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Using Simulation Modeling to Evaluate a Medical Insurer's Reinsurance Coverage – A Case Study

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Abstract

This paper demonstrates how to use simulation modeling to support the decision making process of a medical insurer. We do this in the context of a simplified but realistic example where a medical insurer is evaluating a request for proposal to provide stop-loss coverage for a Trust which provides comprehensive medical coverage to employees of a major conglomerate. We identify issues or risk factors that we want to capture in a simulation model. We discuss why simulation modeling is particularly useful in assessing these risk factors. We then walk the reader through the whole process, from trending the data to creating the simulation model. Next, we go over the outputs generated from the simulation and recognize that the simulation model captures only some of the risk factors faced by the health insurer. Finally, we discuss other risk and success factors for a health insurer and discuss various risk management considerations. In this larger context, we discuss optimal risk management and how simulation modeling may be useful in the process.

<u>Background</u>

Early morning, Friday 28th December 2005, Heather Lindt, manager of Victory Trust was reviewing the PowerPoint presentation she delivered to the Board a day earlier. The first graph, reproduced as Figure 1 below, displays the frequency distribution of claims in 2005. The general shape of the distribution, with a high frequency of small claims and a low frequency of large claims, is typical of Victory Trust's experience. She attributes this to individual catastrophic medical expenses. Heather Lindt is exploring ways to stabilize cash flow and manage funding requirements. Her review of past experience led Heather Lindt to conclude that the best way to manage the fluctuation in loss payments is to purchase a per individual stop loss insurance policy. Since the stop loss premium is inversely related to the amount of loss retained by the Trust, she needs to trade off insurance premium cost with expense fluctuation. She conjectures that the Board will find that the per individual deductible at $200,000 would give the Trust the enough stability.

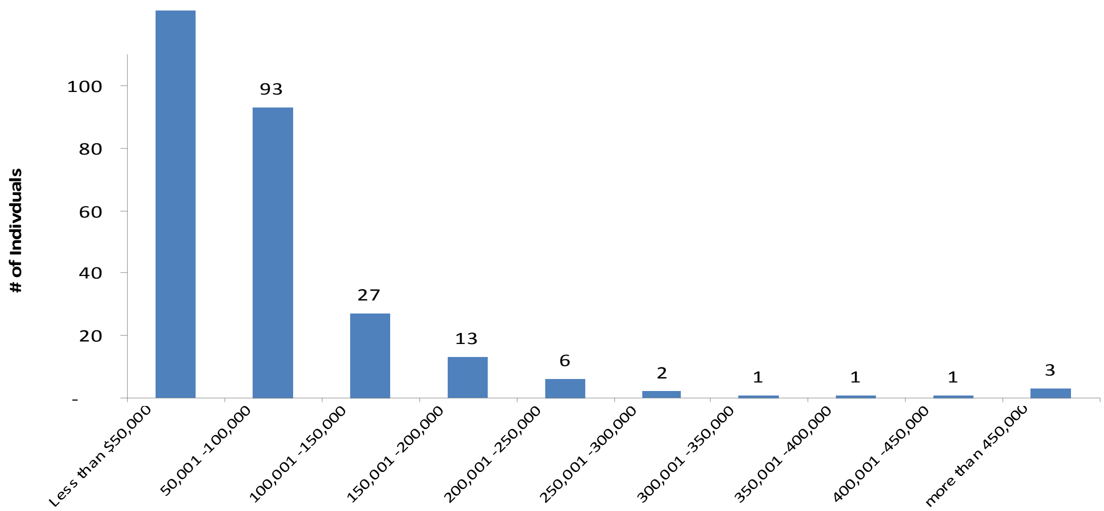

Figure 1 Individual Annual Medical Expense

The next graph, reproduced as Figure 2 below, summarizes the risk that would have been transferred with the stop loss insurance over the past five years. There is significant fluctuation in both the excess claim frequency and average excess claim severity. There is also a general upward trend on the excess claims frequency and excess claim severity.[1]

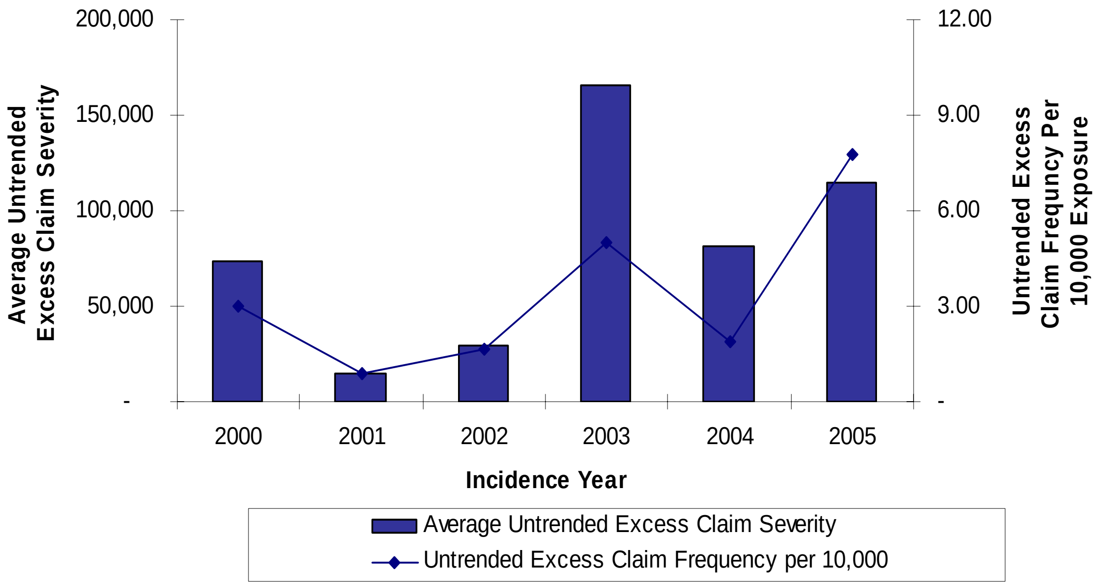

Figure 2 Un-trended Excess Claim Severity

Based on her recommendation, the Board has authorized a request for proposal ("RFP") stating that only policies with an attachment of $200,000, a maximum premium of $15.00 per individual per month and a 6 months run-out period[2] will be given serious consideration. Also, the Board agreed to give Delta Life and Health, a small life and health insurer with which the Trust has had a good, long standing relationship, the first shot at this stop loss opportunity.

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[1] This is largely due to a general trend in medical costs for the population covered by the Victory Trust.

[2] This means claims must be paid within the policy period plus 6 months after the end of the policy period to be eligible under the stop loss policy.

Heather Lindt called Delta's Vice-President, David Jones, about the opportunity. He is quite pleased with the news, which couldn't have come at a better time: he is facing enormous pressure from the Board to deliver significant premium growth. However, he also has to consider the possibility that the Management Committee may be concerned that the product is riskier than Delta's current portfolio.[3] This is of particular concern at this time, given the upcoming rating agency annual review. David Jones decides to make a preliminary assessment of the risk and return associated with the opportunity.

He starts by taking a closer look at medical experience data provided by Victory Trust. The data covers claims of at least $50,000 each from year 2000 to year 2005. Delta examined and concluded that all historical claims over $50,000 were paid before the run-out period expired so there is no need to truncate any claims to reflect the run-out period. Victory Trust certified that claims over $100,000 are complete in the 2000-2005 historical experience period and there are no other potential claims that will penetrate the $200,000 level during that period. Since the claims are complete, there is no adjustment to account for unknown claim development in the 2000-2005 experience period.

To make the claims in different years comparable, he indexes all the claims to year 2005 by multiplying the actual claims during the incidence year by the corresponding cumulative trend factors[4] in Table 1. For example, a ground-up claim of $114,775 in 2000 would be multiplied by 1.78 to produce the trended value of $204,063 for 2005. A ground-up claim of $120,064 in 2003 would be multiplied by 1.27 to produce the trended value of $151,953 for 2005. The resulting trended excess claim cost on a per person per month ("PPPM") basis is graphically illustrated in Figure 3, together with the offered premium rate of $15.00 PPPM.

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[3] Operating with a capital base of $15 million, Delta's current portfolio consists of insurance policies of small sizes and low maximum exposure. Together, its portfolio of group term life, group dental, and group health polices generates total annual gross premium revenue of $25 million.

[4] Annual trend factors are based on trend rates published by actuarial and employee consulting firms including Segal, Towers Perrin, Aon and Milliman.

Year	Annual Trend	Cumulative Trend Factor to 2005
2000	11%	1.78
2001	12%	1.60
2002	13%	1.43
2003	13%	1.27
2004	12%	1.12
2005		1.00

Table 1: Historical Trend Factors

David Jones concludes that the opportunity looks promising, but warrants closer scrutiny. He wants to find out if the margin between the offered premium and the trended experience, as illustrated in Figure 3, is adequate to cover (1) the leveraged medical trend[5] from 2005 to 2006, (2) the known potential claims[6], (3) a reasonable range of claim cost fluctuation with consideration that the risk controls rest largely on the Trust[7], (4) administrative expenses and (5) return on capital.

[5] Medical trend is leveraged for claims in excess of a fixed deductible. For example, a 10% trend on a $300,000 medical expense or $100,000 excess claim after $200,000 deductible becomes a $330,000 medical expense or $130,000 excess claim after $200,000 deductible. The leveraged medical trend in this case is 30% on the excess claim.

[6] As part of the medical underwriting process, the insurer has identified four covered persons who have known medical conditions that could results in medical expenses above the $200,000 deductible level.

[7] The Trust is self-administered through its wholly owned third party administrator. The Trust determines the eligibility of who is covered in the trust, handles all the administration including claim adjudications and obtains stop loss indemnity from the insurer on claims in excess of the self-funded amount for each covered life. This exacerbates Delta's risk at front end at the acceptance stage, as well as, the backend at the claims payment stage because the controls largely rest on the Trust, not Delta's.

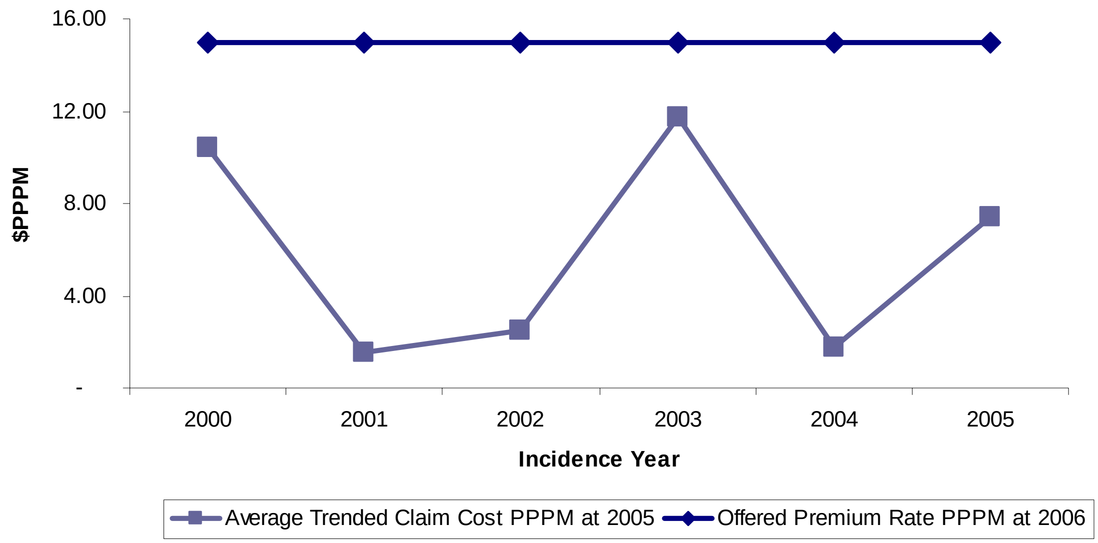

Figure 3 Trended Excess Claim Cost PPPM

While an opportunity may appear profitable on the average, realized results will likely to deviate from expected values. From a capital employment and book value enhancement perspective, the Board is interested in the Victory Trust's new business opportunity, while the Management Committee is concerned about the probability that the new business could deplete Delta's capital position in the event of underwriting loss. Thus, in a sense, the interest of Delta's Board in premium growth and the concern of its Management Committee about incremental portfolio risk are two sides of the same coin. We develop below one of the many ways in which one can employ simulation modeling in establishing a plausible range of values for the probability that the new business from Victory Trust will deplete Delta's capital position.

Simulating Stop Loss Claims Frequency

We use @Risk, an Excel add-in, to demonstrate how to develop and run a simulation model.[8] You need to know about two kinds of cells that @Risk uses. Input cells are random variables. Output cells are the forecasts of the model, or the things we are interested in understanding. In the example, the frequency of claims from unknown conditions, the severity of individual claims (in 2005 values) from unknown conditions, the severity of individual claims (in 2005 values) from known conditions, and the 2006 trend factor are random variables. Input cells themselves use placeholders that are numeric values, as opposed to formulas, and @Risk replaces these placeholders as it draws new values from a distribution. In the example, the output cells of interest are the ending capital position. @Risk runs a simulation by repeatedly drawing random variables for each of the input cells and recalculating the spreadsheet for each draw of the random variables. @Risk then stores the values of the output cells so that it can report the distribution. We model claims frequency and individual loss severity under the assumption that the distribution of trended claims in the experience period (2000-2005) is a good approximation to the distribution of claims in the rating period (2006).[9]

Let's start with claims frequency.[10] Based on the trended claims data, summarized in Table 2 below, 895 claims were filed out of a total number of 81,000 exposures. If the past trend continues, that would put the probability of a claim being made at p=1.10%. Assuming a total number of n=20,000 exposures in the rating period (2006), this would

[8] Two widely used spreadsheet-based simulation software are Crystal Ball and @Risk. A trial copy and information about Crystal Ball can be obtained from http://www.crystalball.com. A trial copy and information about @Risk can be obtained from http://www.palisade.com. Crystal Ball and @Risk have comparable features. Familiarity with one easily transfers to the other. See Joaquin (2007) for a step-by-step teach by example introduction to @Risk.

[9] In reality, the period from 2000 to 2005 may not be homogeneous from year to year. In addition to statistical fluctuations, certain factors might or might not be present in each year. If they are, the degree and influence could be different. For example, low birth weight (high claims) has become more of an issue in recent years partly due to the practice of in-vitro fertilization. The number of transplants has also increased tremendously. Both of these developments are influenced by many factors, including income levels and age distribution. If an underwriter knowingly or unknowingly put bad risks on the book, the book will perform poorly. It is unlikely that we have the same underwriter for all the years. Even when we do, many things could influence the underwriter's practice - s/he could become more experience in risk selection, s/he could be influenced by how s/he is compensated (by volume or profitability), etc.

[10] Claims here mean medical expenses exceeding $50,000 filed with Victory Trust. They might or might not become stop loss claims.

translate to an expected number of claims of np=220.99. Assuming that the loss events are independent, the variance of the number of claims would be np(1-p)=218.55.

Incidence year	Frequency	Exposure	Relative Frequency
2000	96	10,000	0.009600
2001	142	11,000	0.012909
2002	123	12,000	0.010250
2003	225	14,000	0.016071
2004	159	16,000	0.009938
2005	150	18,000	0.008333
Total/Composite	895	81,000	0.011049

Table 2: Claim Frequency based on Trended Data

Since the mean is practically equal to the variance, we choose the Poisson distribution with a mean of 220.99 to represent the frequency of reported claims.[11] This distribution is illustrated in Figure 3 below.[12] We complete our model of claims frequency by incorporating information on potential prospective claims, identified during the standard stop loss underwriting process. Delta established that known medical conditions during the experience period are expected to lead to four claims during the rating period that could penetrate through the stop loss deductible.

[11] If we compute the average frequency and variance per 20,000 for each year, it turns out that our assumption about the mean and the variance is equivalent to assuming that the expected number of claims is equal to the average of the annual average frequency and the variance is equal to the average of the annual variances. We note further that the minimum value of the number of insured claims distribution is less than 5 (the trended 2004 claim frequency per 20,000 covered lives) so the distribution is inclusive of the historical outcome.

[12] By inspection, it is clear that we could have as well modeled claim frequency with a normal distribution with the same mean and variance.

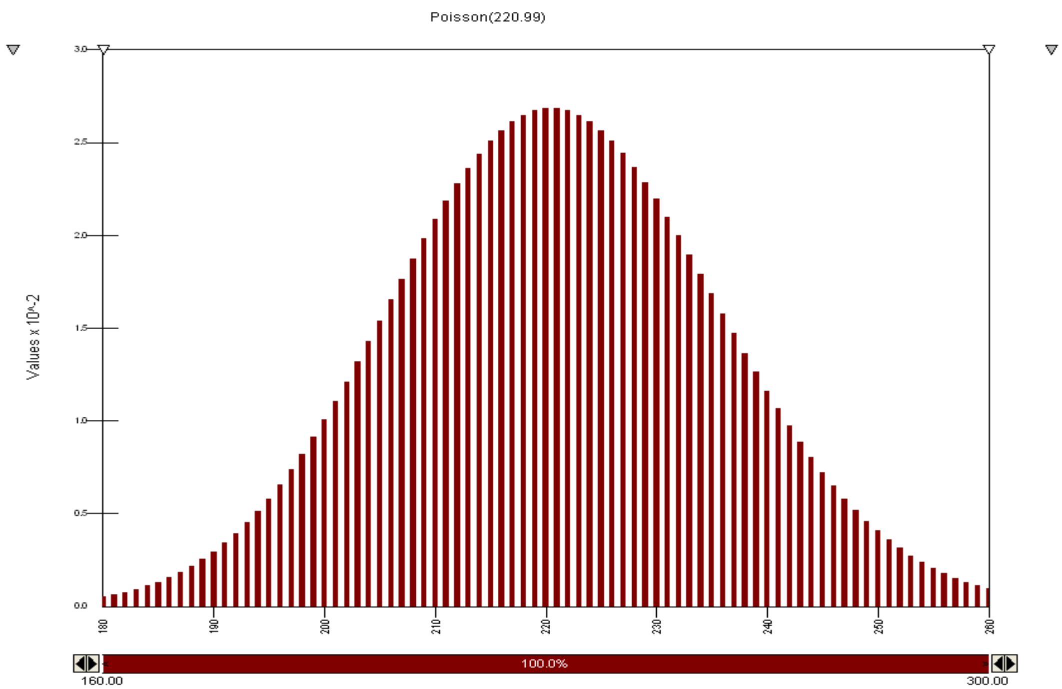

Figure 3: Distribution of Claim Frequency

Total simulated claims

$$\boldsymbol{C} = total\ stop\ loss\ claims = C(U) + C(K)$$

$$\boldsymbol{C}(U) = Total\ claims\ from\ unknown\ conditions$$

$$\boldsymbol{C}(U) = \sum_{i=1}^{N} C(U_i)$$

$$\boldsymbol{C}(K) = Total\ claims\ from\ known\ conditions$$

$$\boldsymbol{C}(K) = \sum_{j=1}^{4} C(K_j)$$

$$\boldsymbol{N} = Number\ of\ covered\ claims\ from\ unknown\ conditions$$

$$\boldsymbol{N} \sim Poisson(\lambda = 221)$$

$$\boldsymbol{Number}\ of\ claims\ from\ known\ conditions = 4$$

Individual Claim Severity

We now model individual claim severity. Earlier, we trended claims during the experience period (2000-2005) to 2005 using historical trend factors. What we do next is find the distribution that fits the trended data best in terms of standard goodness of fit measures, namely, the Chi-square statistic, the Kolmogorov-Smirnov statistic, and the Anderson-Darling statistic.[13] The Chi-square statistic measures how well the expected frequency, given the fitted distribution, compares with the observed frequency from a histogram of the observed data. It is most useful for fitting distributions to nominal data, where the issue of how the data is split to construct the histogram does not arise. The Kolmogorov-Smirnov statistic avoids the problem of specifying the number of intervals to split the data into by focusing only on the maximum vertical distance between the cumulative distribution function of the fitted distribution and that of the data. Its main weakness is that it ignores the lack of fit over the rest of the distribution. In particular, it will generally be insensitive to lack of fit at the tails of the distribution. In contrast, the Anderson-Darling statistic automatically takes the whole distribution into account by taking the probability-weighted sum of the squared vertical distance between the cumulative distribution function of the fitted distribution and that of the data at all data points. Thus, among the three, the Anderson-Darling goodness of fit criterion is the most appropriate for loss modeling applications. Based on this criterion, the distribution which fits the trended claims data best is the lognormal distribution.[14] The fitted lognormal distribution is illustrated in Figure 4 below.

[13] See Vose (2000) for a detailed discussion of goodness of fit criteria.
[14] The best fitting distribution using the Chi-square and the Kolmogorov-Smirnov statistic is the Inverse Gauss distribution.

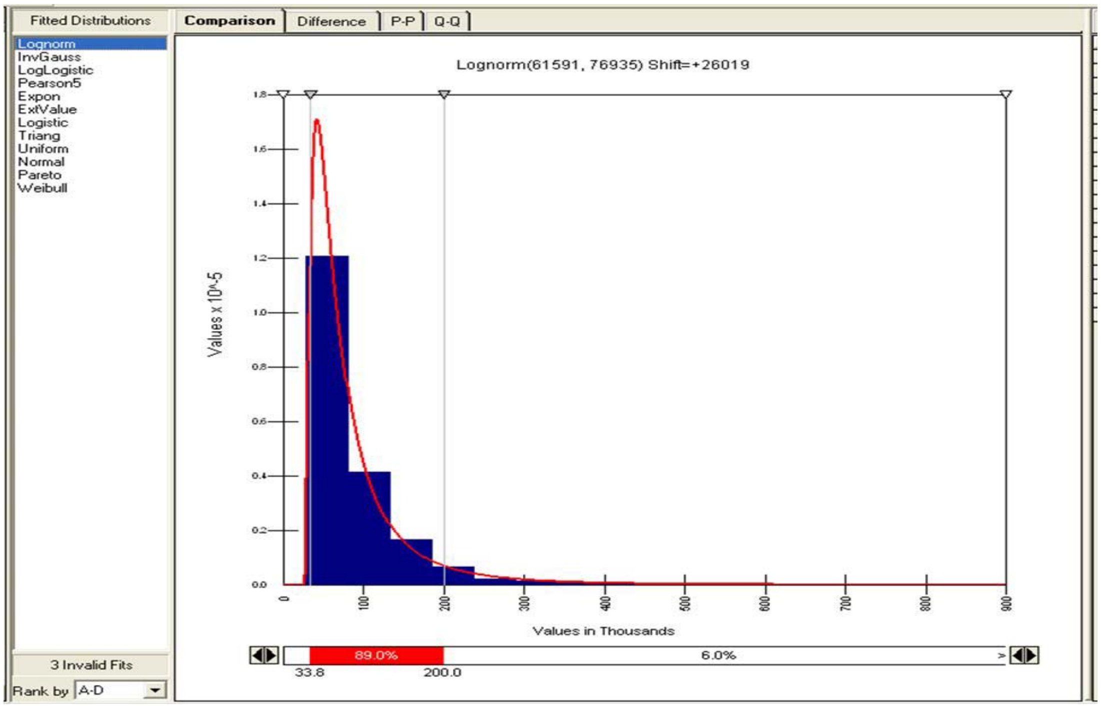

Figure 4: Fitted Claims Distribution

We trend samples from this fitted distribution to 2006, the rating period, using a stochastic trend factor. Based on industry forecasts available as of the end of 2005, we model this trend factor using pert distribution with a minimum value of 10%, a maximum value of 18% and a most likely value of 12%.[15] The associated density curve is given in Figure 5. The stop loss policy under consideration has a $200,000 deductible and the maximum exposure per life per coverage period is $800,000.

[15] Briefly, the Pert distribution can be described as a continuous distribution with compact support, a single mode, and where the likelihood of an outcome becomes less the farther away it is from the mode. The distribution can be made symmetric by choosing the mode to be midway between the maximum and the minimum. It can be made skewed by choosing the mode to be closer to one of the endpoints. In the current context, the parameters would be based on general medical trend, medical trend for large claims, medical provider discounts and the Trust's control on risk acceptance and claims processing.

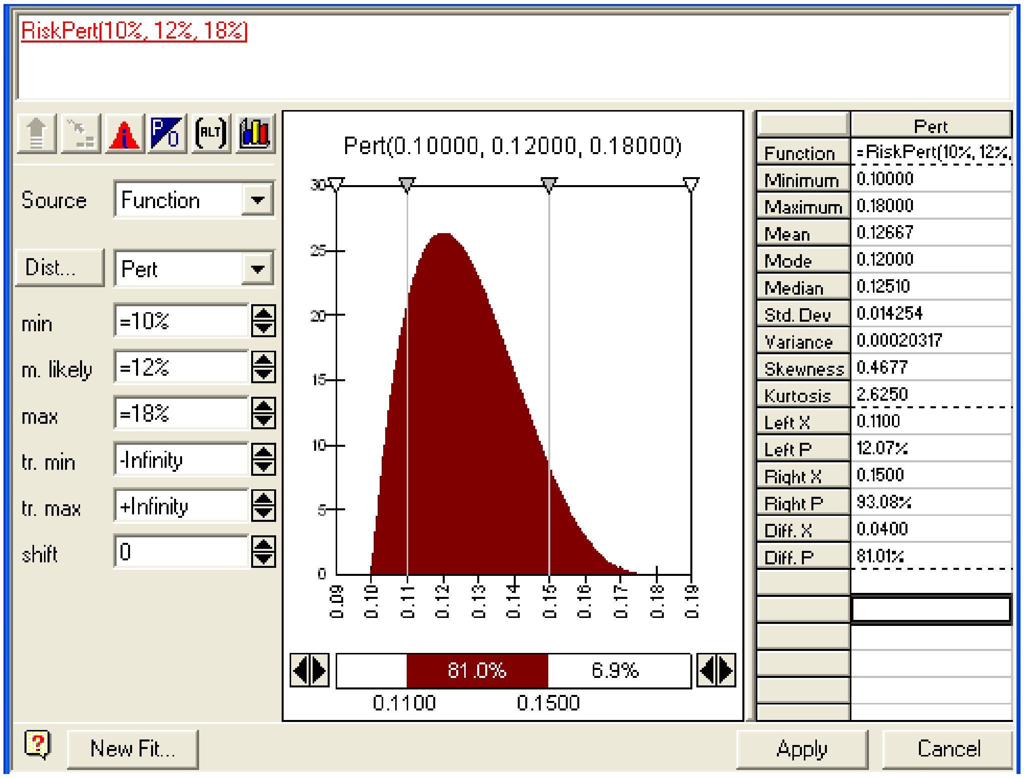

Figure 5: Distribution of 2006 Trend Factor

Severity of individual claims from unknown conditions

$$\boldsymbol{T} = 2006\ trend\ factor$$

$$\boldsymbol{T} \sim Pert(min = 10\%, most\ likely = 12\%, max = 18\%)$$

$$\boldsymbol{C}(U_i) = MIN[MAX(T \times U_i - 200000{,}0), 800000]$$

$$U_i \sim LOGNORMAL(\mu = 61591, \sigma = 76935, shift = 2619)$$

Let us now incorporate the four known claims that could penetrate through the stop loss deductible. Based on expert analysis of the four known conditions, the severity of these claims in 2005 values is assumed to follow the Pert distribution with parameters given in Table 3 (below).[16] The attachment point is $200,000 and the maximum exposure per life per coverage period is $800,000. Also, there is an allowance for total claims from known conditions equal to $96,248.[17] This means, for example, that Delta is expected to pay $829,536 to Victory Trust if the total of excess claims with known conditions is equal to $925,784.

Known Claims	Ground-up Claims Best Estimate	Ground-up Claims Minimum	Ground-up Claims 95th Percentile	Best Estimate Claims Trended to 2006	Minimum Claims Trended to 2006	Ground-up Claims 95th Percentile Trended to 2006	Simulated Claims with Known Condition in Excess of 200,000
1	$250,000	$225,000	$350,000	$280,000	$252,000	$392,000	113,048
2	$250,000	$225,000	$350,000	$280,000	$252,000	$392,000	113,048
3	$450,000	$400,000	$600,000	$504,000	$448,000	$672,000	349,844
4	$450,000	$400,000	$600,000	$504,000	$448,000	$672,000	349,844
Total							925,784
Allowance for Claims on Known Conditions							$96,248
Claims on Known Conditions in excess of Allowance							$829,536

Table 3: Severity of Known Claims

[16] We use the "Alt Parameters" feature of @Risk to substitute the expected value, the minimum value, and the 95th percentile as parameters of the Pert distribution, instead of the minimum, the maximum and the most likely value.

[17] The allowance is equal five percent of the product of the expected number of claims in the rating period and the average claim severity trended to 2005, the final year of the experience period.

Severity of individual claims from known conditions
$\boldsymbol{C}(K_i) = MIN[MAX(T \times K_i - 200000,0), 800000]$
$K_1 \sim PERT(Mean = 250000, Min = 225000, 95th\ percentile = 350000)$
$K_2 \sim PERT(Mean = 250000, Min = 225000, 95th\ percentile = 350000)$
$K_3 \sim PERT(Mean = 450000, Min = 400000, 95th\ percentile = 600000)$
$K_4 \sim PERT(Mean = 450000, Min = 400000, 95th\ percentile = 600000)$

Table 4 summarizes the results from simulating the assumed claims frequency and claim severity distributions.[18] From column (5), we find that the number of claims from unknown conditions filed with the Trust is expected to be 221, which is also equal to the variance. The more relevant figure to the insurer is the number of claims that actually pierces through the $200,000 deductible. From column (6), we find that the number of claims covered by the insurer is expected to be 17 on the average, with a variance of 18. Together, the severity of excess claims from known and unknown conditions is expected to be $2,848,556, with a standard deviation of $773,566.

[18] The simulation involved 10,000 iterations using Latin Hypercube sampling method.

(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
	Total Simulated Loss before Known Conditions	**Simulated Loss from Known Conditions in excess of allowance**	**Total Simulated Loss**	**Simulated Number of Claims Filed with the Trust**	**Simulated Number of Claims Covered by Insurer**
Minimum	130,457	544,476	960,088	165	4
Maximum	6,497,027	1,330,166	7,289,795	279	38
Mean	2,019,019	829,537	2,848,556	221	17
Standard Deviation	766,700	108,305	773,566	15	4
Variance	5.87828E+11	1.17299E+10	5.98404E+11	221	18
Skewness	1	0	1	0	0
Kurtosis	4	3	4	3	3
Number of Errors	-	-	-	-	-
Mode	1,850,832	778,778	2,679,947	220	17
5.0%	906,552	665,565	1,718,556	197	11
10.0%	1,101,333	694,963	1,920,447	202	12
15.0%	1,246,715	717,327	2,066,987	206	13
20.0%	1,356,253	735,561	2,184,140	208	14
25.0%	1,468,088	752,604	2,291,951	211	15
30.0%	1,562,069	766,480	2,395,554	213	15
35.0%	1,656,615	779,913	2,485,844	215	16
40.0%	1,749,753	793,445	2,576,896	217	16
45.0%	1,843,214	807,379	2,670,964	219	17
50.0%	1,931,271	821,235	2,763,032	221	17
55.0%	2,031,723	835,740	2,867,152	223	18
60.0%	2,140,865	850,185	2,969,108	225	18
65.0%	2,254,488	865,467	3,081,865	227	19
70.0%	2,366,755	881,459	3,195,008	229	20
75.0%	2,488,250	899,219	3,317,040	231	20
80.0%	2,624,980	919,416	3,474,580	233	21
85.0%	2,808,267	943,050	3,641,129	236	22
90.0%	3,045,315	973,707	3,872,895	240	23
95.0%	3,383,510	1,019,439	4,224,416	246	25

Table 4: Simulated frequency and severity of claims

Modeling the Stop Loss Opportunity and Hedging the Variability Risk

The extent to which the capital position is sensitive to claims variability depends how the insurer hedges variability risk. We will consider three alternative risk management policies:

Policy 1: No reinsurance.

In this case, the insurer absorbs all of the risk associated with claims variability. Ending capital is calculated as follows:

Policy 1: No reinsurance
S = Starting Capital = $15,000,000
P = Premium Revenue[19] = $3,600,000
C = Stop loss claims = Simulated stop loss claims
E = Administrative expenses[20] = $298,000
NIBT = Net Income Before Tax = P – C - E
T% = Assumed Tax Rate = 35%
NI = Net Income After Tax = NIBT x (1 – T%)
EC = Ending capital [21] = S + NI

Policy 2: 50% quota share reinsurance.

In this case, the insurer shares with its reinsurer a fixed proportion (50%) of the premium, the claims, and applicable insurer's expenses. In exchange, the insurer receives a ceding commission (10% of ceded premium revenue) from the reinsurer. Ending capital is calculated as follows:

[19]Premium revenue=$15 PPPM X 12 Months X 20000 Exposures.

[20] This includes $100,000 for fixed expenses and 5.5% of premium for variable expenses.

[21] Investment income on capital is excluded. Investment income on the incremental cash flow from the stop loss policy is marginal due to the short tail nature of the policy.

Policy 2: 50% quota share reinsurance
S = Starting Capital = $15,000,000
P = Premium revenue = $3,600,000C = Stop loss claims = Simulated stop loss claims
E = Administrative expenses = $298,000
RP = Ceded quota share reinsurance premium revenue = 50% x P = $1,800,000
CC = Quota share reinsurance ceding commission = 10% x RP = $180,000
RC = Quota share reinsurance claim recovery = 50% x Stop loss claim
NIBT = Net Income Before Tax = (P – C – A) – (RP – CC – RC)
T% = Assumed Tax Rate = 35%
NI = Net Income After Tax = NIBT x (1 – T%)
EC = Ending capital = S + NI

Policy 3: 50% quota share reinsurance + aggregate excess reinsurance on the retained share.

With the addition of an aggregate excess reinsurance, the reinsurer agrees to indemnify the primary insurer when the latter's aggregate loss for the year exceeds the retention limit ($1,950,000). In exchange, for a specific aggregate stop-loss maximum coverage ($1,000,000), the insurer pays a corresponding premium ($100,000) to the reinsurer. Ending capital is calculated as follows:

Policy 3: 50% quota share with aggregate excess reinsurance on retained share
S = Starting Capital = $15,000,000
P = Premium revenue = $3,600,000
C = Stop loss claims = Simulated stop loss claims
E = Administrative expenses = $298,000
RP = Ceded quota share reinsurance premium revenue = 50% x P = $1,800,000
CC = Quota share reinsurance ceding commission = 10% x RP = $180,000
RC = Quota share reinsurance claim recovery = 50% x Stop loss clam
ARP = Aggregate excess reinsurance premium = $100,000
ARA = Aggregate excess attachment point = $1,950,000
ARM = Aggregate excess maximum coverage = $1,000,000
ARC = Aggregate excess reinsurance recovery = MIN(MAX[(C – RC) – ARA,0],ARM)
NIBT = Net Income = (P – C – A) – (RP – CC – RC) – (ARP – ARC)
T% = Assumed Tax Rate = 35%
NI = Net Income After Tax = NIBT x (1 – T%)
EC = Ending capital = S + NI

Simulation analysis of alternative risk management policies

We employ simulation to evaluate the upside and downside risks associated with the alternative policies. Table 5 summarizes the results from simulating the assumed ending capital position associated with the three alternative risk management policies. On the average, the ending capital position is higher than the starting capital position of $15,000,000 under all three policies. Without reinsurance, the odds are 3 in 4 that Delta would realize an underwriting profit and enhance its capital position with the Victoria Trust stop loss business opportunity. Further, there is more than 33% probability of improving its capital position by at least $500,000. While the stop loss opportunity looks very attractive, given Delta's small capital base, the Management Committee is concerned that there is 5% probability that Delta will lose at least $500,000 of its $15,000,000 starting capital.

With 50% quota share reinsurance (Policy 2), the average ending capital position is less than the previous case where there is no reinsurance.[22] However, the downside is less as well: Delta will lose less than $300,000 with more than 95% probability. The addition of an aggregate excess reinsurance on the retained share (Policy 3) leads to further, although less pronounced, deterioration in the average ending capital position compared to the pure 50% quota share reinsurance case. But the downside is even less still: Delta will lose less than $250,000 but with more than 95% probability. While the aggregate excess of loss cover provides a strong downside protection, it can be argued that the downside protection does not warrant the high premium level of $100,000. In the end, David Jones decided to recommend acceptance of the Victory Trust stop loss business opportunity. To address the concerns of the Management Committee, David Jones also recommended sharing the risk with a reinsurer through a 50% quota share reinsurance treaty. In addition, he recommended the purchase of an aggregate excess of loss cover as "sleep" reinsurance.

[22] This is as expected because the stop loss opportunity is estimated to be profitable on an "expected" basis. Ceding 50% of the opportunity means less profit on the average. However, the capital position distribution is more favorable with 80% probability that Delta will make money. This is due to the leveraging of the ceding commission. The ceding commission on the 50% reinsured portion is less than 50% of the actual expense. Thus, Delta makes an administrative profit from the quota share reinsurance.

(1)	*(2)*	*(3)*	*(4)*
Outputs	**Capital Position at the end of the year / Without Reinsurance**	**Capital Position at the end of the year / 50% Quota Share**	**Capital Position at the end of the year / with Aggregate Stop-Loss**
Minimum	12,407,933	13,724,117	14,309,117
Maximum	16,522,243	15,781,271	15,716,271
Mean	15,294,739	15,167,519	15,117,670
Standard Deviation	502,818	251,409	219,194
Variance	2.52826E+11	6.32064E+10	4.80461E+10
Skewness	(1)	(1)	(0)
Kurtosis	4	4	2
Number of Errors	-	-	-
Mode	15,404,335	15,280,999	14,760,800
5.0%	14,398,092	14,719,196	14,760,800
10.0%	14,628,487	14,834,393	14,769,393
15.0%	14,778,958	14,909,629	14,844,629
20.0%	14,887,750	14,964,025	14,899,025
25.0%	14,990,169	15,015,234	14,950,234
30.0%	15,069,446	15,054,873	14,989,873
35.0%	15,142,753	15,091,527	15,026,527
40.0%	15,216,136	15,128,218	15,063,218
45.0%	15,282,648	15,161,474	15,096,474
50.0%	15,350,177	15,195,238	15,130,238
55.0%	15,409,748	15,225,024	15,160,024
60.0%	15,471,157	15,255,728	15,190,728
65.0%	15,530,481	15,285,390	15,220,390
70.0%	15,589,033	15,314,666	15,249,666
75.0%	15,656,362	15,348,331	15,283,331
80.0%	15,726,497	15,383,398	15,318,398
85.0%	15,802,732	15,421,516	15,356,516
90.0%	15,897,899	15,469,100	15,404,100
95.0%	16,029,005	15,534,652	15,469,652

Table 5: Comparison of Alternative Policies

Concluding Remarks

One of the useful outputs of a simulation is the ranking of input variables in terms of their influence on an output variable.[23] Table 6 displays such ranking in terms of standardized betas, obtained from multivariate stepwise regression.[24] The precise ranking can vary somewhat across simulations. However, the general pattern would be the same and is more significant than the precise ranking in a specific simulation. In Table 6, the rankings of input variables are about the same across all risk management policy regimes.[25] The number of claims filed with the trust is the most influential variable, followed by severity of claims (in 2005 values) from the two, more costly, known conditions. The severity of claims (in 2005 values) from unknown conditions and the 2006 trend factor also have significant and practically the same degree of influence on the ending capital position. This ranking is suggestive of what needs to be done to achieve a better distribution of the ending capital position. The list also highlights a weakness in the contractual relationship between Victory Trust and Delta Life and Health: Delta relies on the self-funded, self-administered Trust to perform accurate and unbiased administration consistent with guidelines. This, in itself, is a significant risk. Reinsurance would not be effective in managing this type of risk. What can help address this problem would be risk management procedures like:

a) Clear administration and stop loss agreements with strong contractual ramifications

[23] In our example, the output variable of interest is the ending capital position, and the input variables are the number of claims filed with the Trust, the severity of claims (in 2005 values) from each of the four known conditions, the severity of claims (in 2005 values) from unknown conditions, and the 2006 Trend factor.

[24] The stepwise regression technique regresses input variables against the output variable and excludes all variables that provide an insignificant contribution to the explanatory power of the model. The standardized betas are obtained by multiplying the coefficients from the final regression by the ratio of the standard deviation of the specific input variable to the standard deviation of the output variable. Thus, a standardized beta of 2 indicates that if x is increased by one standard deviation, then y is expected to increase by 2 standard deviations.

[25] The standardized betas are identical in the case of no reinsurance and 50% quota share reinsurance. This is to be expected since the 50% quota share does not change the relationship between marginal ending capital position and marginal claim costs. On the other hand, the introduction of an aggregate stop loss would alter this relationship by introducing a discontinuity at the attachment point. And so the coefficients for the last case are slightly different.

b) Frequent underwriting, claim and transactional audits on the Trust's administration Monitoring such as on-going claim experience reports, reports on individuals hitting catastrophic claim diagnosis, and reports on individuals reaching 50% of deductible
c) Claims and medical management support such as health care provider reimbursement negotiations, contracts with tertiary care and specialty provider network networks
d) Close working relationship with the Trust as an "involved" partner informed of underwriting and administration development.

(1)	*(2)*	*(3)*	*(4)*
	Standardized Beta / Without Reinsurance	**Standardized Beta / 50% Quota Share**	**Standardized Beta / with Aggregate Stop-Loss**
Number of claims filed with trust	(0.170)	(0.170)	(0.170)
Claim severity/3rd known condition	(0.087)	(0.087)	(0.088)
Claim severity/4th known condition	(0.080)	(0.080)	(0.082)
Claim severity/unknown condition	(0.068) to (0.082)	(0.068) to (0.082)	(0.065) to (0.077)
2006 trend factor	(0.075)	(0.075)	(0.075)

Table 6: Sensitivity Analysis

The optimal combination and configuration of risk management techniques is best chosen at the enterprise level, after analyzing, individually and collectively, all the risks to which Delta is exposed, not just the risks associated with the Victory Trust stop-loss business opportunity in isolation from other businesses of Delta Insurance. The enterprise risk management (ERM) approach can exploit natural hedges created by different businesses in the insurer's total portfolio and reveal opportunities for more efficient management of risk.[26] In terms of our example, the ERM approach requires supplementing our simulation model with an enterprise-level simulation model which includes not only the Victory Trust stop-loss business opportunity but also Delta's current portfolio of group term life, group dental, and group health policies.

[26] See Lam (2002) for a comprehensive introduction to enterprise risk management.

Caveats

The case is based on actual observed claim costs, which have been altered to disguise the actual nature of the data. This paper is intended to illustrate how simulation modeling can be carried out in a simplified but realistic setting. It is intended to promote the thoughtful application of simulation modeling in the practice of risk management.

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