Reinsurance Proposal Evaluation Model

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1 Executive Summary

Reinsurance is insurance for insurance companies to mitigate risk, and minimize the amount of cash reserves an insurance company needs to hold. Similar to standard health insurance, reinsurance has a premium, deductible, and a maximum. Companies send proposals for reinsurance to my current employment (an insurance company) and my department evaluates these proposals using mathematics, such as expected values, calculus, and probability theory. As a check to these calculations we simulate what we think will happen using resampling techniques in excel. I built a dynamic decision support system that evaluates and analyzes reinsurance proposals using Monte Carlo simulations, or resampling, in excel; i.e., created a model that decides the reinsurance proposal to accept.

The model does the following based on the inputs registered: (1) It calculates the premium of reinsurance, (2) it calculates the end payout of the reinsurance company, (3) it calculates the amount the insurance company is responsible for, (4) it calculates the amount saved by purchasing reinsurance and (5) provides analysis of the output.

Based off the analysis the user can make the decision on which reinsurance to purchase, or to not purchase reinsurance at all.

2 Implementation Documentation

In order to evaluate reinsurance proposals, I needed to (1) sample with replacement from the possible annual claim amounts with the correct probability for each claim, (2) calculate the amount saved by purchasing reinsurance based on the different proposals, (3) analyze the amount saved based on a significant amount of simulations. I did the following in excel to accomplish this:

- Set up the worksheet by adding an inputs area, outputs area and table of claim amounts with their probabilities
- Sampled with replacement from the distribution and stored it in array
- Calculated the premium, payouts, and savings according to the inputs and the sample's distribution
- Stored the simulation data on the worksheet

- Analyzed the simulations with conditional formatting and box & whisker plot
- Made the workbook user friendly by adding buttons, userforms, comments and ribbon modifications

2.1 Set Up the Worksheet

The following table was added as a place to sample from.

	A	B	C	D	E
1	Reinsurance Proposal Evaluation				
2				Sample	3,200
3		Claims frequency	Annual Claim	Claims cdf	Annual Claim
4				0	$0
5		0.13296	$0	0.1329563	$10
6		0.02454	$10	0.1574979	$40
7		0.02057	$40	0.1780692	$70
8		0.02561	$70	0.2036792	$100
9		0.02602	$100	0.2297027	$130
10		0.01823	$130	0.2479334	$150
11		0.02265	$150	0.2705814	$180
12		0.02100	$180	0.2915772	$210
13		0.01996	$210	0.3115376	$240
14		0.01277	$240	0.3243052	$260
15		0.01192	$260	0.3362284	$310
16		0.02487	$310	0.3610983	$360
17		0.02876	$360	0.3898548	$410
18		0.02664	$410	0.4164980	$470

Figure 1: Distribution of Claims Table

The third and fourth column of the table have the following formulas.

	A	B	C	D	E
1	Reinsurance				
2				Sample	=VLOOKUP(RAND(),$D:
3		Claims frequency	Annual Claim	Claims cdf	Annual Claim
4				0	=C5
5		0.132956347984878	0	=B5	=C6
6		0.0245415759383217	10	=B6+D5	=C7
7		0.0205712759383217	40	=B7+D6	=C8
8		0.0256099759383217	70	=B8+D7	=C9
9		0.0260234759383217	100	=B9+D8	=C10
10		0.0182307240616783	130	=B10+D9	=C11
11		0.0226479759383217	150	=B11+D10	=C12
12		0.0209958759383217	180	=B12+D11	=C13
13		0.0199603759383217	210	=B13+D12	=C14
14		0.0127676240616783	240	=B14+D13	=C15

Figure 2: Distribution of Claims Table Formulas

I designated an area for the user to put in their membership and number of simulations needed. This includes an area for members who are in government programs(e.g., Medicaid, or Medicare), and an area for members in commercial lines of business (e.g., Individual, Large Employer, Self Funded).

Inputs	
# of Simulations	1
Government mms	1,000
Commercial mms	9,000
TOTAL # of Members	10,000

Figure 3: Inputs

I designated an area for the standard reinsurance inputs; deductible, first maximum, percent of first maximum covered, second maximum, percent of second maximum covered, payment per member per month for government programs(PMPM-gov), and payment per member per month for commercial lines of business(PMPM-com). I designated an area for the important outputs; the payout of the reinsurance, the amount the insurance is responsible for, the premium, and the amount saved.

Proposal 1				
Deductible	600,000	Reinsurnace	$ 1,950,000	
Maximum 1	5,000,000	Insurance	$ 46,640,400	
% of Maximum 1	50%	Check	$ 48,590,400	TRUE
Maximum 2	-	Premium	$ 213,000	
% of Maximum 2	0%	Save	$ 1,737,000	
PMPM-government	$ 2.00			
PMPM-commercial	$ 1.75			

Proposal 2				
Deductible	1,000,000	Reinsurance	$ 2,440,000	
Maximum 1	2,000,000	Insurance	$ 46,150,400	
% of Maximum 1	70%	Check	$ 48,590,400	TRUE
Maximum 2	3,000,000	Premium	$ 364,800	
% of Maximum 2	80%	Save	$ 2,075,200	
PMPM-government	$ 3.40			
PMPM-commercial	$ 3.00			

Proposal 3				
Deductible	1,000,000	Reinsurance	$ 2,640,000	
Maximum 1	2,000,000	Insurance	$ 45,950,400	
% of Maximum 1	80%	Check	$ 48,590,400	TRUE
Maximum 2	3,000,000	Premium	$ 483,600	
% of Maximum 2	80%	Save	$ 2,156,400	
PMPM-government	$ 4.30			
PMPM-commercial	$ 4.00			

Figure 4: Inputs cont. and Outputs

I designated an area for the savings of each simulation.

	Savings by Simulation			
Simulation	Proposal 1	Proposal 2	Proposal 3	No Reinsurance
1	$ 112,000	$ (189,800)	$ (283,600)	0
2	$ 2,787,000	$ 3,265,200	$ 3,516,400	0
3	$ 1,087,000	$ 1,195,200	$ 1,276,400	0
4	$ (113,000)	$ (364,800)	$ (483,600)	0
5	$ 2,237,000	$ 2,385,200	$ 2,636,400	0
6	$ 3,762,000	$ 3,960,200	$ 4,436,400	0
7	$ 387,000	$ 195,200	$ 156,400	0
8	$ 112,000	$ (189,800)	$ (283,600)	0
9	$ 387,000	$ 195,200	$ 156,400	0
10	$ 2,137,000	$ 2,225,200	$ 2,476,400	0
11	$ 712,000	$ 370,200	$ 356,400	0
12	$ 1,512,000	$ 1,370,200	$ 1,476,400	0
13	$ 1,037,000	$ 545,200	$ 556,400	0
14	$ 2,287,000	$ 3,435,200	$ 3,516,400	0
15	$ (113,000)	$ (364,800)	$ (483,600)	0
16	$ 387,000	$ 195,200	$ 156,400	0
17	$ (213,000)	$ (364,800)	$ (483,600)	0
18	$ 4,962,000	$ 5,880,200	$ 6,356,400	0
19	$ 837,000	$ 825,200	$ 876,400	0
20	$ 1,737,000	$ 2,075,200	$ 2,156,400	0

Figure 5: Simulations Output

2.2 Sample with replacement from the distribution and store the sample in an array

The VLOOKUP function has "approximate match" as an alternate fourth parameter. I used this feature to sample from the claims table and its probabilities.

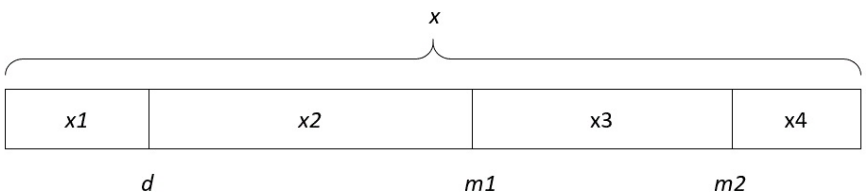
	D	E	F	G
	Sample	=VLOOKUP(RAND(),$D$4:$E$100,2,TRUE)		
	Claims cdf	Annual Claim		# of Simulations
	0	$0		
50	0.1329563	$10		Government mms
10	0.1574979	$40		Commercial mms
40	0.1780692	$70		TOTAL # of Member
70	0.2036792	$100		
00	0.2297027	$130		Proposal 1
30	0.2479334	$150		Deductible
50	0.2705814	$180		Maximum 1
30	0.2915772	$210		% of Maximum 1
10	0.3115376	$240		Maximum 2
40	0.3243052	$260		% of Maximum 2

Figure 6: Sample From Distribution

In VBA I sampled from the distribution n times (n = 10,000, n is the number of members) and stored it in an array.

2.3 Calculations: Premiums, Payouts and Savings

For each claim I calculated how much reinsurance and insurance would pay then aggregated the numbers. The figure below gives an idea on how each individual claim is calculated. In VBA I used an "If.. Elseif.. Else... End If" to do the right calculation for the right claim size.



*Reinsurance = x2 * p1 + x3 * p2*
*Insurance = x1 + x2 * (1-p1) + x3 * (1-p2) + x4*

Let *x = total amount of claim*
x_i = segment i of x
d = deductible
m_i = maximum i
p_i = percent of maximum i

Figure 7: Calculate One Claim

Premiums are calculated by multiplying the PMPM, the number of members, and the number of months. Savings is the premium subtracted from the reinsurance payout.

*Premium = PMPM * 12 * n*

Let n = the number of members

Savings = Reinsurance - Premium

Figure 8: Calculate Premium and Savings

2.4 Store Simulation Data

All calculations are placed in the proper output areas. See figure 4 & figure 5.

2.5 Analysis

For each simulation in the data the proposal with the highest savings is marked green and the proposal with the lowest savings is marked red. A box plot of the savings by proposal was added to assess the variance of each proposal. See figure 5 & figure 10. Based on these two figures the user can see which proposal will generally win the most as well as the variance. The user can make a decision on which proposal to accept, from that information.

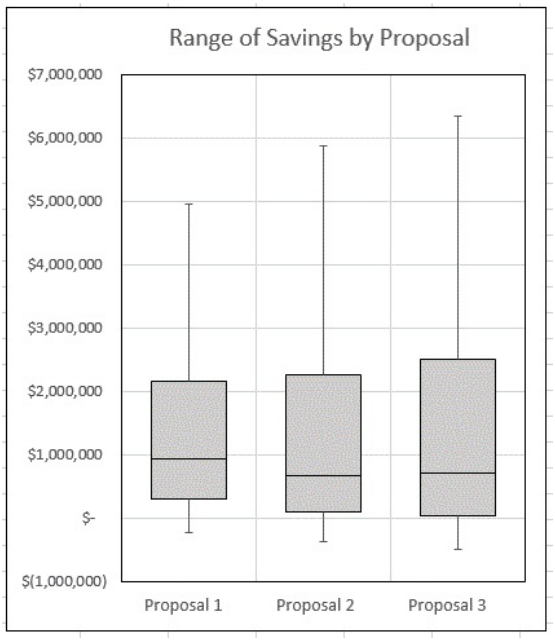


Figure 9: Box Plot of Savings by Proposal

2.6 User Friendly: Userform, Ribbon Modification, Buttons

In order to make the model more user friendly I added a ribbon modification with buttons, buttons on the workbook and a userform to edit inputs. Comments were made for users unfamiliar with some of the terminology. The intended audience of the comments and model is for someone with underwriting experience.

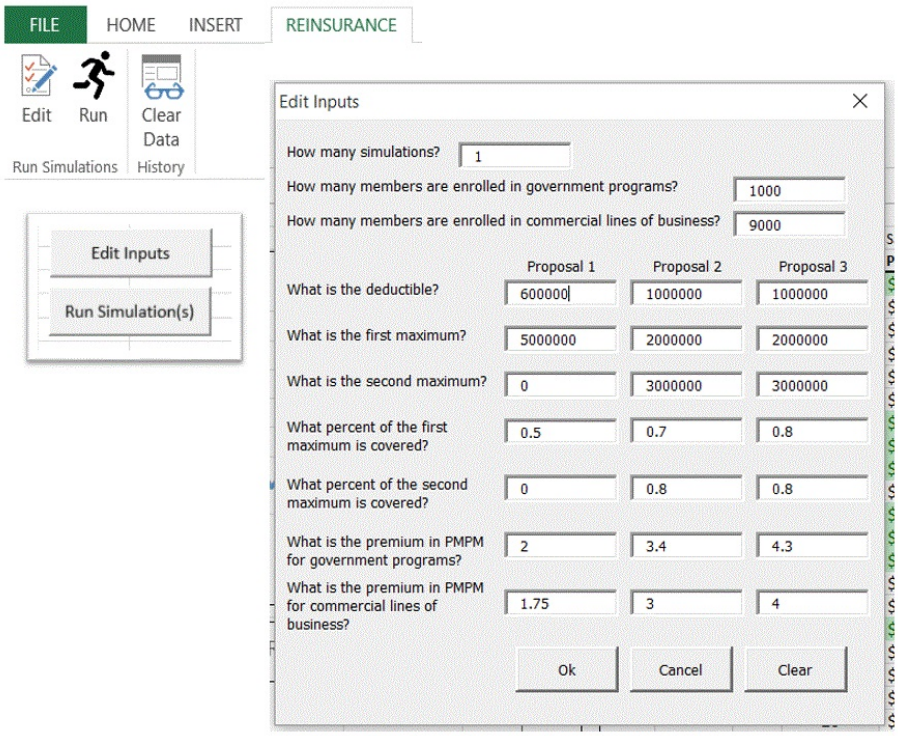


Figure 10: Ribbon Modification, Userform, Buttons

3 Learning and Conceptual Difficulties

3.1 Learned Items

I learned the following:

- How to sample from a discrete distribution in Excel
- How to plot different statistical graphs in Excel; probability distribution functions, cumulative distribution functions, histograms and box and whisker
- How to modify a Ribbon

3.2 Further Improvement

In order to improve the model I hope to do the following:

- Increase the number of proposals that can be compared. The current limit is three.
- Speed up the process of the macro by sampling in a statistical program and then having VBA load the array in the back end.
- Segment the members into even smaller groups rather than only two; commercial and government.

4 Assistance

I received no substantial assistance. All data is masked. The distribution of claims came from data at work and then heavily manipulated. All Inputs are fake, or mock-up.