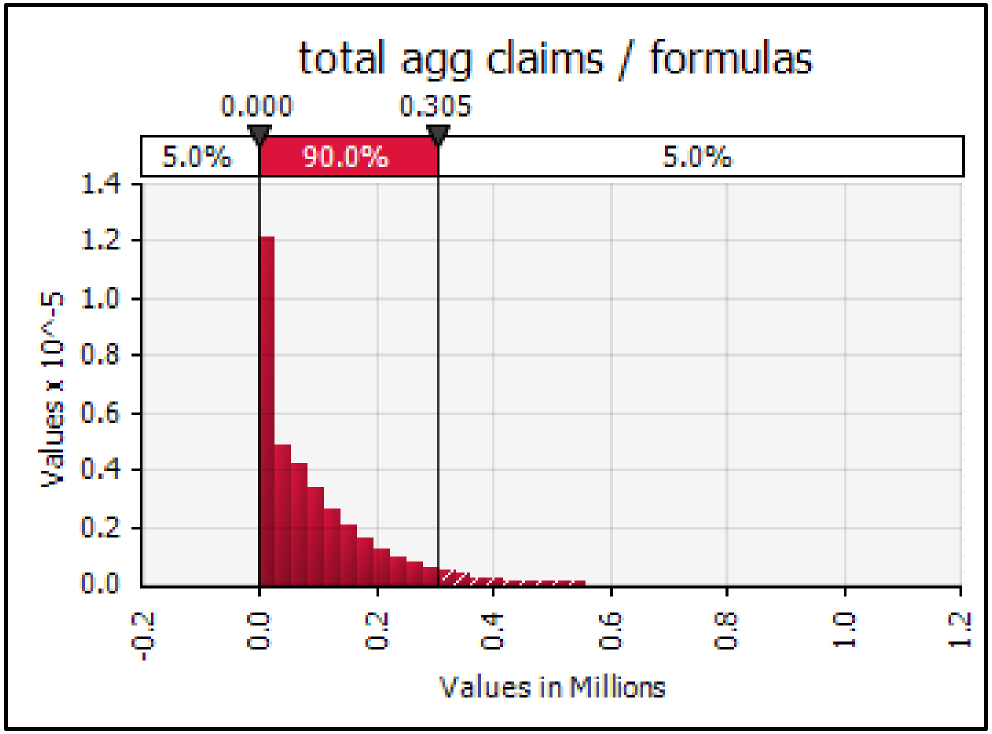
Case Study #2: @Risk Sample Output for Aggregate Stop Loss



Summary Statistics for total agg claims / formulas			
Statistics		**Percentile**	
Minimum	$0	**5%**	$0
Maximum	$1,117,178	**10%**	$0
Mean	$93,130	**15%**	$0
Std Dev	$105,541	**20%**	$2,503
Variance	11138884825	**25%**	$11,909
Skewness	1.973279933	**30%**	$20,992
Kurtosis	9.36901393	**35%**	$30,173
Median	$62,464	**40%**	$40,293
Mode	$0	**45%**	$50,919
Left X	$0	**50%**	$62,464
Left P	5%	**55%**	$73,512
Right X	$304,563	**60%**	$86,317
Right P	95%	**65%**	$100,885
Diff X	$304,563	**70%**	$117,333
Diff P	90%	**75%**	$136,258
#Errors	0	**80%**	$159,493
Filter Min	Off	**85%**	$190,461
Filter Max	Off	**90%**	$234,152
#Filtered	0	**95%**	$304,563

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Case Study #2: Interpreting the Model Results

- In addition to mean and variance, we examine simulated claim costs at varying percentiles (e.g. 75th, 90th, 95th, 97.5th, 99th)
- Then we can directly determine the financial requirements associated with funding the captive to those levels of claim costs
- For example, the required surplus at a given percentile level is equal to the simulated loss (if any)
- Determination of the premium-to-surplus ratio follows directly from simulation results and pricing assumptions

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Case Study #2: Interpreting the Model Results

Captive Program Feasibility Study								
Simulation Results and Recommended Surplus Levels								
hypothetical results - for illustrative purposes only								
Specific Stop Loss Results	mean	75th percentile	80th percentile	85th percentile	90th percentile	95th percentile	97.5th percentile	99th percentile
Gross Premium	$15,148,374	$15,148,374	$15,148,374	$15,148,374	$15,148,374	$15,148,374	$15,148,374	$15,148,374
Ceding Commission	$3,635,610	$3,635,610	$3,635,610	$3,635,610	$3,635,610	$3,635,610	$3,635,610	$3,635,610
Claims	$10,301,607	$11,624,634	$12,097,324	$12,750,441	$13,722,963	$15,375,748	$17,459,119	$20,954,139
Profit/(Loss)	$1,211,157	($111,870)	($584,560)	($1,237,676)	($2,210,199)	($3,862,984)	($5,946,355)	($9,441,375)
Required surplus to fund claims	--	$111,870	$584,560	$1,237,676	$2,210,199	$3,862,984	$5,946,355	$9,441,375
Ratio: gross premium to required surplus	--	135.4	25.9	12.2	6.9	3.9	2.5	1.6
Aggregate Stop Loss Results	mean	75th percentile	80th percentile	85th percentile	90th percentile	95th percentile	97.5th percentile	99th percentile
Gross Premium	$537,640	$537,640	$537,640	$537,640	$537,640	$537,640	$537,640	$537,640
Ceding Commission	$129,034	$129,034	$129,034	$129,034	$129,034	$129,034	$129,034	$129,034
Claims	$93,119	$136,250	$159,480	$190,459	$234,150	$304,528	$371,114	$458,103
Profit/(Loss)	$315,487	$272,356	$249,127	$218,148	$174,456	$104,078	$37,492	($49,496)
Required surplus to fund claims	--	$0	$0	$0	$0	$0	$0	$49,496
Ratio: gross premium to required surplus	--	n/a	n/a	n/a	n/a	n/a	n/a	10.9
Specific and Aggregate Combined	mean	75th percentile	80th percentile	85th percentile	90th percentile	95th percentile	97.5th percentile	99th percentile
Gross Premium	$15,686,014	$15,686,014	$15,686,014	$15,686,014	$15,686,014	$15,686,014	$15,686,014	$15,686,014
Ceding Commission	$3,764,643	$3,764,643	$3,764,643	$3,764,643	$3,764,643	$3,764,643	$3,764,643	$3,764,643
Claims	$10,394,726	$11,760,884	$12,256,804	$12,940,899	$13,957,114	$15,680,276	$17,830,233	$21,412,241
Profit/(Loss)	$1,526,644	$160,487	($335,434)	($1,019,529)	($2,035,743)	($3,758,906)	($5,908,863)	($9,490,871)
Required surplus to fund claims	--	$0	$335,434	$1,019,529	$2,035,743	$3,758,906	$5,908,863	$9,490,871
Ratio: gross premium to required surplus	--	n/a	46.8	15.4	7.7	4.2	2.7	1.7

- Gross premium and expenses are defined in the model by pricing assumptions
- Simulated claims are the variable in the table
- Required surplus and ratios are calculated directly

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Questions?

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