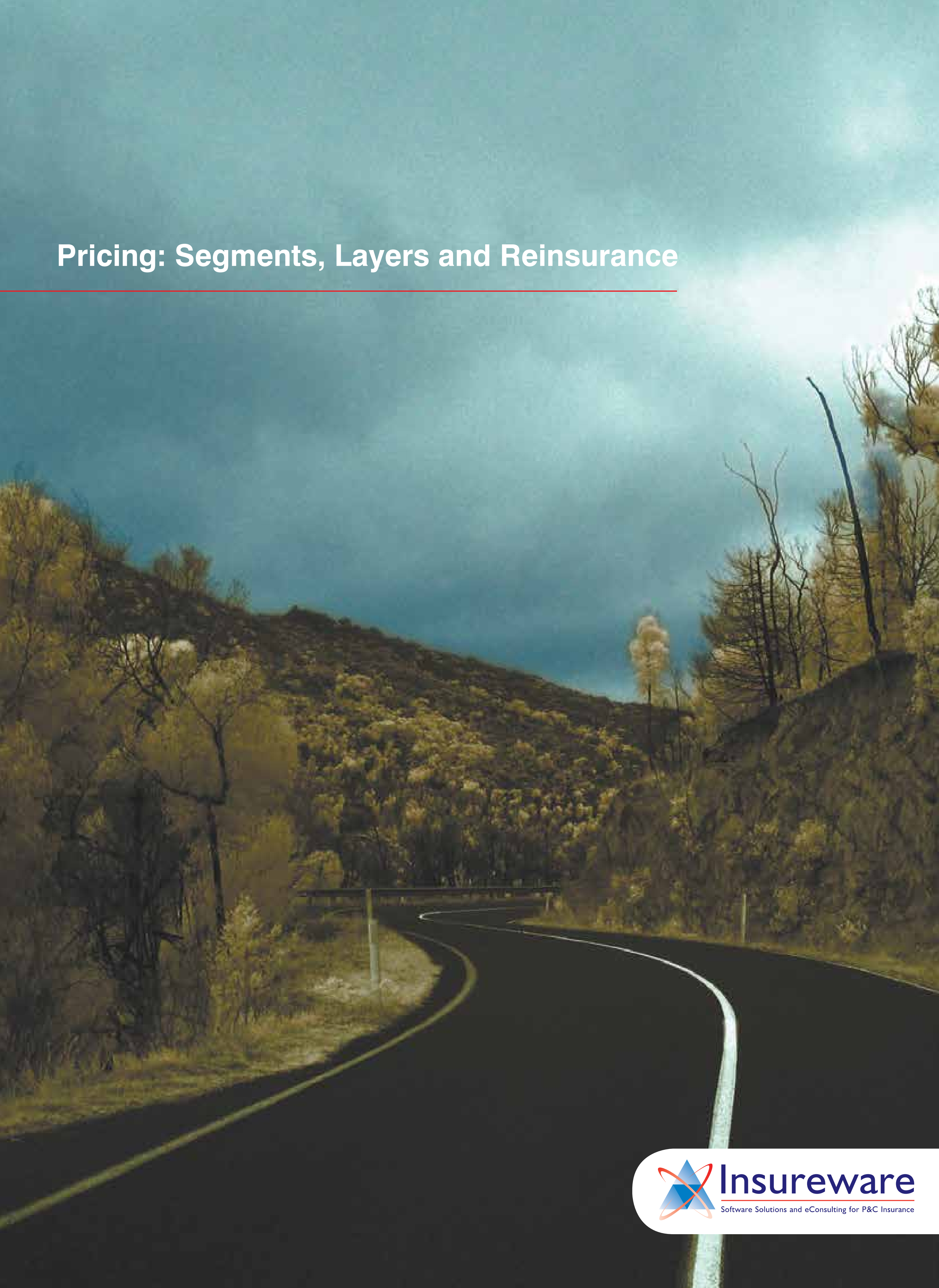
Pricing: Segments, Layers and Reinsurance



Insureware

Software Solutions and eConsulting for P&C Insurance

Contents

1. Introduction and Summary

Pricing, reserving and reinsurance of long tail liabilities are connected issues. All relate to modelling loss development arrays. In order to calculate the required measures accurately, it is important to use a modelling framework capable of extracting all the pertinent information from the data. Any assumptions made by the model or future forecasting scenarios should be transparent, auditable and verifiable.

Two modelling frameworks that satisfy these criteria are briefly described. These frameworks are both included in ICRFS-Plus™ - the only commercially available, interactive, integrated modelling software providing high powered analysis at unparalleled speed.

Within these frameworks, reserve risk, future accident (underwriting) year risk and the combined (reserving and future accident year) risk can be meaningfully evaluated. Combined risk is of the most import given that typically there is a significant proportion of renewable business. The two projections, reserve and underwriting, are not independent – it is important to consider the benefit of risk diversification of future underwriting periods with the reserve risk.

Case studies are provided which illustrate creative solutions to pricing and reinsurance applications. Examples include:

- Pricing future underwriting years - single and multiple segments;
- Assessing capital efficiency of outward reinsurance;
- Selecting optimal layers as outward reinsurance structures;
- Pricing high severity / low frequency layers;
- Assessing prospective and retrospective adverse development cover;
- Protection against adverse calendar year trends.

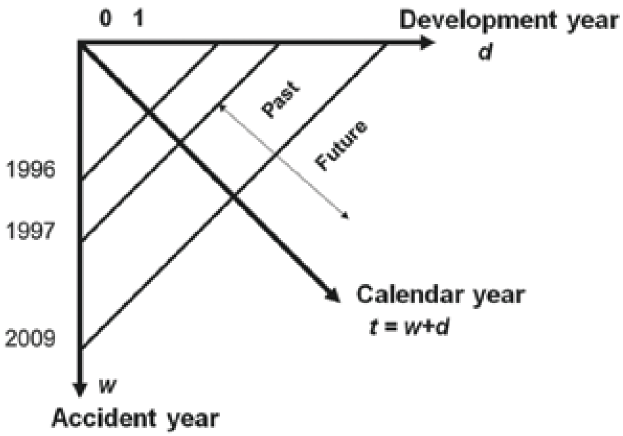
The selected examples highlight the effectiveness of ICRFS-Plus™ as a tool for assessing and pricing risk. All metrics are derived from the data where future assumptions are under the actuaries control. Additional distribution assumptions are not required. Note that loss distributions can be assessed from the perspective of the cedant or inward reinsurer simultaneously.

1.1. Modelling frameworks

In the Probabilistic Trend Family (PTF) modelling framework an optimal model is identified (designed) that captures (adjusts for) the trends in the three directions: development period, accident period and calendar period; and the distributions of the volatilities about the trends.

Single composite models are designed in the Multiple Probabilistic Trend Family (MPTF) modelling framework for multiple segments or LOBs. These models are built from the identified PTF models and include the correlation structure between the segments or LOBs.

The diagram below depicts the three directions with arguments d, w and t. Since t = w + d, it is axiomatic that any calendar year trend projects onto the development year and accident year directions.



The PTF and MPTF models uniquely address the features within the data – there is no set algorithm specifying a priori where trends (or volatility) changes occur. Trends are fully interpretable and are able to be related to events occurring in the business (whether driven by internal or external drivers). Each cell of the loss development array is related by the trend structure on a log scale. Correlations between the distributions, whether within or between segments (or LOBs), are incorporated directly in the model.

Random (loss development array) samples from the identified MPTF model are indistinguishable from the real loss development arrays in respect of statistical features. This test mitigates model specification error.

An identified model and forecast scenario projects log-normal distributions and their correlations (within segments; and, for MPTF, between segments) for each cell. Future trends: development year, calendar year and accident year (for pricing); and process volatility about the trends are completely within the actuary's control.

In this way, reserving, pricing, and reinsurance calculations can be conducted in a transparent manner with appropriate consideration of risk. For instance, if environmental conditions suggest a bad year for storms in the next underwriting period, then this expectation can be included in the projection by increasing the accident year level parameter and/or volatility by an appropriate magnitude. Alternatively, legislative changes may emerge as calendar year effects. If the actuary has information to suggest changes in forecast assumptions, then future trends can be monitored and revised accordingly.

In these modelling frameworks, probability distributions and their correlations are specified by the models and forecast scenarios for each cell. This attribute allows the design of creative solutions to estimate any statistical metric from the projected distributions. The same single composite model can be used for reserving, pricing, assessing risk diversification credit, evaluating inward/outward reinsurance programs, calculating Solvency II one year risk horizon metrics and much more! Further details can be found in other promotional material and on Insureware's website (www.insureware.com).

1.2. Case studies

The remainder of this document comprises a series of case studies illustrating the depth and breadth of applications of ICRFS-Plus™ to long-tail liability risk management.

Section 2: Pricing future underwriting years

Various strategies for pricing future underwriting years are discussed. Three examples serve to illustrate methods for pricing single segments, pricing multiple segments, and strategically amortising premium changes to reach management targets. Loss distribution metrics, including and T-V@R with: Tail-Value-at-Risk (T-V@R), are summarised in preparation for the subsequent sections.

Section 3: Assessing capital efficiency of outward reinsurance

Techniques to assess the capital efficiency of existing outward reinsurance, including E&O D&O segments, are demonstrated via two examples.

Section 4: Selecting optimal layers as outward reinsurance structures

Several examples of layers and the methods of selecting optimal, capital efficient, outward reinsurance structures are presented. The reinsurer loss distributions are also defined so efficiency can be considered from the point of view of the cedant or inward reinsurer.

Section 5: Pricing high severity / low frequency layers

An example of pricing the layer 5M xs 5M using the data limited to 5M and the data limited to 10M is described. The 5M xs 5M layer is replete with zeroes and pricing this layer on its own would be guesswork. The strategies encompassed in this section show how sparse upper layers can be projected utilising information in the ground-up or other limited data.

Section 6: Assessing prospective and retrospective adverse development cover

Creative solutions are presented which illustrate the assessment of adverse development cover both retrospectively and prospectively. The analysis is performed on multiple lines, an individual line, and the combination of different adverse development structures by segment.

Section 7: Adverse development cover as protection against adverse calendar year trends

A real-life example shows calendar year trends where a high 35%+_4% trend was observed in the data previously. Adverse development cover is presented as a strategy for protection should this trend arise in the immediate future.

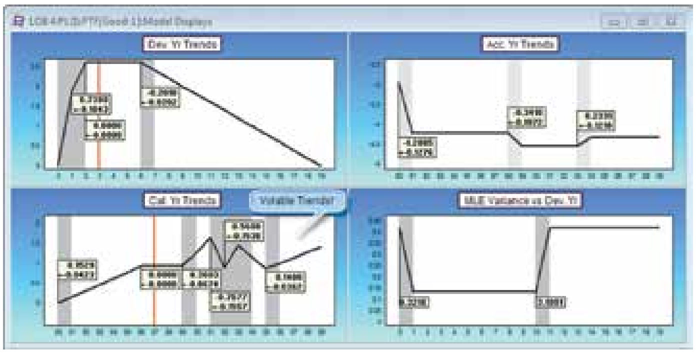
2. Pricing future underwriting years

2.1. Future underwriting year forecast scenarios

Two examples for single lines of business (LOB 4 and PM) are provided to illustrate the level of control over future trend and volatility assumptions the actuary has in the ICRFS-Plus™ probabilistic modelling frameworks.

- The same model should be used to project reserve and future periods;
- The effect of the assumptions on pricing future underwriting years are considered;
- Trends in loss ratios are examined and linked with calendar year trends;
- Premiums are set based on target expected loss ratios in combination with future forecast assumptions.

As probabilistic models relate every cell, trends can be projected in any time direction including extending beyond the boundaries of the loss data into future development or underwriting periods.



Control over future assumptions, particularly regarding future underwriting years, is essential. Future assumptions should be explicit so that their effect on pricing and reserve risk can be well understood.

In ICRFS-Plus™ the user has full control over all forecast assumptions within the probabilistic trend family modelling frameworks.

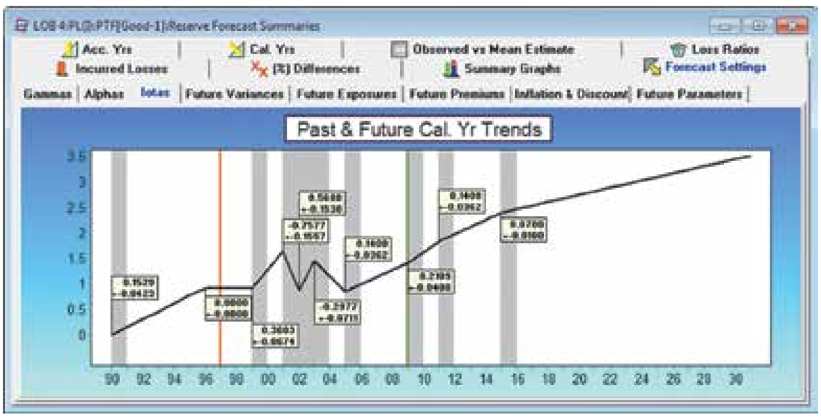
The model display to the right shows the measured trends for LOB 4 in each direction (development, accident, and calendar) along with the process volatility (lower right display) variance of the normal distributions by development period. The process volatility is high for this line and so is the parameter uncertainty by calendar year. The development trend does not begin decaying until seven years. That is, it takes seven years before the incremental paid losses start decreasing by development period.

The volatility in the calendar year trends (which measure the combination of both economic and social inflation) are of primary importance when assessing the future underwriting year's loss distribution. Exposure and accident level related risk assumptions for the future underwriting year are controlled via the alpha parameter.

In the following example we show the relevant windows to control the future forecast assumptions of the trends in the three directions. Similar control is also provided for the process volatility but is not included here.

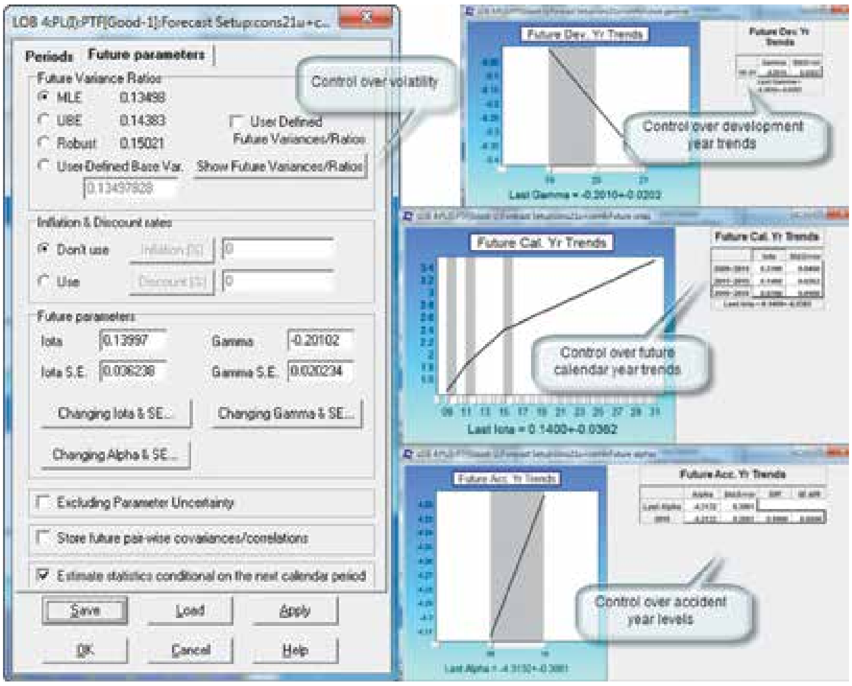
Changes assumed by the actuary in this forecast are:

- The calendar year trends change from 14%+_3.62% (the trend since 2005) to 21%+_4% for the next two years, 14%+_3.62% for the following four years, and 7%+_1% thereafter.
- The accident year level for the next underwriting year is expected to increase by 10% (on average) versus the previous (2009) level. A high level of uncertainty (5%) is associated with this increase.

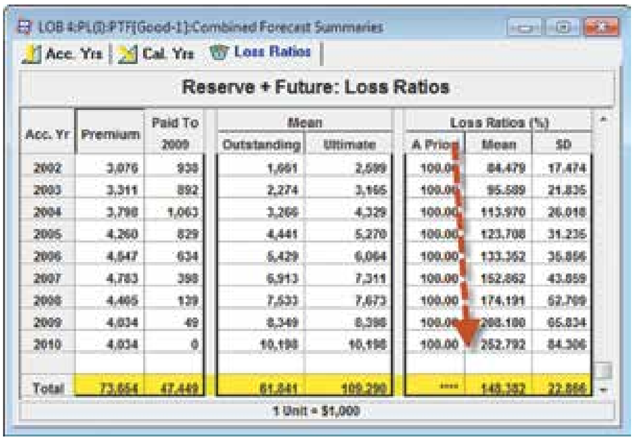


Pricing

Although the forecast is extended for two periods in the development direction, no changes were made to the development year trend.



Forecast scenarios can readily be compared to evaluate economic risk, exposure risk, and adverse development. Future underwriting year risk, reserve risk, and combined (future + reserve) risk, can all jointly be assessed under varying scenario conditions.



LOB 4:PL(I):PTF[Good-1]:Combined Forecast Summaries

Reserve + Future: Loss Ratios

Acc. Yr	Premium	Paid To 2009	Mean Outstanding	Mean Ultimate	Loss Ratios (%) A Prior	Loss Ratios (%) Mean	Loss Ratios (%) SD
2002	3,076	938	1,661	2,599	100.00	84.479	17.474
2003	3,311	892	2,274	3,166	100.00	95.589	21.836
2004	3,798	1,063	3,266	4,329	100.00	113.970	26.018
2005	4,260	829	4,441	5,270	100.00	123.708	31.236
2006	4,647	634	5,429	6,064	100.00	133.352	35.856
2007	4,783	398	6,913	7,311	100.00	152.862	43.859
2008	4,405	139	7,533	7,673	100.00	174.191	52.709
2009	4,034	49	8,349	8,398	100.00	208.180	65.834
2010	4,034	0	10,198	10,198	100.00	252.792	84.306
Total	73,654	47,449	61,041	109,290	****	148.382	22.866

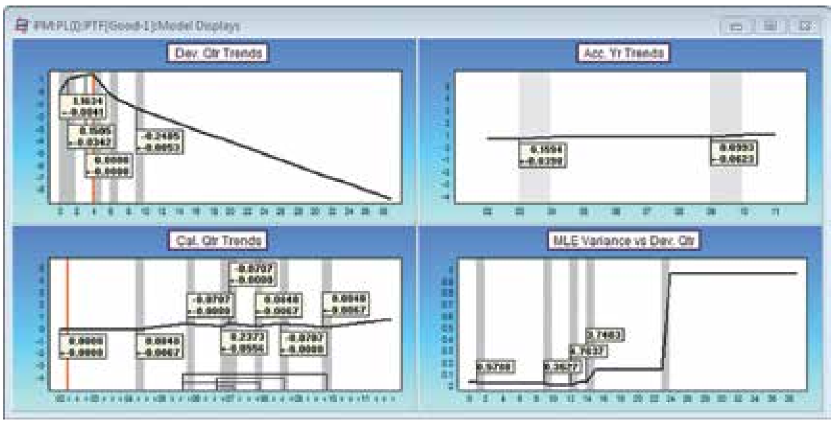
1 Unit = $1,000

For this line, earned premium is low resulting in high loss ratios. The mean loss ratios are exceeding 100% from 2004 onward. They are also exhibiting a positive trend as the losses are increasing faster than earned premium. The calendar year trend is projecting along the accident years (and development years) and is increasing at a faster rate than the earned premium. Due to the high volatility in the line (including parameter uncertainty), the standard deviations of the loss ratios are also very high.

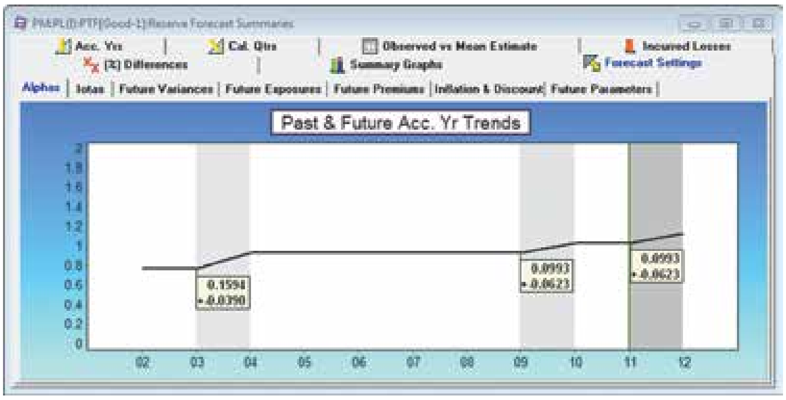
This would be of primary concern for pricing as this implies that other lines written are expected to compensate for this line's premium being too low. If the premium for 2010 is at the same level as 2009, then the expected loss ratio is 253% for this scenario.

2.1.1. Primary Motor

Consider the following Primary Motor line. The trends in the three directions along with process volatility are shown below.

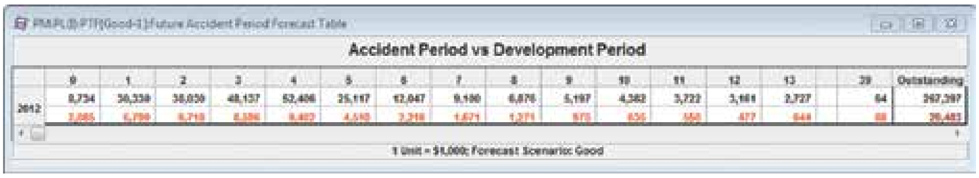


For this example, the increase in losses for 2009~2010 is attributable to bad weather conditions. Furthermore, the pricing actuary has information forecasting subsequent deterioration for the 2012 year. The scenario for the future underwriting year can be revised as follows:



Above, the same 9.93%+_6.23% increase is assumed to occur in the next underwriting year. No changes are made to the trend assumptions in the other two directions; nor are any changes made in respective to volatility.

All trend assumptions made for the future can be related to the trends measured in the data. Transparent trend assumptions can aid discussions with shareholders, regulators, and auditors.



PM:PL(I):PTF[Good-1]:Future Accident Period Forecast Table

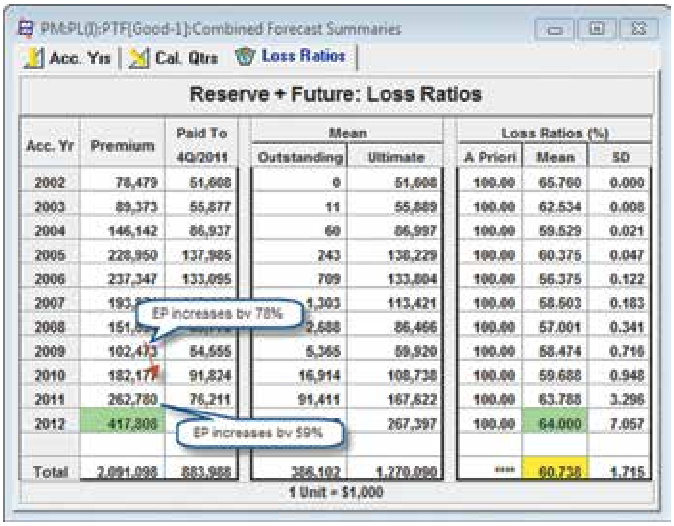
Accident Period vs Development Period

	0	1	2	3	4	5	6	7	8	9	10	11	12	13		39	Outstanding
2012	8,734	30,330	38,030	48,157	52,406	25,117	12,047	9,100	6,876	5,197	4,382	3,722	3,161	2,727		64	267,397
	2,085	6,799	6,718	8,586	9,402	4,510	2,316	1,671	1,271	875	635	550	477	644		88	39,483

1 Unit = $1,000; Forecast Scenario: Good

Lognormal distributions are projected for each cell in the underwriting year. The distributions are correlated via the trend structure. All the trend and volatility assumptions driving these distributions are known and can be related to the data and business knowledge.

The earned premium, in order to maintain the same expected loss ratio as the previous year, requires an increase of 59% over the earned premium in 2010. For comparison, the earned premium increased by 78% for the corresponding increase in 2009~2010.



Reserve + Future: Loss Ratios

Acc. Yr	Premium	Paid To 4Q/2011	Mean Outstanding	Mean Ultimate	Loss Ratios (%) A Priori	Loss Ratios (%) Mean	Loss Ratios (%) SD
2002	78,479	51,608	0	51,608	100.00	65.760	0.000
2003	89,373	55,877	11	55,889	100.00	62.534	0.008
2004	146,142	86,937	60	86,997	100.00	59.529	0.021
2005	228,950	137,985	243	138,229	100.00	60.375	0.047
2006	237,347	133,095	709	133,804	100.00	56.375	0.122
2007	[illegible]	[illegible]	1,303	113,421	100.00	58.603	0.183
2008	[illegible]	[illegible]	2,688	86,466	100.00	57.001	0.341
2009	102,473	54,555	5,365	59,920	100.00	58.474	0.716
2010	182,177	91,824	16,914	108,738	100.00	59.688	0.948
2011	262,780	76,211	91,411	167,622	100.00	63.788	3.296
2012	417,808	[illegible]	[illegible]	267,397	100.00	64.000	7.057
Total	2,091,098	883,988	386,102	1,270,090	****	60.738	1.715

1 Unit = $1,000

The pricing actuary can be more / less aggressive in pricing according to business policy and current market conditions. The most important attribute is that all appropriate assumptions can be varied and clearly evaluated. Discussions regarding future assumptions for models in the PTF/MPTF modelling frameworks are informative and aid in presentation to senior management, as compared to arguments over link ratios; for example, whether a ratio should be 1.15 instead of 1.1?

2.2. Multiple lines

A single composite model can be used to jointly project future underwriting period(s) for multiple Lines of Business. This example considers the task of pricing six LOBs.

Management expected loss ratio targets are considered as well as amortisation to reach these targets;

Risk margins are included as a component of the premium as an example of this business strategy;

The effect of risk diversification of the future underwriting year with the reserve periods is examined.

Reserve distribution correlation (*) is usually very low between reserve and underwriting risk. Any correlations between future and reserve periods are driven by common parameters. Common parameters are a further reason not to separate the reserve and underwriting calculations.

(*) See also "Understanding Correlations" by Insureware.

This section illustrates a number of concepts:

- Pricing multiple Lines of Business, segments, or layers simultaneously;
- Including risk capital / margins when considering pricing; and
- Amortising premium requirements to reach management targets (of expected loss ratios).

The following results are for the writing of six LOBs (the model displays are presented in section 6.1) for the next underwriting year assuming no change in exposure (for simplicity).

LOB 1-LOB 6:CDS:MPTF[Good2-1]:Future Forecast Summaries

Aggregate | LOB 1:PL(I) | LOB 2:PL(I) | LOB 3:PL(I) | LOB 4:PL(I) | LOB 5:PL(I) | LOB 6:PL(I)

Summary by Datasets | Acc. Yrs | Cal. Yrs | Loss Ratios | Clusters | LOB Comparisons

Breakdown by LOB | Reserve Mean/CV Percentage Graphs

Future Underwriting Year (2010); Breakdown by LOB

	Premium	Mean		Std Dev	Loss Ratios (%)	
		Outstanding	Ultimate		Mean	Std Dev
LOB 1:PL(I)	103,030	92,779	92,779	13,729	90.050	13.325
LOB 2:PL(I)	10,413	4,638	4,638	966	44.542	9.277
LOB 3:PL(I)	496,651	274,752	274,752	24,159	55.321	4.864
LOB 4:PL(I)	4,034	9,213	9,213	3,029	228.383	75.090
LOB 5:PL(I)	9,460	5,824	5,824	1,454	61.565	15.371
LOB 6:PL(I)	13,844	9,627	9,627	1,524	69.538	11.006
Total	637,432	396,834	396,834	28,113	62.255	4.410

1 Unit = $1,000

Forecast scenario: cons21u+oneyear

Loss ratios above are based on the premium for the previous year (2009) and are unadjusted. If left unchanged, some lines are expected to run at, or close to, an overall loss (LOB 1 and LOB 4 particularly).

The corresponding table for the reserve component is displayed below. For the sake of this example, the Expected Loss Ratios (ELR) are considered the long-term performance targets desired by management.

LOB 1-LOB 6:CDS:MPTF[Good2-1]:Reserve Forecast Summaries

Aggregate | LOB 1:PL(I) | LOB 2:PL(I) | LOB 3:PL(I) | LOB 4:PL(I) | LOB 5:PL(I) | LOB 6:PL(I)

Summary by Datasets | Acc. Yrs | Cal. Yrs | Observed vs Mean Estimate | Loss Ratios | Incurred Losses | (%) Differences | Summary Graphs | Clusters | LOB Comparisons

Breakdown by LOB | Reserve Mean/CV Percentage Graphs

Reserve Breakdown by LOB

	Premium	Paid To 2009	Incurred To 2009	CRE 2009	Mean		Std Dev	Loss Ratios (%)	
					Outstanding	Ultimate		Mean	Std Dev
LOB 1:PL(I)	3,069,115	1,032,476	1,116,869	84,394	87,858	1,119,691	12,202	36.477	0.398
LOB 2:PL(I)	339,674	136,891	137,638	739	1,143	138,034	943	40.637	0.842
LOB 3:PL(I)	6,075,198	3,190,096	3,477,378	286,798	409,791	3,600,390	26,640	52.394	0.382
LOB 4:PL(I)	63,628	47,449	76,316	28,867	51,698	99,047	13,575	142.260	19.901
LOB 5:PL(I)	209,269	48,624	73,701	25,177	33,218	81,743	6,373	39.069	3.046
LOB 6:PL(I)	610,237	157,467	199,894	42,627	22,247	179,664	3,524	29.448	0.414
Total	11,377,098	4,613,401	5,081,889	438,485	666,904	5,280,485	33,023	46.718	0.203

1 Unit = $1,000

Forecast scenario: cons21u+oneyear

We observe:

- LOB 1 is currently aggressively priced and the premium should be increased over time to return the ELR for this LOB to the long-term target of 47%;
- Premium for LOB 2 can be increased to maintain the long-term target;
- Premium for LOB 3 can be increased to maintain the long-term target;
- LOB 4 is extremely volatile and premium should be increased according to the desired risk level. As the volume in LOB 4 is low compared to the other lines, minimal changes may be satisfactory in the short term (this is the application we apply here);
- LOB 4 and LOB 6 are both historically good performers but, to gain market share, the ELR has been allowed to increase to center between 55%~60% - this strategy is to continue for 2010;
- The largest line, LOB 3, has the most flexibility for adjustment to offset lower premiums in other lines.

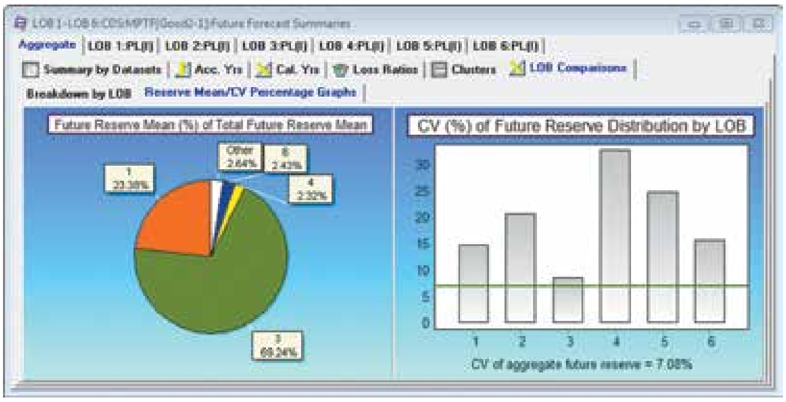
Applying the above considerations, with no provision for risk margins or discounting, the target premium levels for the six segments are as follows:

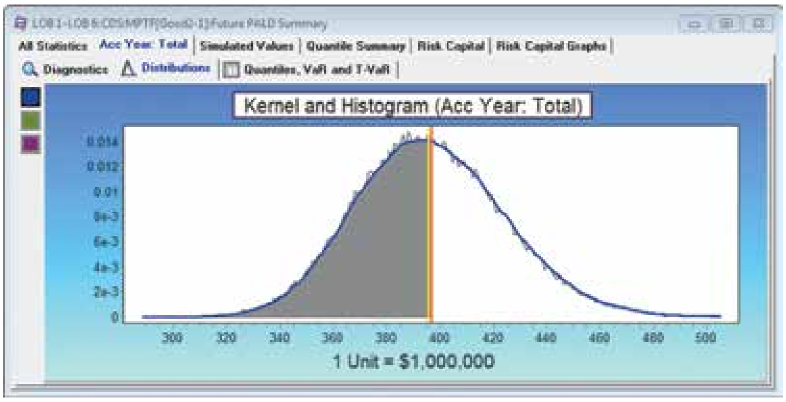
LOB 1 - 6 Future underwriting year 2010									
	Premium (2009)	Mean Outstanding	Ultimate	Std Dev	Loss Ratios (%) Mean	Loss Ratios (%) Std Dev	Target LR (%)	Premium (2010)	% Change
LOB 1	103,030	92,779	92,779	13,729	90.05	13.33	70.33	131,913	28
LOB 2	10,413	4,638	4,638	966	44.54	9.28	44.54	10,413	0
LOB 3	496,651	274,752	274,752	24,159	55.32	4.86	55.32	496,650	0
LOB 4	4,034	9,213	9,213	3,029	228.38	75.09	150.00	6,142	52
LOB 5	9,460	5,824	5,824	1,454	61.57	15.37	57.00	10,218	8
LOB 6	13,844	9,627	9,627	1,524	69.54	11.01	57.00	16,889	22
Total	637,432	396,834	396,834	28,113	62.26	4.41	59.03	672,225	5

1 Unit = $1,000

The business strategy is unlikely to accommodate radical changes in premium - and increasing premium for LOB 4 by 52% for no change in exposure would constitute a major increase. To achieve the desired loss ratio (in aggregate), an increase in premium of at least 5% is sufficient. The increases (decreases) can then be allocated to each line based on market strategy and in combination with other risk factors (including risk capital and premium risk).

The mean and volatility (represented by the CVs) are shown for the future underwriting year (2010) below. The largest lines by reserve mean are LOB 3 and LOB 1, whereas the riskiest lines are LOB 4 and LOB 5. The latter lines are small relative to the other segments.





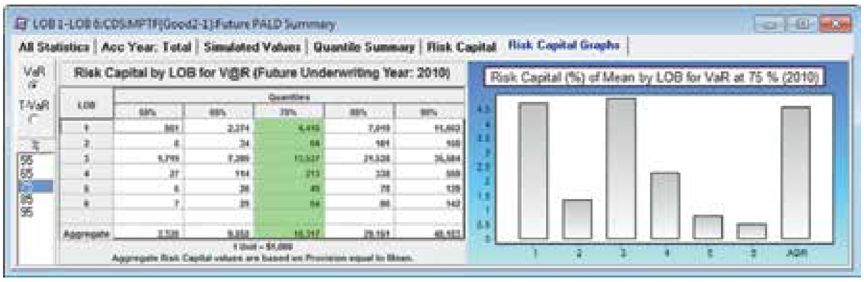
The distribution of the total losses for the future underwriting year (2010) for the aggregate of the six lines is displayed above. The total mean is at the 52% quantile (percentile). If premium was raised to cover the future underwriting year's mean only, then losses up to 100M are at risk (at the 99.95th percentile). Risk appetite will depend on a number of factors. Here the business strategy is to price the undiscounted premium at the 75th percentile of the total losses for the next underwriting year. The losses at the 75th percentile (and others) are displayed below. The quantiles are also an estimate and the associated uncertainty can be calculated.

Quantile Summary for Future Underwriting Year (2010)
(Sample Distribution)

Accident	55% Mean	55% S.E.	65% Mean	65% S.E.	75% Mean	75% S.E.	85% Mean	85% S.E.	95% Mean	95% S.E.
2010	399,134	110	406,620	114	415,017	112	426,819	142	444,770	224
Total	399,134	110	406,620	114	415,017	112	426,819	142	444,770	224

1 Unit = $1,000

Risk capital (in this case V@R at 75%) as a percentage of mean - illustrates the riskiness of the lines. The total risk capital is allocated to each line based on a variance-covariance formula; basically, in proportion to each lines contribution to the total volatility.



The revised table below shows the target premium levels for the six segments where risk capital allocation at the 75th percentile is incorporated in the ultimate.

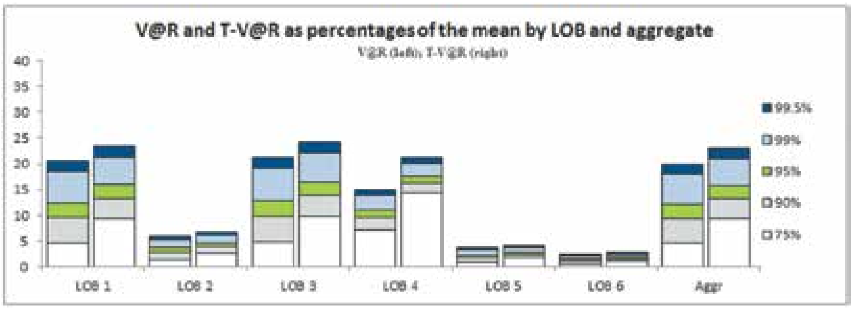
LOB 1 - 6 Future underwriting year 2010	Premium (2009)	Mean Outstanding	Mean Ultimate	Ultimate (75th %-ile)	Mean Loss Ratios (%): 75th %-ile	Target ELR (%)	Premium (2010)	% Change
LOB 1	103,030	92,779	92,779	97,189	90.05	70.33	138,183	34
LOB 2	10,413	4,638	4,638	4,702	44.54	44.54	10,556	1
LOB 3	496,651	274,752	274,752	288,279	55.32	55.32	521,102	5
LOB 4	4,034	9,213	9,213	9,426	228.38	150.00	6,284	56
LOB 5	9,460	5,824	5,824	5,873	61.57	57.00	10,304	9
LOB 6	13,844	9,627	9,627	9,681	69.54	57.00	16,984	23
Total	637,432	396,834	396,834	415,151	62.26	59.03	703,254	10
1 Unit = $1,000								

The total increase in premium for 2010 is now 10% in order to reach the target ELR set by management for this underwriting year. Allocation to each line is suggested based on the contribution of each line to the mean and volatility at the 75th percentile. This suffices to illustrate a process which may be followed as preliminary to determining premium. Further considerations like return on investment on premium, premium risk, and other risk factors are beyond the scope of this brochure.

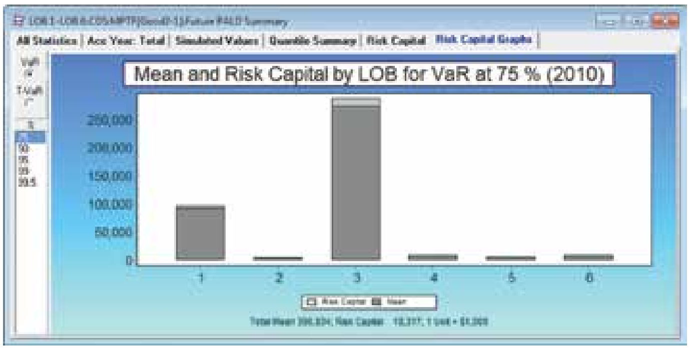
Acquisitions can be considered in a similar fashion - considering both premium expectations along with risk diversification gained by writing the acquired business(es).

2.2.1 V@R versus T-V@R

The Value-at-Risk at the 75th percentile ($V@R_{75}$) is the capital that would be lost should the mean be reserved and the actual losses come in at the 75th percentile. The Tail-Value-at-Risk (T-V@R) is the average capital that would be lost should the mean be reserved and the actual losses exceed the specified percentile. In this respect, V@R is the minimum loss of capital given a percentile is reached; thus T-V@R is greater than V@R.

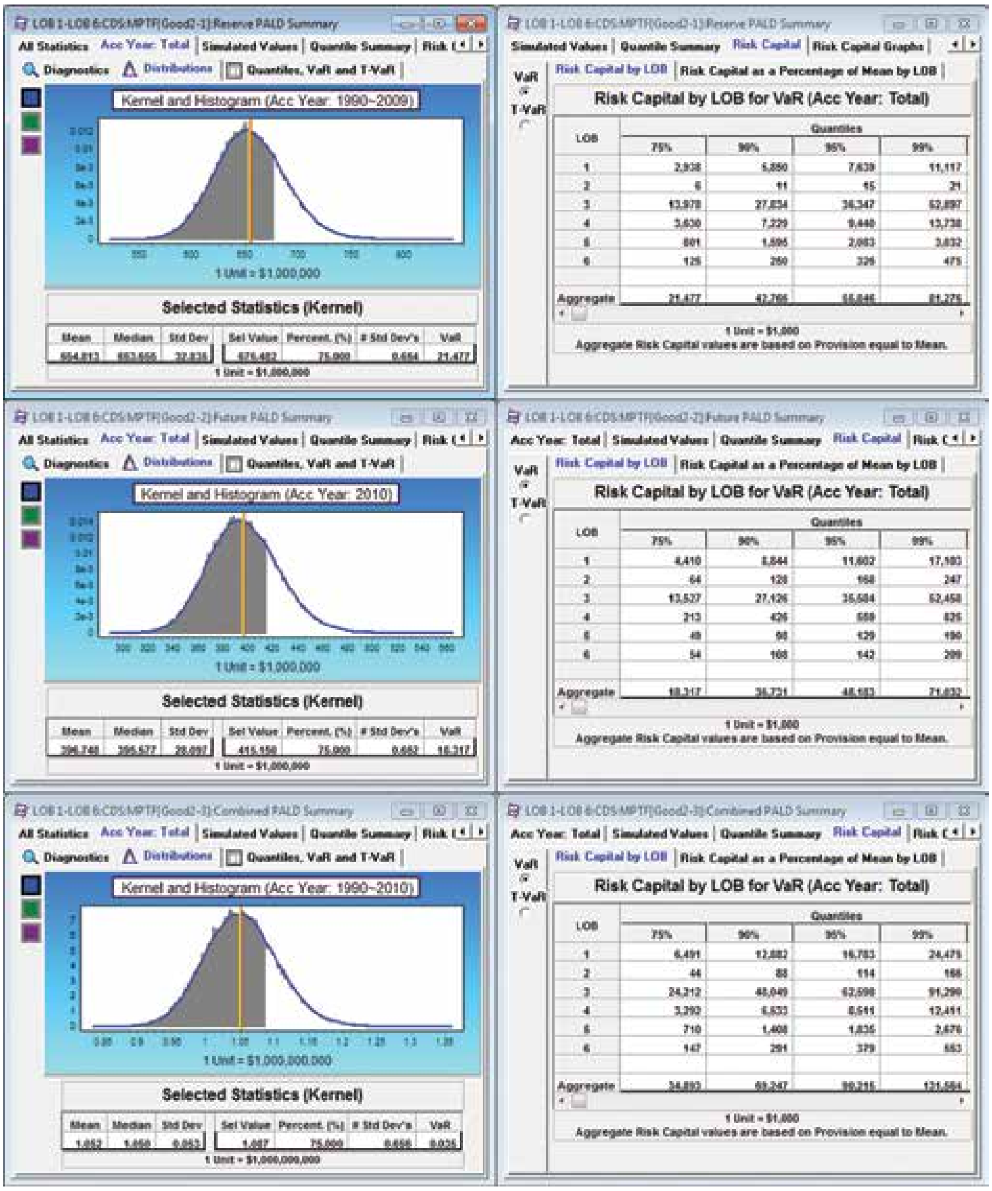


The lines receiving the most risk capital are the largest lines - LOB 1 and LOB 3 respectively. Premium raised for LOB 3 (and the currently good loss ratio) likely reflects the higher level of risk capital allocated to this line. LOB 3 provides a good diversification buffer for the more risky lines (LOB 4 is priced conservatively in the scenario considered for the next underwriting year).



2.2.2 Reserve Risk, underwriting risk, and combined (underwriting + reserve) risk

The above procedure of analysing the risk capital allocated to the future underwriting year for the six segments treats the future underwriting year on its own and does not consider diversification credit with the reserve distribution. Combined risk is always less than the sum of future plus reserve risk. In practice, the diversification gained by considering the combination of future underwriting year risk and reserve risk jointly is a significant factor.



For the 75th percentile, the gain in diversification benefit for the future underwriting year is significant. The total reserve risk capital (V@R) at 75% is 21.5M (left), for the future underwriting year, the risk capital (V@R) at 75% is 18.3M (center). Treating the two risk capital calculations separately results in a total risk capital calculation of 39.8M. When analysing the joint distributions from the reserve + future underwriting year, the total risk capital (V@R) at 75% is 34.9M (bottom). The reduction in the total required risk capital of 4.9M can be used to offset the risk capital margin for the premium in the future underwriting year (since premium has already been raised for the reserve period).

If this methodology is applied, the premium only needs to be increased by 9% to accomplish the same management targets.

2.3 Key learnings

- Projection for reserves and future underwriting years should use the same model;
- In the examples provided, the forecast scenarios for future underwriting years use the same calendar year trend assumptions as for the reserve component. This is not essential;
- Trends in mean loss-ratios provide timely information regarding premiums and the level of risk taken on by the insurer;
- Premiums can be amortised according to management requirements and business strategy;
- Premiums can also include risk margins in addition to the best estimate;
- Combined risk (future underwriting year + reserve) is less than the sum of the two risk components.

3. Assessing current outward reinsurance

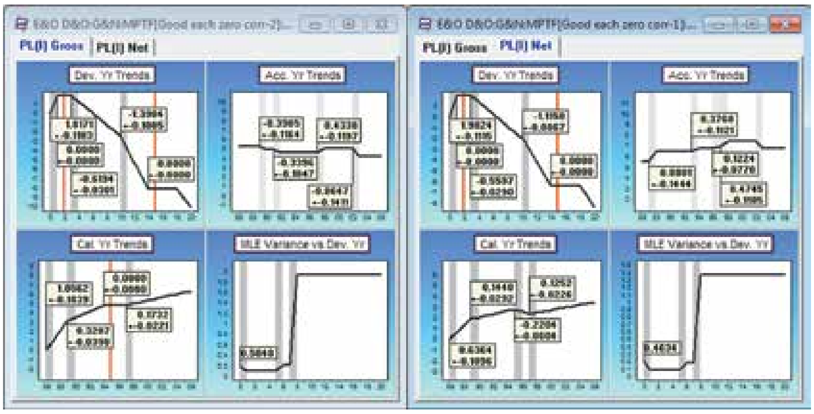
3.1. Case study: E&O D&O

Outward reinsurance can be evaluated for capital efficiency retrospectively. Additional cover can also be evaluated. We present a case study involving E&O and D&O where we have Gross and Net of Reinsurance data.

- Model trend structure is very similar between Gross and Net of Reinsurance data;
- Process (volatility) correlation is very high since Net of Reinsurance is a subset of Gross;
- The current outward reinsurance is capital efficient for the cedant;
- The capital efficiency of the reinsurer is also evaluated.

This study illustrates the effectiveness of outward reinsurance in respect of capital efficiency and reduction of volatility in the losses Net of Reinsurance for the cedant.

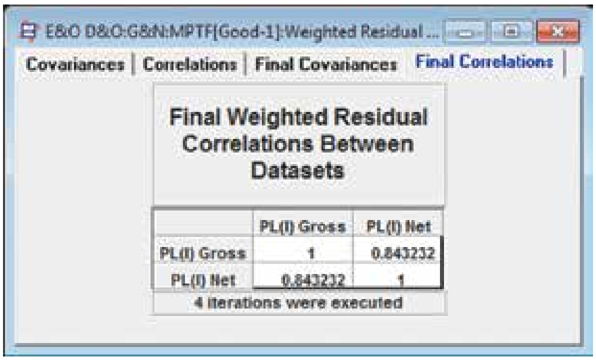
The Multiple Probabilistic Trend Family (MPTF) modelling framework is used to analyse these segments jointly. The two model displays for the E&O D&O data, Gross and Net of Reinsurance respectively, are shown below.



The model trend structure is the same as one would expect (except for the early accident years). Calendar and development parameters are structurally almost identical; parameter changes occur at the same time points. This feature of the data indicates common calendar year drivers for the two segments – exactly what one expects from Gross and Net of Reinsurance.

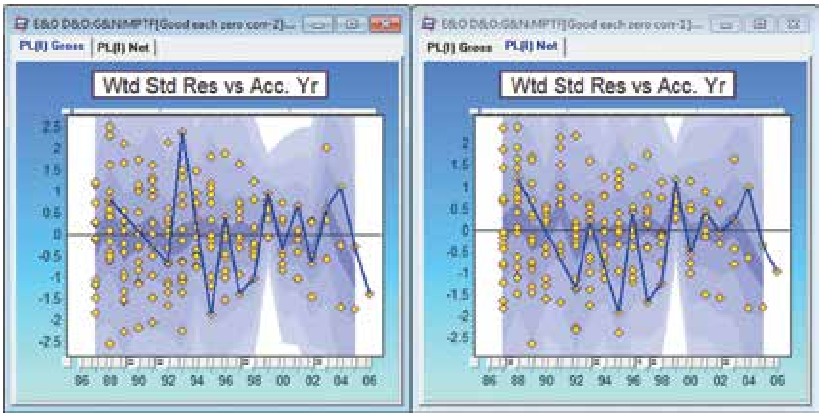
The calendar year trend is higher in the Gross than the Net of Reinsurance, so a cursory conclusion suggests inflation is higher in the Gross than the Net of Reinsurance. However, a closer examination reveals that the development trends are higher in the Net of Reinsurance than the Gross – the projected trends (sum of all directions) are very similar in the two segments. The key difference is in the process volatility; the Net of Reinsurance has significantly lower process volatility (lower right displays). This is the reason the Net of Reinsurance is successful – the more volatile claims are the ones being ceded to the reinsurer.

The process (volatility) correlation of 0.843 is not used in the models above (to ensure repeated measurements are not used) to estimate model parameters or in forecasting.

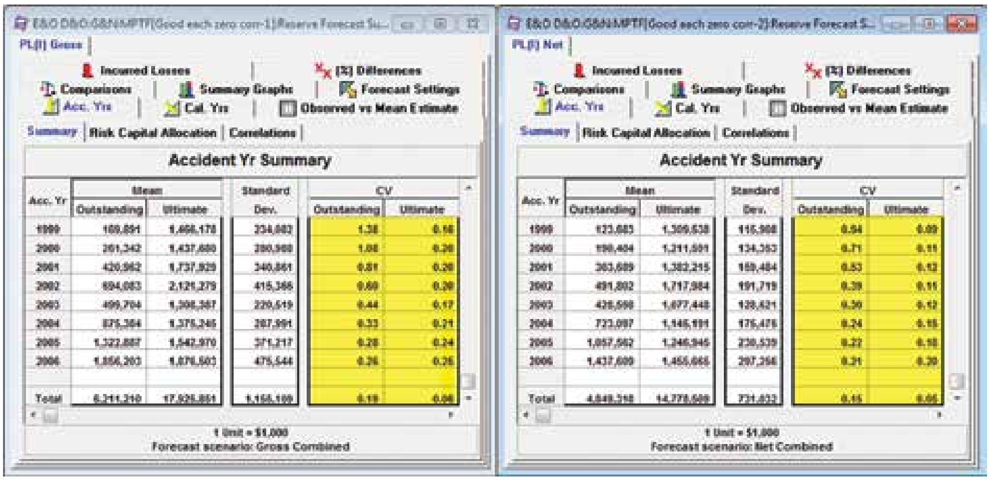


	PL(I) Gross	PL(I) Net
PL(I) Gross	1	0.843232
PL(I) Net	0.843232	1

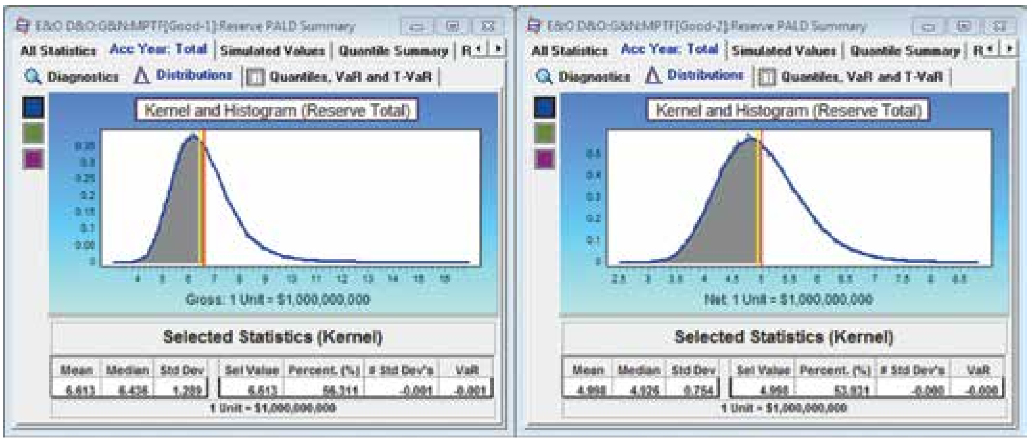
What does a high process correlation (between two sets of normally distributed residuals) imply? Namely, that the two segments behave in a similar fashion when it comes to observations arriving above or below the fitted trend lines. Process correlation is always relative to a fitted model.



The above displays show the trace line for calendar year 2006 (the last calendar year), for the same corresponding accident years. A trace line connects residuals from the same period (here calendar year 2006) making it easy to find the corresponding residuals when examining another direction. The shape of the trace line is very similar – when residuals are above the line in Gross they are extremely likely to also be above the line in the Net of Reinsurance – similarly points below the line (in fact for this trace there is a one-to-one correspondence). This is expected as Net or Reinsurance is a part of Gross.



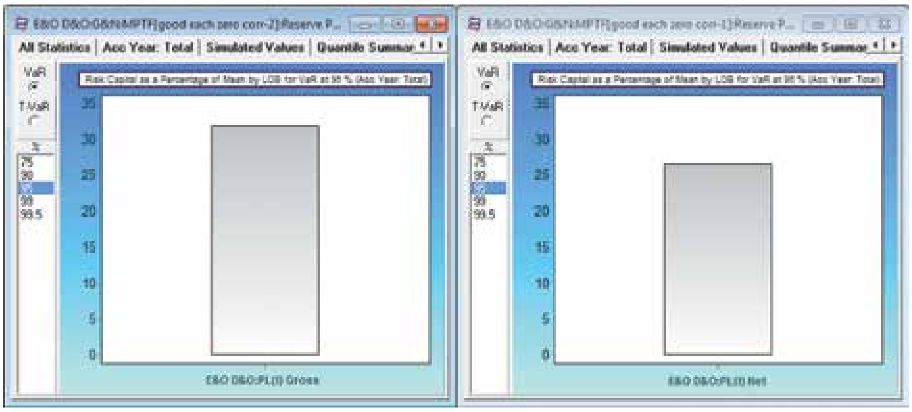
The forecast summary by accident year, with CVs highlighted, confirms the observation made above that the Net of Reinsurance is more capital efficient. The CVs are consistently lower for the Net of Reinsurance; this is a sign of capital efficient reinsurance for the cedant. This is confirmed by simulating from the projected log-normal distributions for each cell (and their correlations) to obtain the complete distribution of aggregates below.



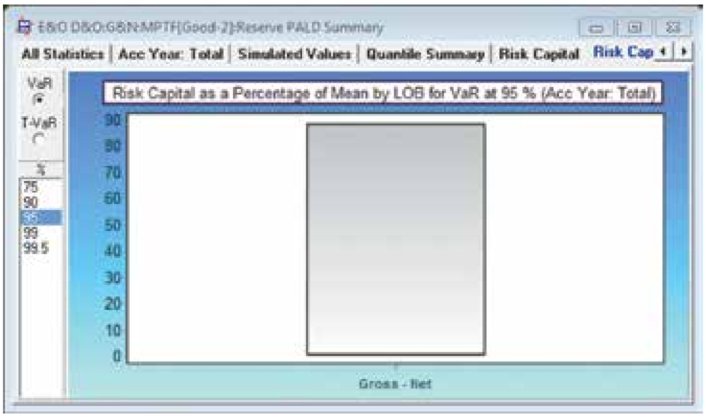
Similar conclusions can be drawn from the distribution graphs above for the Gross (left) and Net of Reinsurance (right) respectively. The Gross projections are far more skewed than the Net; and only the Kernel provides a good fit to the Gross projections.

3.1.1. Risk capital efficiency

The comparative capital efficiency for the two segments, Gross and Net of Reinsurance, shows that in terms capital efficiency, the reinsurance is working for the cedant. The Gross data requires significantly more risk capital (as a percentage of the mean), than the Net of Reinsurance.



From the Gross and Net of Reinsurance data we can also calculate (approximately) the capital efficiency of the reinsurer by calculating the difference between the Gross and Net of Reinsurance forecasts for each cell.



The risk capital efficiency of the reinsurer is very poor with the required risk capital being 89% of the mean. Note that the correlations between Gross and Net of Reinsurance were taken into account when calculating this figure at the 95th percentile.

3.2. Case study: FAC ENG

This case study illustrates current outward reinsurance that is not capital efficient from the perspective of the cedant.

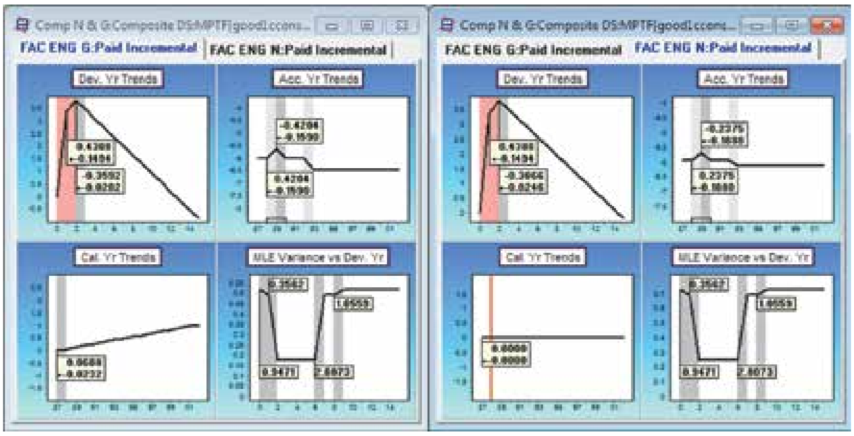
Model trend structure is very similar between Gross and Net of Reinsurance data;

Gross data calendar year trends are growing whereas Net of Reinsurance trends are not;

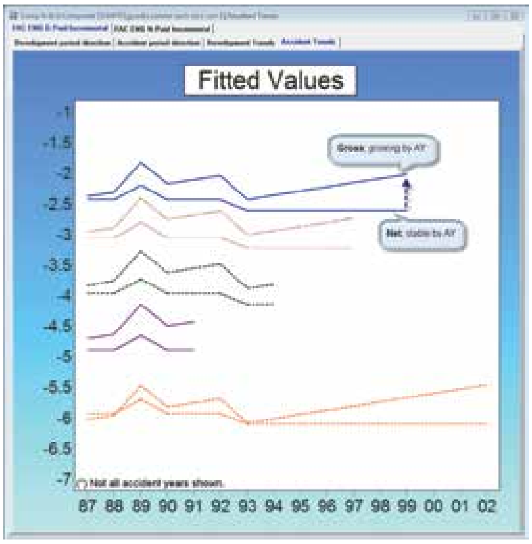
The process volatility is significantly higher in the Net of Reinsurance data.

The reinsurance seems to be effective in that the Gross data are growing whereas the Net of Reinsurance data are stable, however the higher volatility in the Net of Reinsurance data results in no gain in capital efficiency.

The Multiple Probabilistic Trend Family (MPTF) modelling framework is used to analyse the Gross and Net of Reinsurance data for FAC ENG jointly. The two model displays for the two segments are shown below. The red bar indicates common parameters between the two sections. Note the presence of a calendar year trend in the Gross data which is not present in the Net of Reinsurance. The same exposure base is used for both Gross and Net of Reinsurance eliminating any differences in trends arising from exposure.

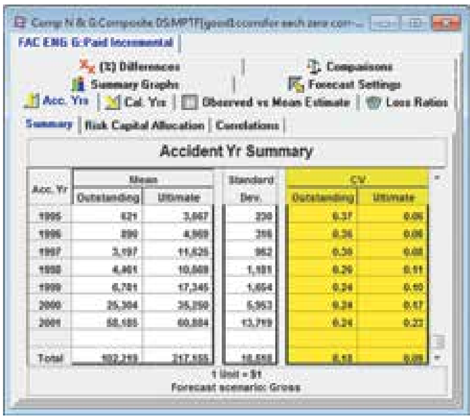


The difference in the models is critical for the first two development year periods (where the constraint exists), but has significantly less impact in the later development year periods as the Net of Reinsurance decay is not as strong as the Gross thus cancelling out the calendar effect in the development direction. The difference is only 1.6% and is within the standard error of both parameters.



The calendar year trend projects onto both development year and accident year directions. It is in the accident year direction (left) that the growth occurs in the Gross (upper lines of each colour) but not in the Net of Reinsurance (lower lines of each colour). This is good in the sense that it is the part that is growing that is being ceded, however the outward reinsurance is not capital efficient.

The forecast summary excerpts for the two segments are illustrated by accident year; CVs are highlighted. The CV of the Net of Reinsurance is the same as than the Gross in total, but higher by individual accident years. The latter is a result of the higher process volatility in the Net of Reinsurance data.

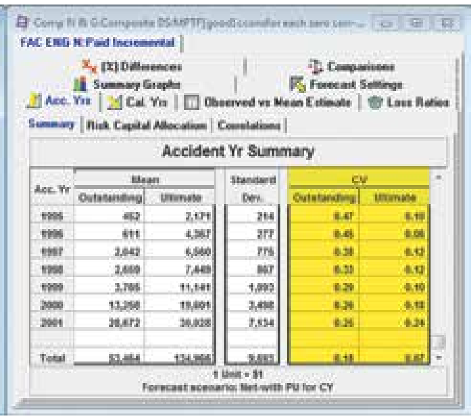


FAC ENG G:Paid Incremental

Accident Yr Summary

Acc. Yr	Mean Outstanding	Mean Ultimate	Standard Dev.	CV Outstanding	CV Ultimate
1995	621	3,067	230	0.37	0.06
1996	890	4,969	316	0.36	0.06
1997	3,197	11,626	962	0.30	0.08
1998	4,401	10,608	1,101	0.26	0.11
1999	6,781	17,345	1,654	0.24	0.10
2000	25,304	35,250	5,953	0.24	0.17
2001	58,105	60,884	13,719	0.24	0.22
Total	102,219	217,155	18,658	0.18	0.09

1 Unit = $1
Forecast scenario: Gross

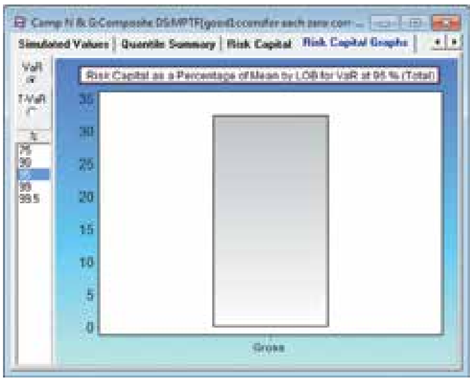


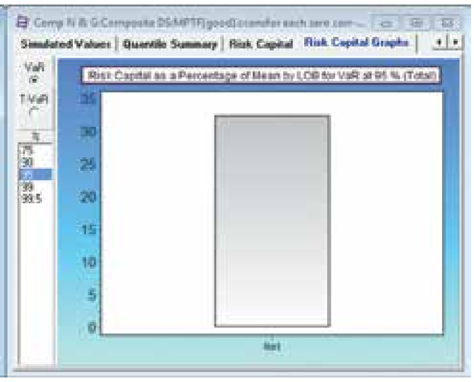
FAC ENG N:Paid Incremental

Accident Yr Summary

Acc. Yr	Mean Outstanding	Mean Ultimate	Standard Dev.	CV Outstanding	CV Ultimate
1995	452	2,171	214	0.47	0.10
1996	611	4,367	277	0.45	0.06
1997	2,042	6,560	775	0.38	0.12
1998	2,659	7,449	867	0.33	0.12
1999	3,705	11,141	1,092	0.29	0.10
2000	13,250	19,601	3,498	0.26	0.18
2001	28,672	30,028	7,134	0.25	0.24
Total	53,464	134,966	9,691	0.18	0.07

1 Unit = $1
Forecast scenario: Net-with PU for CY





The risk capital as a percentage of the mean is almost identical for Gross and Net of Reinsurance – there is no advantage in this outward reinsurance program in terms of capital efficiency for the cedant.

3.3. Key learnings

- Not all reinsurance programs are capital efficient for the cedant – two contrasting examples were given;
- ICRFS-Plus™ modelling frameworks can be used to assess existing outward or inward; reinsurance, retrospective or prospectively
- Reinsurance structures can be examined from the point of view of the cedant or the reinsurer.

4. Layers

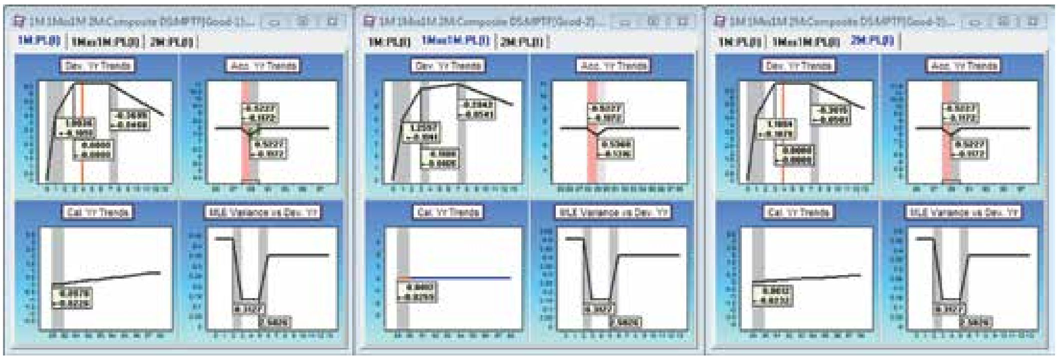
4.1. 1M, 1M xs 1M, 2M

In this example, data are split into three layers - paid losses with each individual paid loss limited to 1M, paid losses with individual losses between 1M and 2M (1M xs 1M), and paid losses with individual losses limited to 2M. All losses are capped at 2M.

We observe:

- Calendar year trends in the layers are unique. The calendar year trend in the layer 1M xs 1M are not statistically different from zero whereas the layers Lim 1M and Lim 2M show statistically significant positive trends;
- There is no gain in risk capital efficiency ceding the layer 1M xs 1M retrospectively;
- There is a small gain in risk capital efficiency when ceding the layer 1M xs 1M prospectively;
- If both reserve and future underwriting years are considered, then there is no gain in risk capital efficiency in ceding 1M xs 1M both retrospectively and prospectively.

The corresponding MPTF model displays are shown below; these models include constraints in the accident direction.



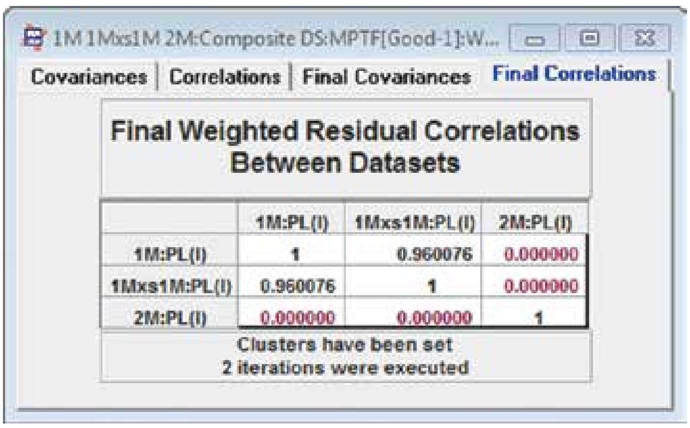
The key features of interest are that in the claims limited to 1M and in the claims limited to 2M, there is evidence of a calendar year trend, however in the losses 1M xs 1M there is no statistically significant calendar year effect.

The Layer 1M has a higher inflation rate than 2M, and 1Mxs1M has an inflation rate that is statistically insignificant. If the only available array is 1Mxs1M then it would be prudent not to set the inflation to zero, as process volatility is high.

The calendar year trend is estimated in the model, even though it is not statistically significant, so correlation is maintained between the calendar year parameters. The relationship between the parameters is important since the two pieces are highly correlated and the calendar year trend is significant in 2M.

The other two directions, development year and accident year, are similar although there is a positive development trend in 1M xs 1M where the other layers have a zero trend.

The layers are highly correlated and the model above uses the high correlation between the layer limited to 1M and 1M xs 1M. Including the correlation between 2M and the other two pieces would be inappropriate since this would be equivalent to using repeated measurements; all the information to estimate 2M from 1M + 1M xs 1M is already in the model.


1M 1Mxs1M 2M:Composite DS:MPTF[Good-1]:W...

Covariances | Correlations | Final Covariances | Final Correlations

Final Weighted Residual Correlations Between Datasets

	1M:PL(I)	1Mxs1M:PL(I)	2M:PL(I)
1M:PL(I)	1	0.960076	0.000000
1Mxs1M:PL(I)	0.960076	1	0.000000
2M:PL(I)	0.000000	0.000000	1

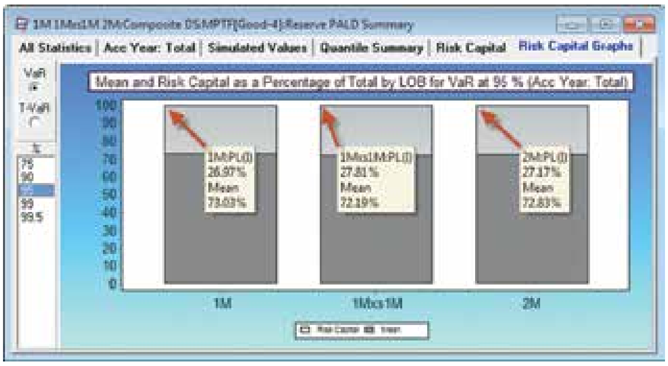
Clusters have been set
2 iterations were executed

The efficiency of the layers can be readily evaluated by comparing the CVs (highlighted) of the forecasts for the layers along with the percentage of risk capital over the mean for each layer.

From the table below for the reserve forecast, the respective CVs are essentially the same for all layers. This indicates there is no gain in efficiency to cede the 1M xs 1M layer.

Acc. Yr	1M Mean Outstanding	1M Mean Ultimate	1M Standard Dev.	1M CV Outstanding	1M CV Ultimate	1M xs 1M Mean Outstanding	1M xs 1M Mean Ultimate	1M xs 1M Standard Dev.	1M xs 1M CV Outstanding	1M xs 1M CV Ultimate	2M Mean Outstanding	2M Mean Ultimate	2M Standard Dev.	2M CV Outstanding	2M CV Ultimate
1985	0	22,454	0	****	****	0	26,488	0	****	****	0	48,940	0	****	****
1986	822	22,084	592	0.72	0.03	914	24,204	722	0.79	0.03	1,889	46,441	1,403	0.74	0.03
1987	2,084	28,457	1,107	0.53	0.04	2,114	28,724	1,230	0.58	0.04	4,535	57,518	2,481	0.55	0.04
1988	3,991	29,275	1,778	0.45	0.06	3,699	27,429	1,805	0.49	0.07	8,215	57,227	3,762	0.46	0.07
1989	4,083	25,818	1,684	0.41	0.07	3,459	22,322	1,553	0.45	0.07	7,937	48,336	3,353	0.42	0.07
1990	11,085	38,454	3,951	0.36	0.10	8,697	30,531	3,407	0.39	0.11	20,297	69,319	7,419	0.37	0.11
1991	17,304	41,936	5,753	0.33	0.14	12,447	29,749	4,558	0.36	0.15	29,916	71,850	10,154	0.34	0.14
1992	26,489	51,843	8,405	0.32	0.16	17,449	33,647	6,078	0.35	0.18	43,116	84,666	13,916	0.32	0.16
1993	36,655	54,035	11,115	0.30	0.21	21,960	31,177	7,295	0.33	0.23	57,207	83,804	17,698	0.31	0.21
1994	47,163	59,374	13,450	0.29	0.23	25,579	31,856	7,992	0.31	0.25	71,055	89,548	20,685	0.29	0.23
1995	58,809	67,930	16,294	0.28	0.24	28,851	33,477	8,773	0.30	0.26	85,836	99,603	24,250	0.28	0.24
1996	71,721	75,684	19,747	0.28	0.26	31,834	33,400	9,644	0.30	0.29	101,684	107,213	28,472	0.28	0.27
1997	82,016	83,273	23,498	0.29	0.28	32,998	34,030	10,431	0.32	0.31	112,190	114,478	32,720	0.29	0.29
1998	91,757	91,764	27,744	0.30	0.30	33,512	33,971	11,211	0.33	0.33	120,984	121,450	37,284	0.31	0.31
Total	453,958	692,381	92,550	0.20	0.13	221,508	421,004	47,474	0.21	0.11	664,877	1,100,797	136,900	0.21	0.12

1 Unit = $1,000



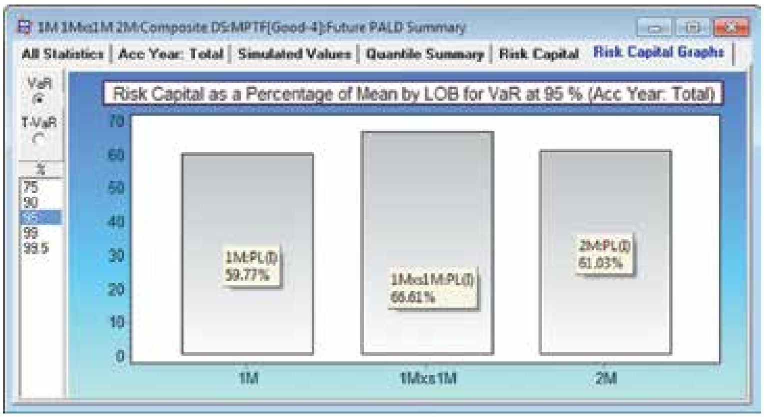
The above confirms the hypothesis stated above. The level of risk capital required, as a percentage of the total capital, is the same for all layers. For this to be true, the V@Rs must be approximately additive for the two layers (1M, 1Mxs1M) compared with 2M - illustrated below. The average percentage difference in the V@Rs (1M + 1Mxs1M versus 2M) is only 2.3%.

Risk Capital by Layer for V@R (Total)					
LOB	Quantiles				
	75%	90%	95%	99%	99.50%
1M	55,307	122,857	167,640	259,439	296,150
1Mxs1M	28,175	63,044	86,102	134,069	153,053
Sum	83,482	185,901	253,742	393,508	449,203
2M	81,628	181,696	248,043	384,267	438,710
1 Unit = $1,000					

This result does not hold for pricing the next underwriting year; instead there is an efficiency gain, albeit slight, from ceding the 1M xs 1M layer. This arises due to the high process volatility associated with the first three development periods particularly.

The forecast tables for the next underwriting period (1999) are shown for the three layers below.

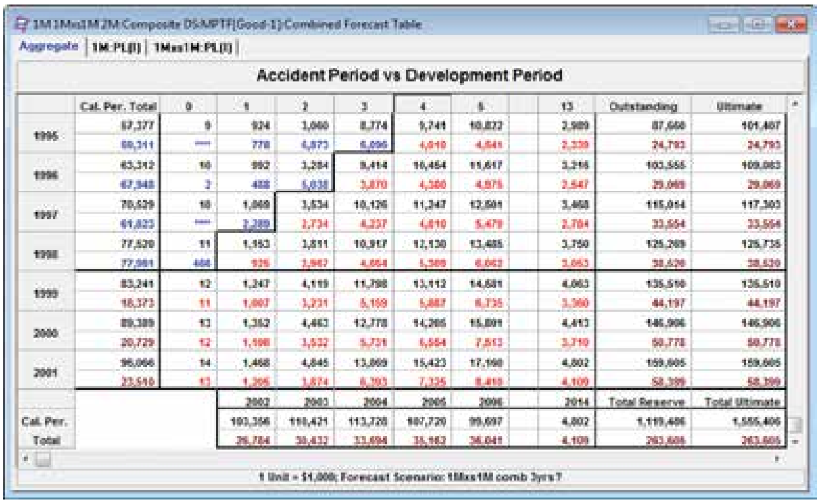
The risk capital efficiency at 95% for the future underwriting year is illustrated below. There is 1.25% gain in efficiency from ceding 1M xs 1M. This difference, although small, is significant. If reserve and underwriting risk are considered then no benefit is found since the reserve component dominates.



Risk capital requirements based on Value-at-Risk (V@R) are shown below for the three layers for the future underwriting year 1999 for various percentiles. Here the average difference between the V@Rs (1M + 1Mxs1M versus 2M) is 5.5%; a significantly higher figure.

Risk Capital by Layer for V@R (1999)					
LOB	Quantiles				
	75%	90%	95%	99%	99.50%
1M	17,597	43,043	60,803	100,897	118,270
1Mxs1M	6,249	15,759	22,497	37,984	44,800
Sum	23,846	58,802	83,300	138,881	163,070
2M	22,720	55,781	78,942	131,304	154,355
1 Unit = $1,000					

Forecast tables for the next three underwriting periods (1999~2001) are shown below for the aggregate of 1M and 1M xs 1M. The distribution means and standard deviations are for the sum of correlated log normals. The individual layers can also be viewed enabling pricing to be conducted on either the individual layers or the aggregate of the layers. This pricing can also be compared with projecting 2M on its own.


1M 1Mxs1M 2M:Composite DS:MPTF[Good-1]:Combined Forecast Table

Aggregate | 1M:PL(I) | 1Mxs1M:PL(I)

Accident Period vs Development Period

	Cal. Per. Total	0	1	2	3	4	5		13	Outstanding	Ultimate
1995	97,377	9	924	3,060	8,774	9,741	10,822		2,989	87,660	101,407
	80,311	****	778	6,873	6,096	4,010	4,541		2,339	24,793	24,793
1996	63,312	10	992	3,284	9,414	10,454	11,617		3,216	103,555	109,083
	67,948	2	488	5,038	3,870	4,300	4,875		2,547	29,069	29,069
1997	70,529	10	1,069	3,534	10,126	11,247	12,501		3,468	115,014	117,303
	61,823	****	2,289	2,734	4,237	4,810	5,479		2,784	33,554	33,554
1998	77,520	11	1,153	3,811	10,917	12,130	13,485		3,750	125,269	125,735
	77,981	466	935	3,967	4,664	5,309	6,062		3,053	38,520	38,520
1999	83,241	12	1,247	4,119	11,798	13,112	14,681		4,063	135,510	135,510
	16,373	11	1,007	3,231	5,159	5,887	6,735		3,360	44,197	44,197
2000	89,389	13	1,352	4,463	12,778	14,266	15,891		4,413	146,906	146,906
	20,729	12	1,198	3,532	5,731	6,554	7,513		3,710	50,778	50,778
2001	96,066	14	1,468	4,845	13,869	15,423	17,160		4,802	159,605	159,605
	23,510	13	1,206	3,874	6,393	7,335	8,410		4,109	58,399	58,399
			2002	2003	2004	2005	2006		2014	Total Reserve	Total Ultimate
Cal. Per.			103,356	110,421	113,728	107,720	99,697		4,802	1,119,486	1,555,406
Total			26,784	30,432	33,694	35,162	36,041		4,109	263,606	263,605

1 Unit = $1,000; Forecast Scenario: 1Mxs1M comb 3yrs?

4.2 CSLE-02: evaluating optimal layer retention and pricing layers

The data for this case study comprises a set of layers and the ground up data.

Layers to be evaluated comprise:

- Limited to 100k; 100k+
- Limited to 10k; 90k XS 10k; 100k+
- Limited to 50k; 50k XS 50k; 100k+

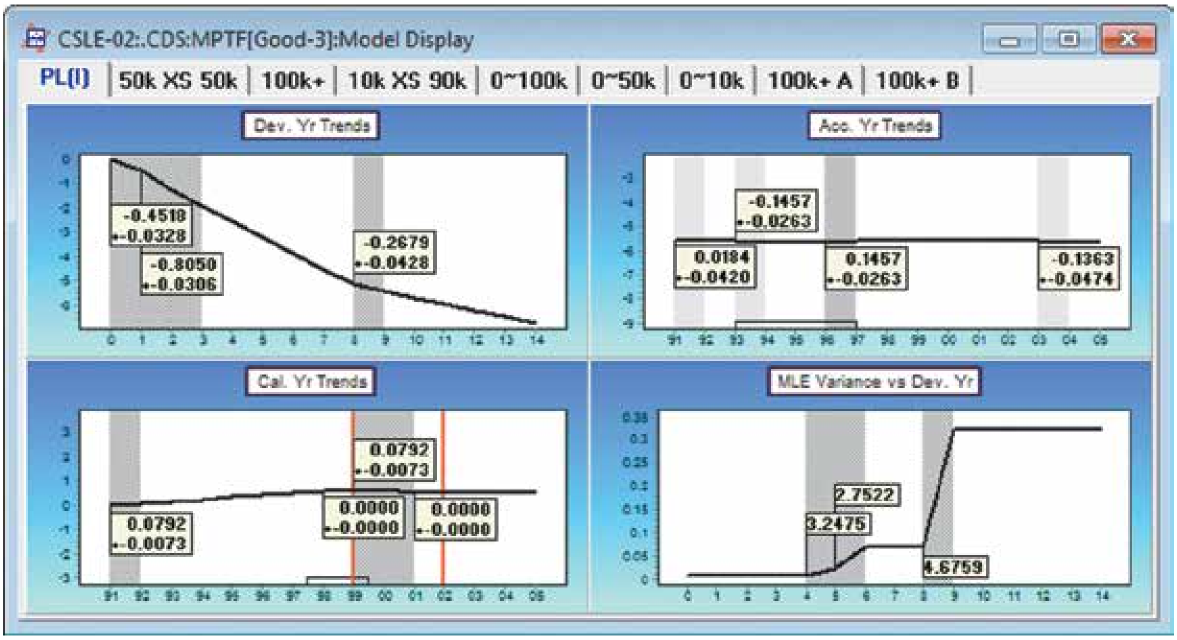
We show:

- Not all layer combinations are efficient;
- Trends are different in each layer; it is important to consider the composition of the trends being ceded.
- Correlations between the different layers must be considered.

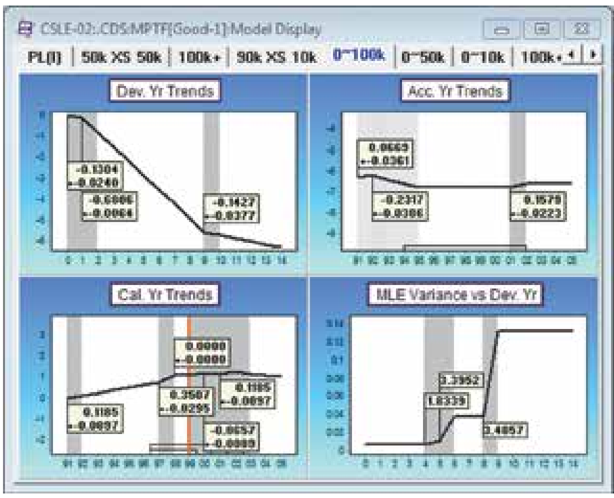
4.2.1. Model structure

Models are designed for the ground up data and each layer and a single composite model identified in the MPTF modelling framework. Note that the layers comprising each segmentation of the ground up data retain their process correlation, but there is no correlation set between different layer compositions. In order to facilitate correlations between the segments and the layer 100k+ multiple copies of the 100k+ data are included in the composite model. The models for the 100k+ data vary slightly according to the correlations between them and the other layers; there are no material differences in the projections for the 100k+ layer.

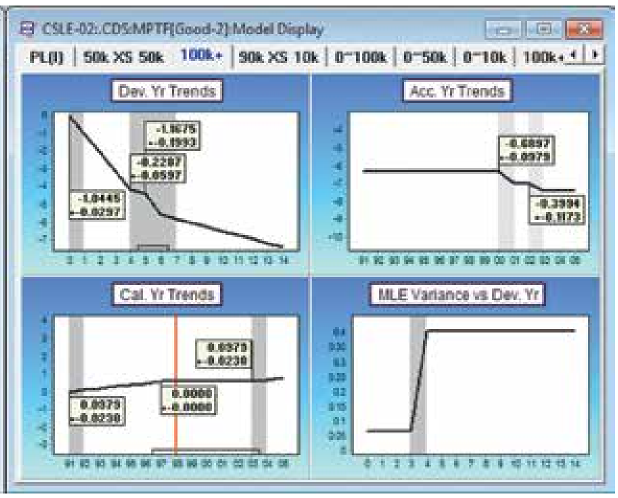
.



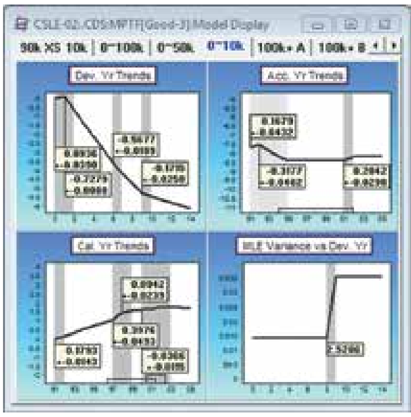
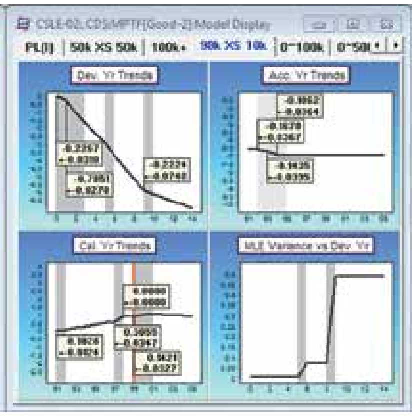
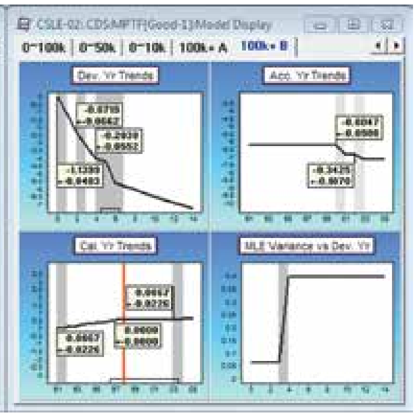
Ground Up

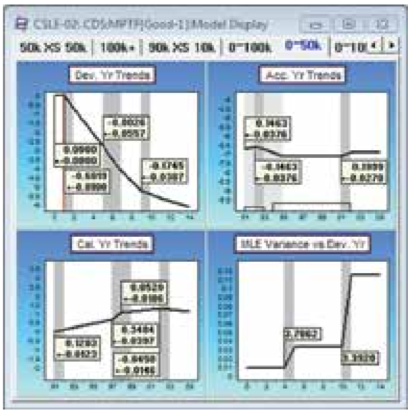
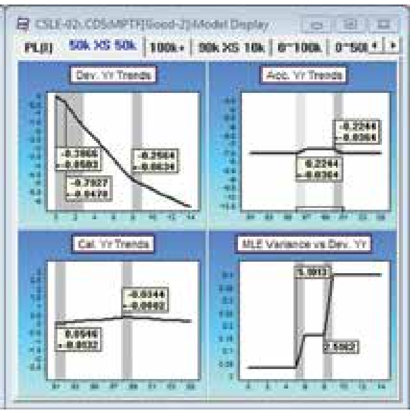
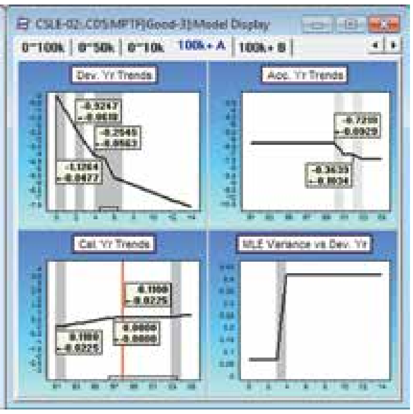


Limited 100K



100K+

		
0~10K	90K xs 10K	100K+

		
0~50K	50K xs 50K	100K+

4.2.2. Process (volatility) correlations

Below are the process volatility correlations between the segments. Note each layer group are in independent clusters and multiple copies of the 100K+ layer are included to correctly account for correlation between the different data splits.

CSLE-02:.CDS:MPTF[Good-3]:Weighted Residual Covariances Between Datasets

Covariances | Correlations | Final Covariances | Final Correlations

Final Weighted Residual Correlations Between Datasets

	PL(I)	50k XS 50k	0~50k	100k+ A	100k+	0~100k	90k XS 10k	0~10k	100k+ B
PL(I)	1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
50k XS 50k	0.000000	1	0.409537	0.645975	0.000000	0.000000	0.000000	0.000000	0.000000
0~50k	0.000000	0.409537	1	0.211322	0.000000	0.000000	0.000000	0.000000	0.000000
100k+ A	0.000000	0.645975	0.211322	1	0.000000	0.000000	0.000000	0.000000	0.000000
100k+	0.000000	0.000000	0.000000	0.000000	1	0.436403	0.000000	0.000000	0.000000
0~100k	0.000000	0.000000	0.000000	0.000000	0.436403	1	0.000000	0.000000	0.000000
90k XS 10k	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	1	0.339016	0.524981
0~10k	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.339016	1	-0.071417
100k+ B	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.524981	-0.071417	1

Clusters have been set
7 iterations were executed

From the above models, we can then assess the capital efficiency of ceding/retaining different layers from the perspective of the insurer and reinsurer. Inward reinsurance can then be priced accordingly, or outward reinsurance purchased, with full knowledge of the benefits.

Note also, the benefit of identifying the trends applicable to the different layers. The most optimal split has a capital efficiency of the aggregate (sum of layers) at 7.19%. This is lower than the model for the ground up where the data are modelled as one paid loss array. There are different trends identifiable in each layer and the additional information available in the split aids modelling.

4.2.3. Risk capital efficiency of each layer and the ground up

The following table shows the risk capital efficiency of each analysis.

Segment	Mean	V@R (99.5%)	Risk Capital % of Mean
Ground-Up	442,281	36,953	8.36
0~100	**371,663**	**23,165**	**6.23**
100k+	53,253	14,211	26.69
Sum (0~100 + 100k+)	424,916	30,562	7.19
0~10k	168,273	16,031	9.53
90k xs 10k	206,013	14,884	7.22
100k+	55,891	14,593	26.11
Sum (0~10 + 90k xs 10k + 100k+)	430,177	31,082	7.23
0~50k	338,358	26,431	7.81
50k xs 50k	49,595	6,279	12.66
100k+	55,304	14,530	26.27
Sum (0~50 + 50k xs 50k + 100k+)	443,257	35,491	8.01

The most capital efficient split for the cedant (marked in bold) out of the layers considered above is to retain all claims less than 100k and cede the excess. This split also happens to be the best in terms of modelling efficiency; the least efficient is to model the ground up data as one piece without segmentation into layers.

The most capital efficient layer for the reinsurer is the 90k xs 10k layer.

4.3. Key learnings

- Splitting the data into layers can yield surprising results; not all layer combinations are efficient nor is it necessarily efficient to split the data into layers at all;
- Trends are generally expected to be different in each layer, but care must be taken with understanding the resultant trends in the models. It is important to know what risks are being ceded.

  The above information is essential when either assessing or pricing reinsurance. Using ICRFS-Plus™ many layer combinations can be analysed in the MPTF modelling framework.

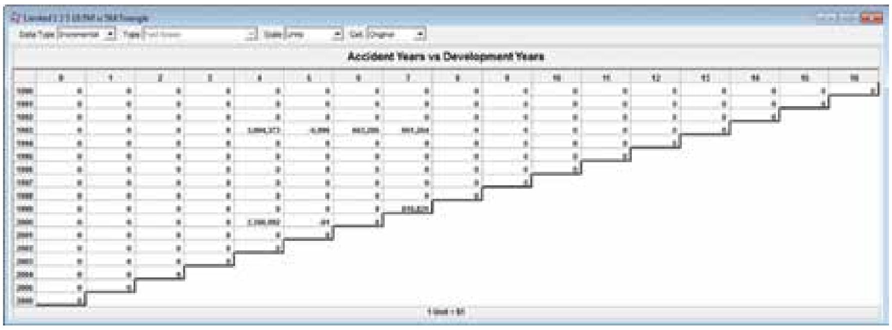
5. High Severity / Low Frequency

5.1 Example: Pricing 5M xs 5M from data limited to 5M and data limited to 10M

Pricing high severity / low frequency data is typically problematic. In this example, the 5M xs 5M layer is replete with zeroes and pricing this layer on its own would be guesswork. The strategies encompassed in this section show how sparse upper layers can be projected utilising information in the ground-up or other limited data.

We use the information in the limited 5M and limited 10M data to calculate the total reserve and to price the next underwriting year.

Consider the task of pricing 5M xs 5M from the data:



If only this data were available, then the task would be incredibly difficult if not impossible. It would be inappropriate to fit a single distribution to the data as the distributions in each cell are different. Without knowledge of how the cells are related, pricing becomes reduced to guess work.

The data are sparse, scattered, and when the limit is breached: extreme.

In addition to the 5M xs 5M layer, we have data at four different layers: Limited to 1M, Limited to 2M, Limited to 5M, and Limited to 10M. Since the model structure was found to be the same in all layers (parameters are located at the same point), correlations between the layers can be used with no double counting effect (unlike other examples presented in this document) due to the working of the estimation algorithms.

The process correlations between the layers were used, and constraints between parameters were applied where appropriate.

Data 2:CDS_Exp:MPTF[Good-2]:Weighted Residual Covariances Between Dat...

Covariances | Correlations | Final Covariances | Final Correlations

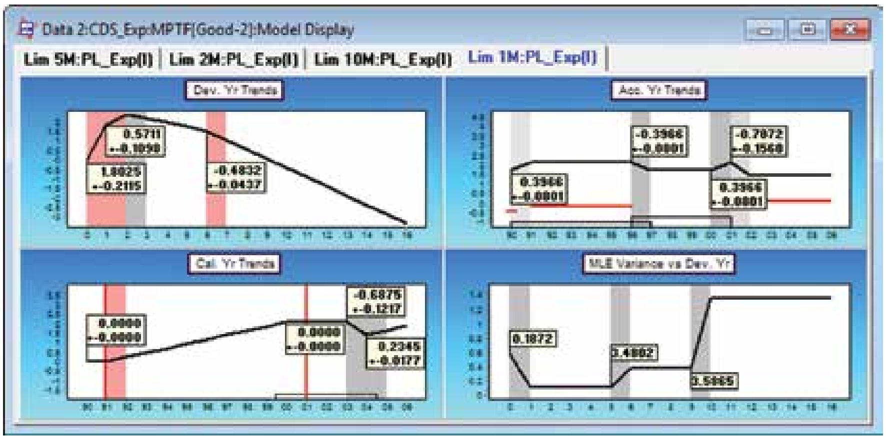
Final Weighted Residual Correlations Between Datasets

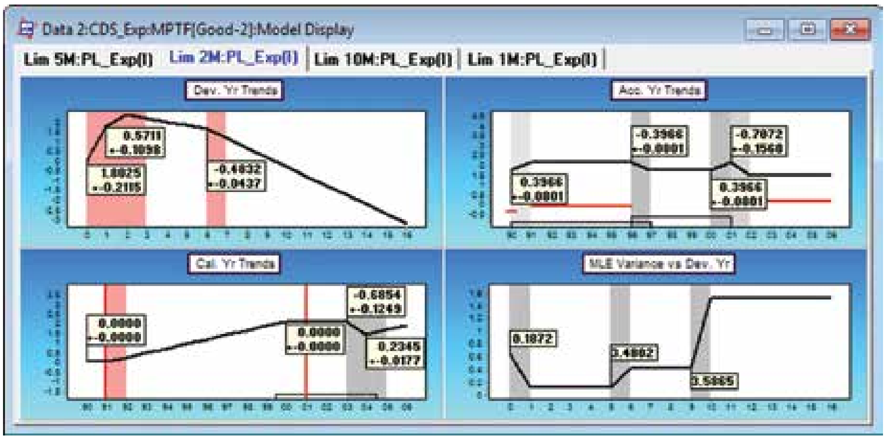
	Lim 5M:PL_Exp(I)	Lim 2M:PL_Exp(I)	Lim 10M:PL_Exp(I)	Lim 1M:PL_Exp(I)
Lim 5M:PL_Exp(I)	1	0.972967	0.997398	0.936708
Lim 2M:PL_Exp(I)	0.972967	1	0.969441	0.977902
Lim 10M:PL_Exp(I)	0.997398	0.969441	1	0.933630
Lim 1M:PL_Exp(I)	0.936708	0.977902	0.933630	1

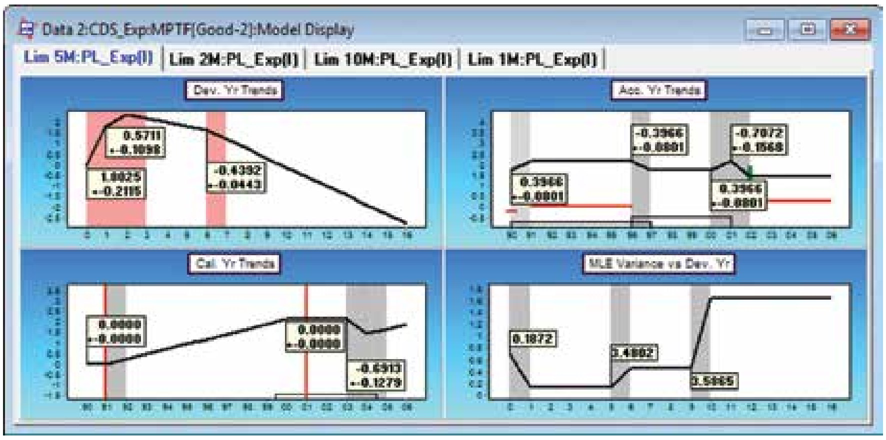
3 iterations were executed

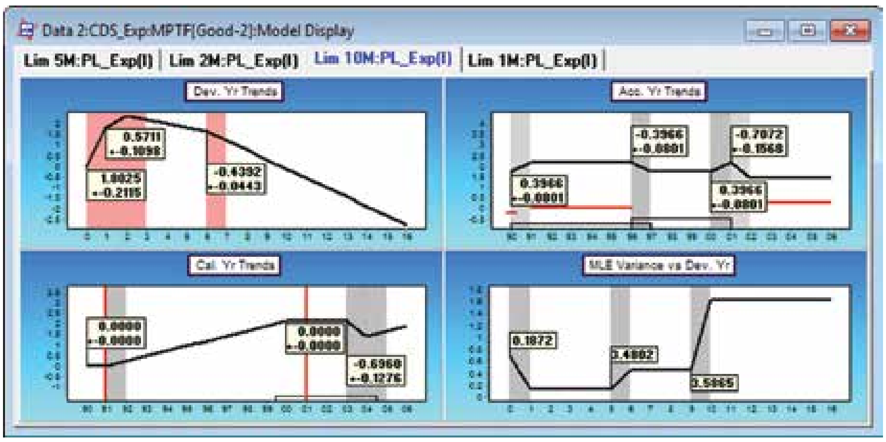
Pricing

The model displays corresponding to each layer limit are shown below.









The model displays show common parameters in the development direction between all layers (red bars). The calendar parameters vary slightly in the upper two layers (statistically they are the same) and the process volatility is also unique to each layer. In all cases, parameter changes (including heteroscedasticity) occur at the same place.

We forecast distributions for 5M xs 5M by subtracting Limited 5M from Limited 10M. The forecast table is shown below.

Data 2:CDS_Exp:MPTF[Good-2]:Reserve Forecast Table

5 xs 5M | 1 xs 1M | 3 xs 2M | Lim 5M:PL_Exp(I) | Lim 2M:PL_Exp(I) | Lim 10M:PL_Exp(I) | Lim 1M:PL_Exp(I)

Accident Period vs Development Period

	Cal. Per. Total	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Outstanding	Ultimate
1993	25	7	8	21	24	27	30	96	80	52	33	122	38	31	26	21	18	12	84	4,364
	0	0	0	0	0	3,064	-4	683	651	0	0	0	0	0	0	123	104	69	176	176
1994	47	10	14	33	37	41	46	142	91	59	38	66	66	45	38	31	21	13	103	103
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	212	179	119	79	314	314
1995	79	13	19	44	49	56	61	141	91	69	16	84	70	68	48	31	29	13	171	171
	0	0	0	0	0	0	0	0	0	0	0	0	0	334	271	176	169	79	482	482
1996	143	16	27	65	72	80	67	154	99	27	22	117	97	88	52	34	22	15	300	300
	0	0	0	0	0	0	0	0	0	0	0	0	537	447	295	196	130	67	802	802
1997	248	26	42	99	118	91	76	175	47	40	33	179	141	92	60	39	26	17	544	544
	3,004	0	0	0	0	0	0	0	0	0	0	842	701	613	338	224	149	99	1,404	1,404
1998	377	38	62	146	121	101	84	81	68	57	48	241	156	102	66	42	28	19	702	702
	-0	0	0	0	0	0	0	0	0	0	178	1,325	866	668	376	248	165	110	1,767	1,767
1999	805	82	140	247	265	171	44	179	149	125	105	467	264	172	112	73	48	31	1,337	1,954
	663	0	0	0	0	0	0	0	617	464	362	2,342	1,466	963	635	421	280	187	3,040	3,040
2000	982	99	131	232	193	49	56	218	182	152	98	382	248	161	105	69	45	30	1,473	3,830
	851	0	0	0	0	2,357	-0	0	675	534	359	2,108	1,379	906	598	397	264	177	2,962	2,962
2001	1,239	141	188	332	85	97	110	404	338	218	141	548	356	232	151	98	65	42	2,593	2,593
	0	0	0	0	0	0	0	1,506	1,231	795	518	3,030	1,983	1,304	861	571	381	255	4,590	4,590
2002	1,308	63	84	45	51	58	66	233	150	97	63	243	158	103	67	44	29	19	1,271	1,271
	0	0	0	0	0	0	279	858	547	354	230	1,348	883	581	384	255	170	114	2,134	2,134
2003	1,524	46	19	46	52	58	66	172	111	71	46	180	117	76	50	32	21	14	1,015	1,015
	0	0	0	0	0	239	252	625	404	262	170	998	654	421	288	189	126	85	1,611	1,611
2004	574	36	36	62	79	79	66	171	110	71	46	180	117	76	50	32	21	14	1,104	1,104
	2,357	0	0	0	386	303	252	627	404	262	170	999	655	421	285	190	127	85	1,657	1,657
2005	812	27	37	88	98	82	68	179	115	74	48	187	122	79	52	34	22	15	1,264	1,264
	-0	0	0	309	279	218	264	684	422	273	178	1,044	685	452	299	199	133	89	1,799	1,799
2006	1,095	38	51	122	160	86	71	186	119	77	50	194	126	82	54	35	23	15	1,391	1,391
	657	0	218	472	393	327	274	678	437	284	186	1,084	712	468	311	207	138	93	1,915	1,915
	Total Fitted/Actual		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total Reserve	Total Ultimate
Cal. Per.	9,148		1,495	1,762	1,658	1,549	1,603	1,374	1,033	811	673	580	369	267	123	71	38	15	13,349	20,636
Total	7,287		3,399	2,473	2,847	2,887	3,620	2,808	2,098	1,705	1,523	1,476	966	616	482	361	165	93	8,465	8,465

1 Unit = $1,000; Forecast Scenario: Excess + 2007

A key feature is that the mean for each cell is low (most entries are zero), but the standard deviations for each cell are extremely high – thus allowing for the extreme cases observed in the 5M xs 5M data triangle.

Data 2:CDS_Exp:MPTF[Good-2]:Reserve Forecast Summaries

5 xs 5M | 1 xs 1M | 3 xs 2M | Lim 5M:PL_Exp(I) | Lim 2M:PL_Exp(I) | Lim 10

Incurred Losses | Combination Settings

Summary by Datasets | Acc. Yrs | Cal. Yrs

Summary | Correlations

Accident Yr Summary

Acc. Yr	Mean		Standard	CV	
	Outstanding	Ultimate	Dev.	Outstanding	Ultimate
1990	0	0	0	****	****
1991	7	7	40	5.91	5.91
1992	22	22	90	4.16	4.16
1993	51	4,364	176	3.44	0.04
1994	103	103	314	3.06	3.06
1995	171	171	482	2.82	2.82
1996	300	300	802	2.67	2.67
1997	544	544	1,404	2.58	2.58
1998	702	702	1,767	2.52	2.52
1999	1,337	1,954	3,040	2.27	1.56
2000	1,473	3,830	2,962	2.01	0.77
2001	2,593	2,593	4,590	1.77	1.77
2002	1,271	1,271	2,134	1.68	1.68
2003	1,015	1,015	1,611	1.59	1.59
2004	1,104	1,104	1,657	1.50	1.50
2005	1,264	1,264	1,799	1.42	1.42
2006	1,391	1,391	1,915	1.38	1.38
Total	13,349	20,636	8,465	0.63	0.41

1 Unit = $1,000
Forecast scenario: Excess + 2007

Pricing

As with any other ICRFS-Plus™ Probabilistic Trend Family model, we can price future underwriting periods. Again we use the models for the data limited to 10M and the data limited to 5M to produce the forecast for the difference (shown below).

Data 2:CDS_Exp:MPTF[Good-2]:Future Accident Period Forecast Table

5 xs 5M | 1 xs 1M | 3 xs 2M | Lim 5M:PL_Exp(I) | Lim 2M:PL_Exp(I) | Lim 10M:PL_Exp(I) | Lim 1M:PL_Exp(I)

Accident Period vs Development Period

	Cal. Per. Total	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Outstanding
2007	47	47	69	123	102	85	71	185	119	77	50	195	127	83	54	35	23	15	1,459
	184	184	267	473	394	329	275	681	439	285	186	1,090	716	473	313	208	139	94	1,950
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total Outstanding
Cal. Per. Total			69	123	102	85	71	185	119	77	50	195	127	83	54	35	23	15	1,459
			267	473	394	329	275	681	439	285	186	1,090	716	473	313	208	139	94	1,950

1 Unit = $1,000; Forecast Scenario: Excess = 2007

Data 2:CDS_Exp:MPTF[Good-2]:Future Forecast Summaries

5 xs 5M | 1 xs 1M | 3 xs 2M | Lim 5M:PL_Exp(I) | Lim 2M:PL_Exp(I) | Lim 10M:I

Summary by Datasets | Acc. Yrs | Cal. Yrs | Combination Settings

Correlations | Standard Deviations

Totals | Acc. Yrs | Cal. Yrs

Future Forecast Correlations Within Combination (Totals)

	Lim 5M:PL_Exp(I)	Lim 10M:PL_Exp(I)
Lim 5M:PL_Exp(I)	1	-0.995484
Lim 10M:PL_Exp(I)	-0.995484	1

The outstanding distribution correlation is negative due to the subtraction of the limits. The correlation in the reserve distributions is very high (as expected).

Data 2:CDS_Exp:MPTF[Good-2]:Future Forecas...

5 xs 5M | 1 xs 1M | 3 xs 2M | Lim 5M:PL_Exp(I) | Lim 2M:P

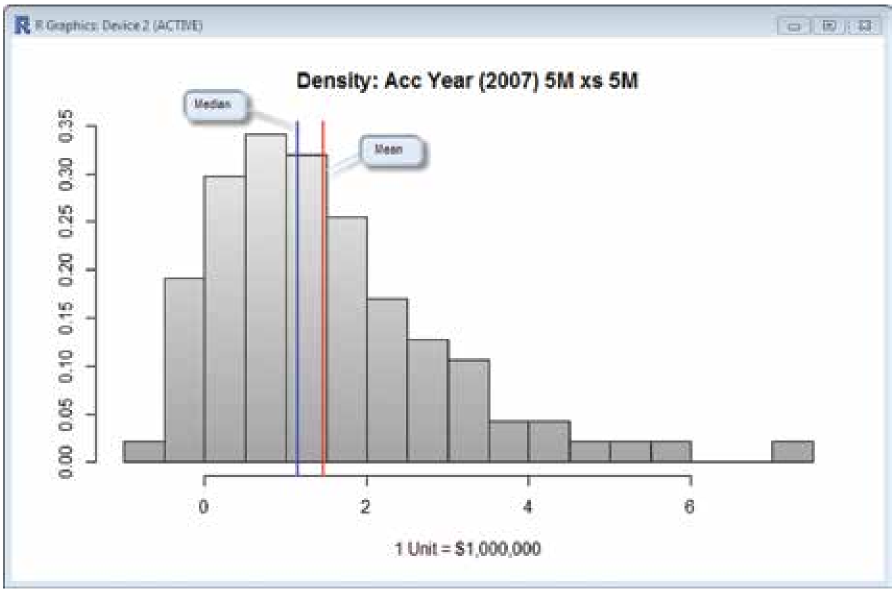
Summary by Datasets | Acc. Yrs | Cal. Yrs | Combination Settings

Summary | Correlations

Future Calendar Yr Summary

Calendar Yr	Mean Outstanding	Standard Dev.	CV Outstanding	Cum. Means as % of total
2007	47	184	3.92	3.21
2008	69	267	3.86	7.96
2009	123	473	3.86	16.36
2010	102	394	3.86	23.35
2011	85	329	3.87	29.16
2012	71	275	3.89	34.02
2013	185	681	3.68	46.70
2014	119	439	3.68	54.88
2015	77	285	3.69	60.17
2016	50	186	3.71	63.59
2017	195	1,090	5.60	76.93
2018	127	716	5.66	85.60
2019	83	473	5.73	91.25
2020	54	313	5.81	94.95
2021	35	208	5.90	97.37
2022	23	139	6.02	98.96
2023	15	94	6.14	100.00
Total	1,459	1,950	1.34	100.00

1 Unit = $1,000
Forecast scenario: Excess = 2007



The density plot of the differences between the layers is depicted above. The negatives emerge as a result of the differences (negatives can occur in the XS layer – see original data) but are unlikely to happen.

If the layer to be priced was outside the interval of the data, then the best way to approximate this layer would be to predict the mean for the layer using the trends in the projections from lower limits. The means (and other distribution characteristics) are then modelled and subsequently projected into the high limits.

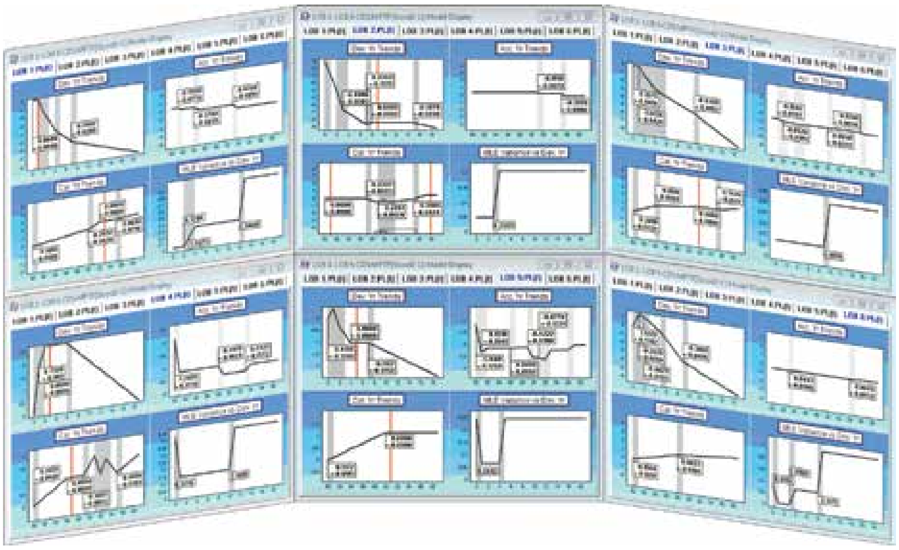
5.2. Key learnings

- If the ground up data are available, then high severity / low frequency layers can readily be priced using ICRFS-Plus™;
- If losses being priced are outside the range of the excess data, then approximations of the excess distribution (mean and standard error) can be approximated via projection of lower layers.
- Fitting a single severity (claim size) distribution to all individual losses is inappropriate since the severity distributions vary by development, accident, and calendar period. That is, the frequency/severity distributions are not homogenous across periods.

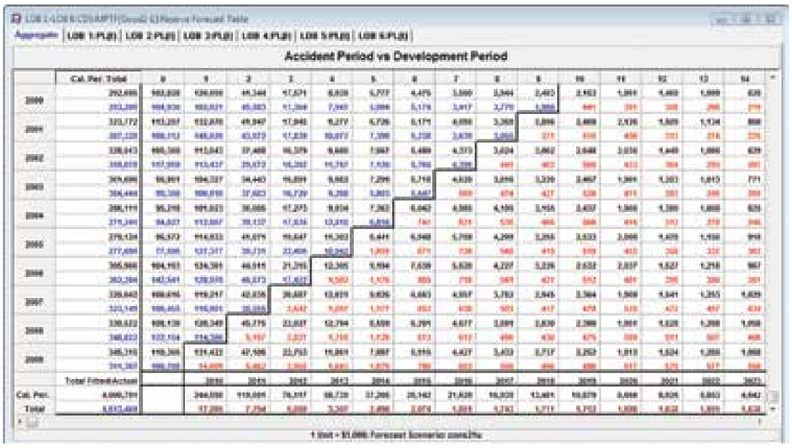
6. Adverse Development Cover

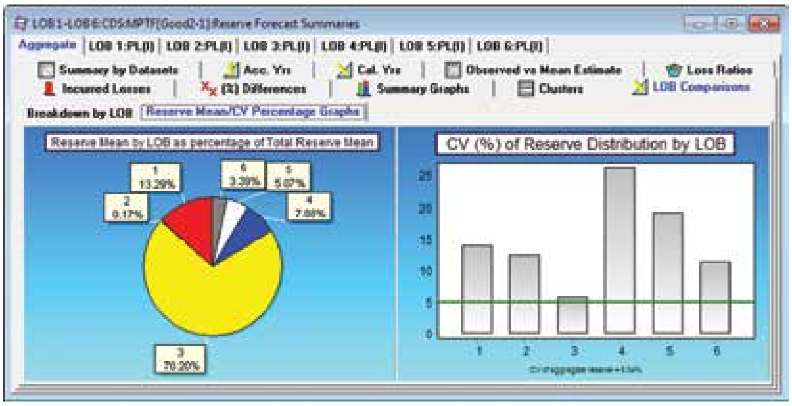
6.1. LOB 1 through 6

This case study illustrates how Adverse Development Cover (ADC) can be priced or evaluated for capital efficiency for a single LOB or multiple LOBs. Complex reinsurance structures are discussed including, varying limits on individual LOBs as well as the aggregate of LOBs and multiple limits by accident year. Retrospective and prospective reinsurance structures can be considered.

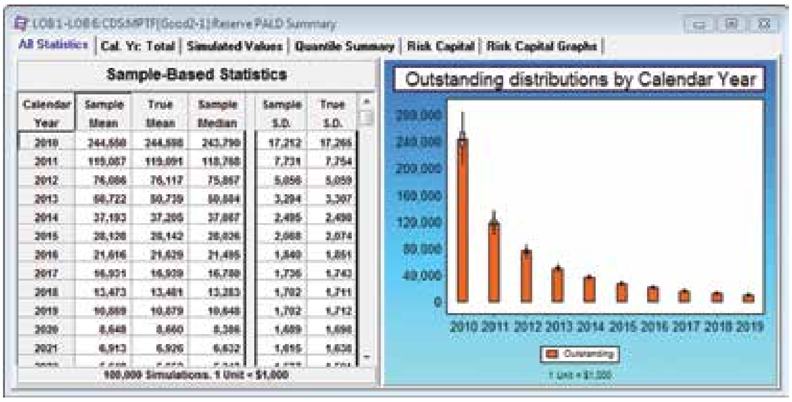


The MPTF modelling framework projects correlated log-normal distributions by cell for each LOB. The aggregate forecast table contains means and standard deviations by cell as shown below. The distributions of the aggregate are obtained by simulating from the correlated log-normal distributions to obtain distributions by cell, period total, and total reserve.



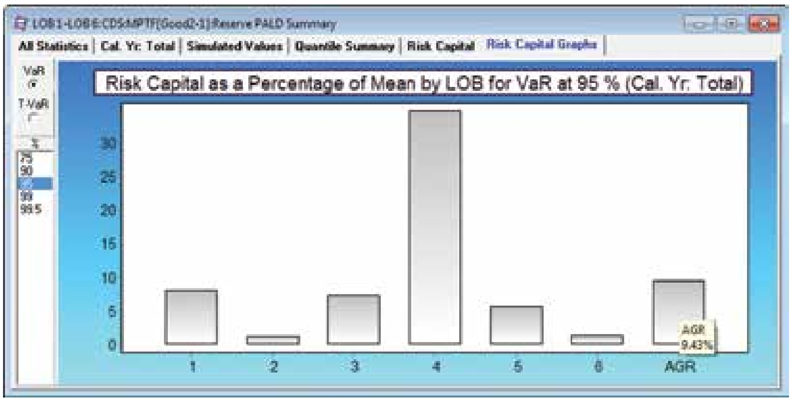


LOB 4 represents 7.88% of the total mean reserve but will require a significant proportion of the risk capital as this line has the largest CV and second largest reserve standard deviation.



Calendar Year	Sample Mean	True Mean	Sample Median	Sample S.D.	True S.D.
2010	244,550	244,598	243,790	17,212	17,265
2011	119,087	119,091	118,768	7,731	7,754
2012	76,086	76,117	75,867	5,056	5,059
2013	50,722	50,739	50,584	3,294	3,307
2014	37,193	37,205	37,067	2,495	2,498
2015	28,128	28,142	28,026	2,068	2,074
2016	21,616	21,629	21,495	1,840	1,851
2017	16,931	16,939	16,780	1,736	1,743
2018	13,473	13,481	13,283	1,702	1,711
2019	10,869	10,879	10,648	1,702	1,712
2020	8,648	8,660	8,386	1,689	1,698
2021	6,913	6,926	6,632	1,615	1,638

Risk capital is particularly important for the next three calendar years, thereafter it is less important. However, total allocation of risk capital based on the variance-covariance formula allocates significant capital to LOB 4 – the main driver of risk in the later calendar years.



Capital efficiency of the aggregate of the six LOBs is 9.43%. Most of the risk capital is allocated to LOB 4; LOBs 2 and 6 receive little risk capital.

Consider Adverse Development Cover for the aggregate of the six LOBs. Suppose the lower attachment point (M1) is the mean of the total reserve loss distribution and the upper attachment point (M2) corresponds to the 90th percentile of the total aggregate loss distribution. That is: M1 = 660M and M2 = 706M respectively. Sample statistics for the ground up, insurer, and outward reinsurer follow.

LOB 1-LOB 6:CDS:MPTF[Good2-1]:Re

All Statistics | Layer Distributions | Insurer's Quantiles, VaR and T-VaR | Reinsurer's Qua

Sample-Based Statistics (Incremental)

Calendar	All			Insurer (100%)			Reinsurer (100%)		
Yr	Mean	S.D.	CV	Mean	S.D.	CV	Mean	S.D.	CV
2010	244,550	17,212	0.07	244,550	17,212	0.07	0	0	****
2011	119,087	7,731	0.06	119,087	7,731	0.06	0	0	****
2012	76,086	5,056	0.07	76,086	5,056	0.07	0	0	****
2013	50,722	3,294	0.06	50,722	3,294	0.06	0	0	****
2014	37,193	2,495	0.07	37,193	2,495	0.07	0	0	****
2015	28,128	2,068	0.07	28,125	2,075	0.07	3	224	83.83
2016	21,616	1,840	0.09	21,585	1,922	0.09	31	687	22.20
2017	16,931	1,736	0.10	16,782	2,106	0.13	149	1,445	9.71
2018	13,473	1,702	0.13	13,059	2,528	0.19	413	2,238	5.42
2019	10,869	1,702	0.16	10,096	2,862	0.28	773	2,795	3.62
2020	8,648	1,689	0.20	7,554	2,909	0.39	1,094	2,976	2.72
2021	6,913	1,615	0.23	5,623	2,714	0.48	1,289	2,878	2.23
2022	5,648	1,677	0.28	4,275	2,473	0.58	1,373	2,661	1.94
2023	4,636	1,533	0.33	3,276	2,193	0.67	1,360	2,396	1.76
2024	3,849	1,470	0.38	2,563	1,939	0.76	1,286	2,120	1.65
2025	3,225	1,422	0.44	2,049	1,742	0.85	1,176	1,864	1.58
2026	2,668	1,323	0.50	1,634	1,533	0.94	1,034	1,604	1.55
2027	2,139	1,195	0.56	1,279	1,317	1.03	859	1,331	1.55
2028	1,625	1,041	0.64	958	1,097	1.15	667	1,046	1.57
2029	1,080	796	0.74	631	800	1.27	449	730	1.63
2030	543	511	0.94	316	479	1.52	227	413	1.82
Total	659,626	36,125	0.05	647,443	23,832	0.04	12,183	16,779	1.38

Limits: M1=659,626 M2=706,350 M2-M1=46,724

100,000 Simulations. 1 Unit = $1,000

Based on limits described above, the CV of the insurer shows a slight improvement (from 5% to 4%). What about capital efficiency? These results are provided below, where see that the insurer, assuming this ADC policy, now requires a risk capital percentage of 4.23% of the mean, while the outward reinsurer requires 283% of the expected mean.

Insurer			Reinsurer		
Sample Mean	V@R 95%	% Risk Capital	Sample Mean	V@R 95%	% Risk Capital
647.44	27.42	4.23	12.18	34.52	283.35
1 Unit = $1,000,000					

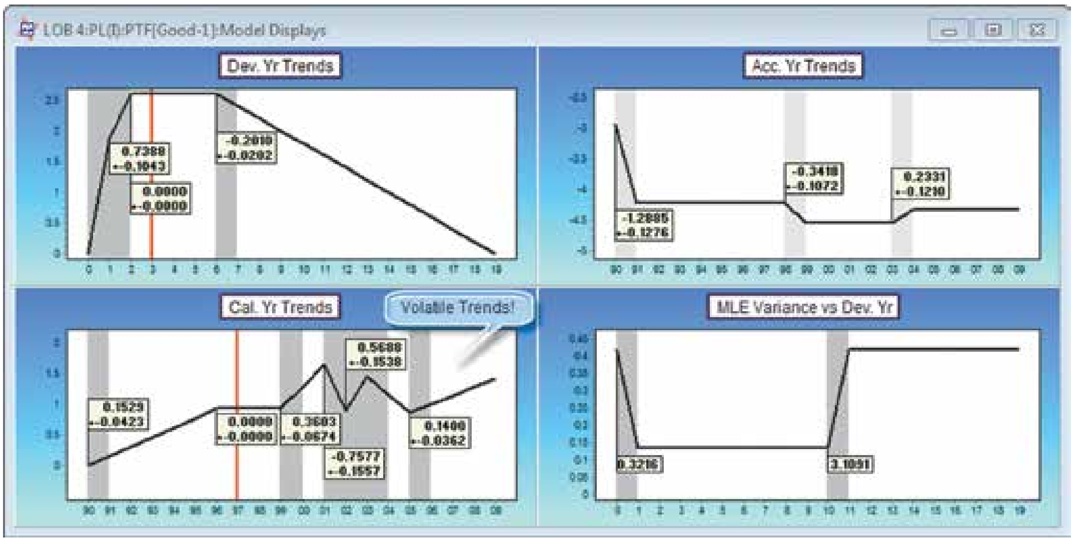
The insurer does show considerable improvement in terms of the % risk capital of the mean versus the % risk capital of the mean for the aggregate of the six LOBs (9.43% from the risk capital allocation graph presented earlier).

If the outward reinsurance is accessed (47% probability based on simulations) there is a good chance (26%) that all the reinsurance capital will be required.

6.2. LOB 4

The most volatile line of the six LOBs in the previous section is LOB 4. There are two reasons for this. Firstly, the calendar year trends are very volatile - the most recent trend (14%+_3.51%) has a CV of 25%! The uncertainty associated with the trend has significant impact on the standard deviations and associated risk capital. The second reason is that the process volatility is relatively high – especially in the late development years.

The model display highlights both these features.



The standard deviations of the calendar year totals increase significantly by the calendar periods. This is the reason that a high level of risk capital is allocated to LOB 4 when considering the six lines jointly – the parameter uncertainty has major impact. Since the uncertain trend is in the calendar year direction, the most recent accident years are the most adversely affected (see below).

LOB 1-LOB 6:CDS:MPTF[Good2-1]:Reserve Forecast Table

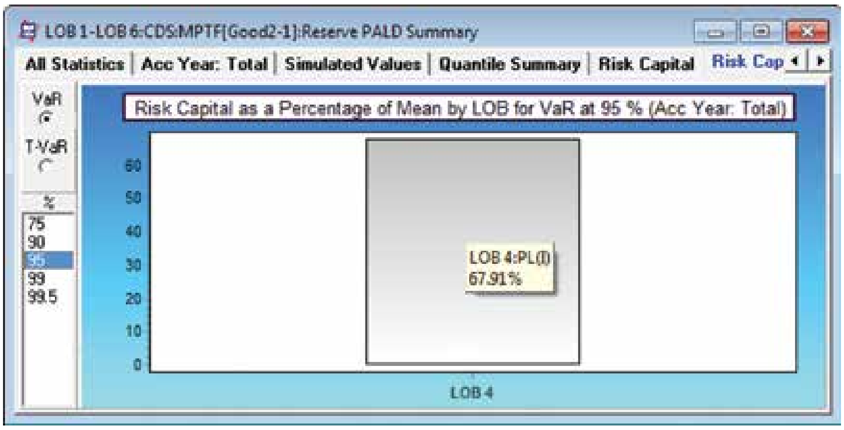
Aggregate | LOB 1:PL(I) | LOB 2:PL(I) | LOB 3:PL(I) | LOB 4:PL(I) | LOB 5:PL(I) | LOB 6:PL(I)

Accident Period vs Development Period

	Cal. Per. Total	0	1	2	3	4	5	6	7	8	9	10	11	12
2004	3,048	16	68	162	186	214	247	284	268	254	240	227	248	236
	3,086	40	63	132	243	350	233	115	110	107	105	103	197	191
2005	2,127	14	87	209	240	276	319	368	347	329	311	295	323	306
	1,926	15	32	162	236	384	120	152	147	144	142	140	261	256
2006	2,318	16	102	246	283	326	376	435	411	389	369	350	383	365
	2,341	20	44	270	300	131	156	185	181	178	175	174	318	311
2007	2,559	20	127	305	352	406	470	543	514	487	462	439	481	458
	2,026	13	122	262	142	168	200	240	236	232	230	229	410	402
2008	2,864	21	137	329	380	439	508	588	557	528	502	477	524	499
	2,464	7	132	133	157	187	225	271	267	264	263	262	459	451
2009	3,243	24	156	372	430	498	577	669	634	602	572	545	598	571
	3,808	49	64	154	183	220	266	323	319	317	315	314	541	532
	Total Fitted/Actual		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Cal. Per.	47,219		3,649	3,874	3,981	4,036	4,022	3,916	3,701	3,487	3,284	3,078	2,876	2,641
Total	47,449		594	732	840	968	1,088	1,190	1,256	1,319	1,388	1,448	1,510	1,489

1 Unit = $1,000; Forecast Scenario: cons21u

The company obtains significant risk diversification credit by writing this line in combination with the other five lines. The total percentage risk capital is 9.43% versus 68% for LOB 4 on its own!



Is there any benefit to obtaining reinsurance for LOB 4 on its own and how do different retention levels affect the efficiency of the risk capital required?

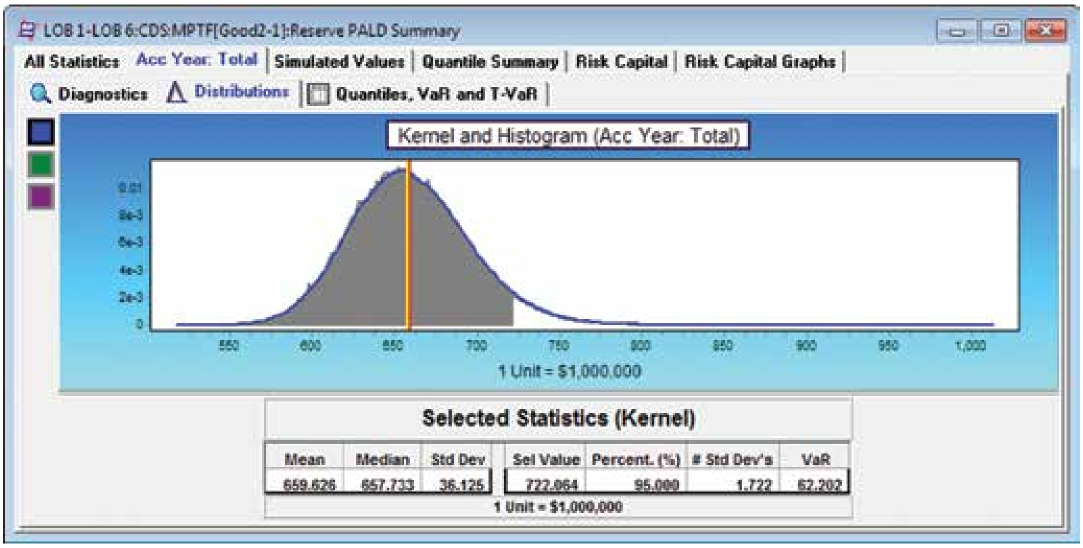
The following table shows the benefit to the insurer for various retention levels compared to the ground up data at the 95% risk capital level.

The insurer is assumed to take all losses up to the projected mean loss (the respective M1. The outward reinsurer takes any losses between the mean and various attachment levels (the respective M2). Any losses above the upper attachment point are also taken by the insurer. The benefit in terms of capital efficiency is shown below – in particular, the % risk capital required by the insurer after taking outward reinsurance. Note for the final entry, M2 is above the 95% quantile for the total losses (94.5M), thus significant benefit is obtained by the insurer compared to the other levels.

LOB 4									
		Insurer				Reinsurer			
M1	M2	Mean	SD	CV	% Risk Capital (95%)	Mean	SD	CV	% Risk Capital (95%)
0.0	355.0	56.5	20.4	0.36	67.91				
56.5	66.7	53.1	16.8	0.32	58.65	3.3	4.5	1.3	208.54
56.5	71.8	52.0	15.4	0.30	52.12	4.4	6.3	1.4	248.64
56.5	76.9	51.2	14.2	0.28	44.57	5.2	7.8	1.5	292.18
56.5	82.0	50.6	13.1	0.26	36.22	5.8	9.0	1.5	338.77
56.5	97.3	49.5	11.0	0.22	13.90	6.9	11.6	1.7	453.13
Units = $1,000,000									

This information is also critical to the outward reinsurer; any pricing for this LOB on its own should be priced conservatively due to the level of risk taken.

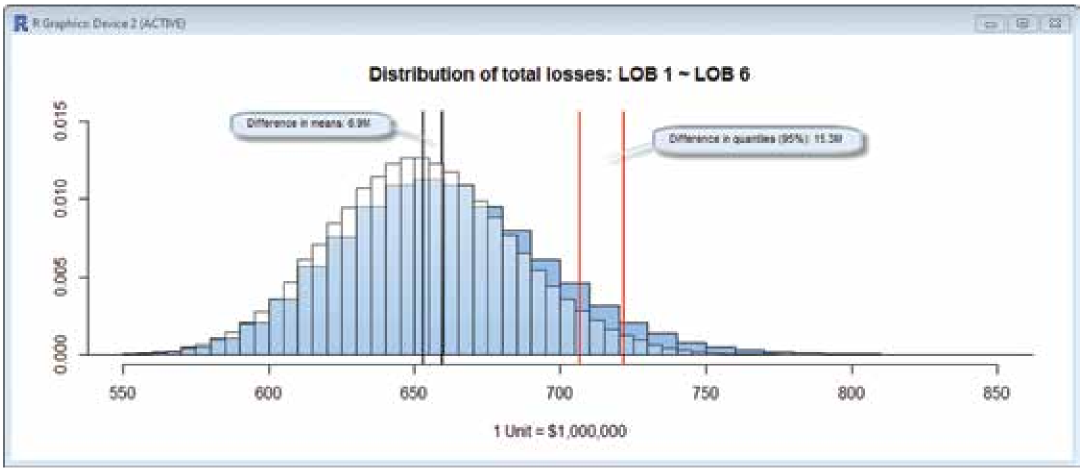
The diversification credit obtained by writing LOB 4 jointly with the other LOBs (then purchasing outward reinsurance) can be contrasted with purchasing outward reinsurance for LOB 4 on its own. Subsequent adverse development cover can then be considered on the new aggregate of the six lines where LOB 4 is now Net of the Reinsurance. The highest attachment point for M2 (above) was used for LOB 4 for comparison purposes.



The above corresponds to the distribution of the aggregate of the six LOBs (no outward reinsurance). The V@R at 95% is 62.2M (using the Kernel – a smoothed form of the sample), and this corresponds to the risk capital efficiency percentage of 9.43%.

The two aggregate loss distributions with and without outward reinsurance on LOB 4 are overlaid below (blue corresponds to the distribution of the total losses without reinsurance, the light grey to the distribution of the total losses with outward reinsurance on LOB 4: M2 = 97.3M as shown previously).

The difference in the quantiles (15.3M) is split between the difference in means (6.9M) and the difference in V@R (about 8.4M). The outward reinsurance on LOB 4 translates into a gain in capital efficiency for the aggregate; the risk capital as a percentage of the mean drops from 9.43% to 8.24%.



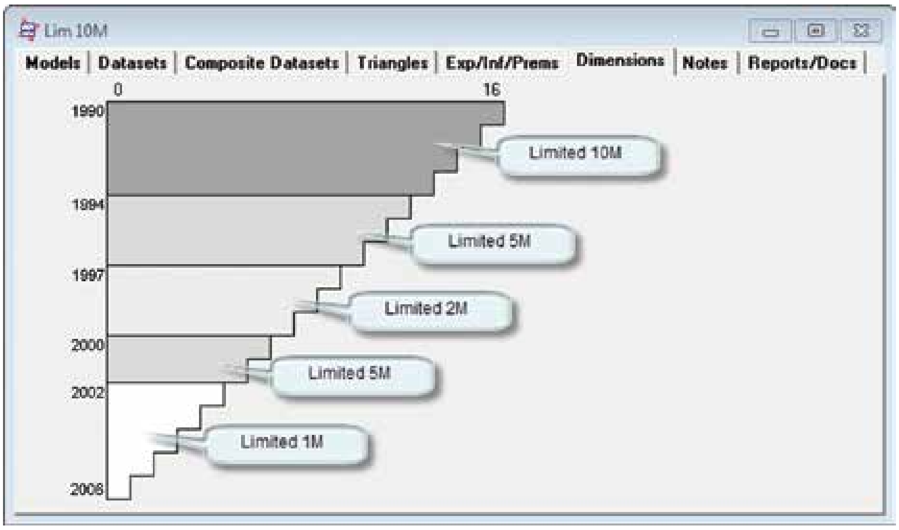
Similarly, the CV of the aggregate distribution is now 4.9%; down from 5.5% shown previously.

The above results also give a value of the outward reinsurance in respect of the aggregate loss distribution. The insurer is expected to compensate the outward reinsurer to a value above the mean losses for the outward reinsurer – however the total compensation (mean + risk) should not exceed the difference in quantiles at the level of risk the insurer is evaluating (here 95%).

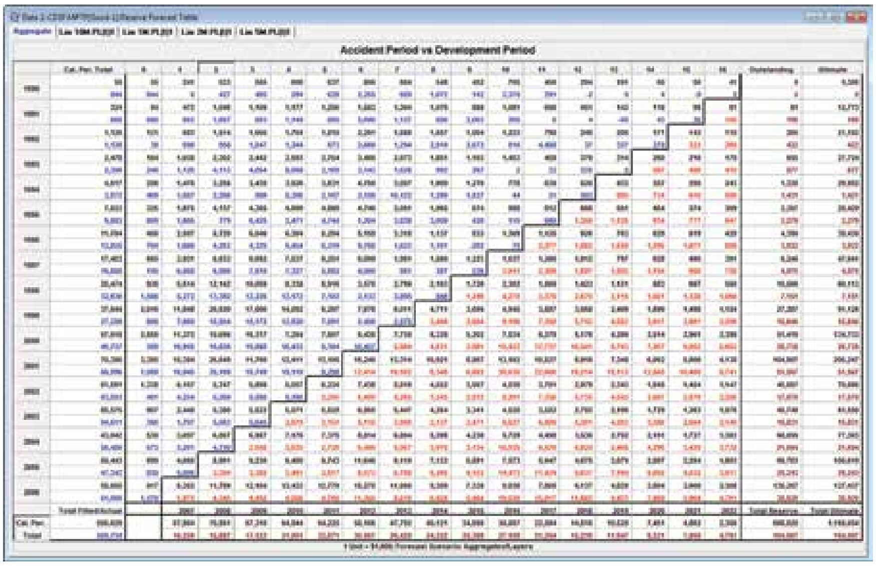
This outward reinsurance structure may be more cost effective than writing adverse development cover against the aggregate of the six lines.

6.3. Pricing adverse development cover across differing limits

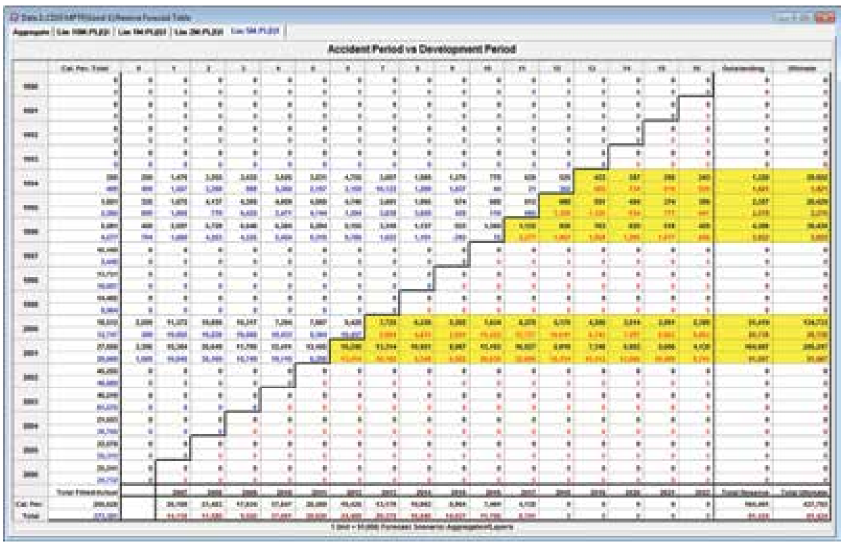
Consider the task of pricing adverse development cover where the following layers are applied. The same data as used for the 5M xs 5M analysis previously is considered – see previous model displays.



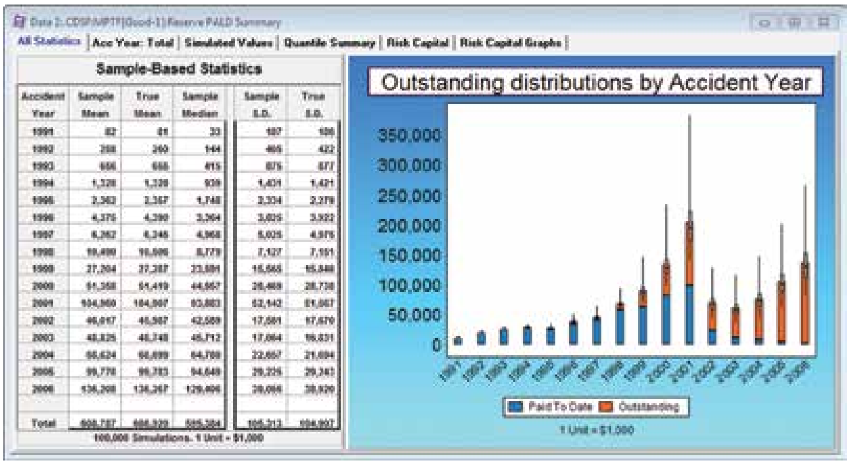
Reinsurance is required on the aggregate of the layers where they apply. This can also readily be done in the MPTF modelling framework. The aggregate forecast of the four layers is shown below.

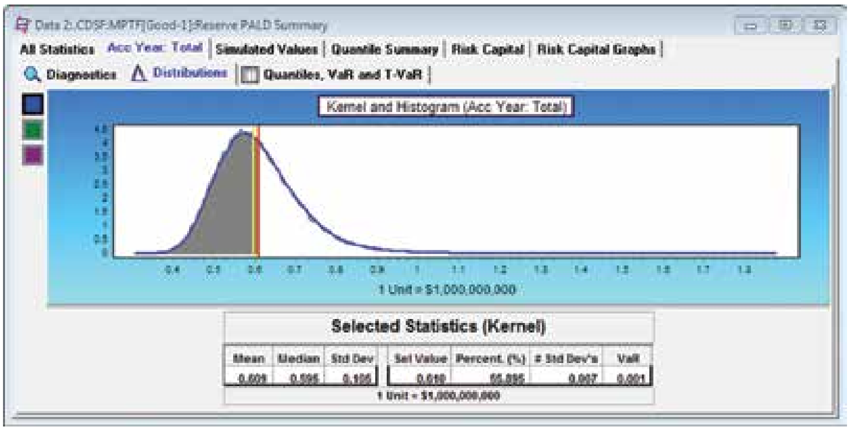


The forecasts for each layer correspond to the accident years they apply for. For instance, Lim 5M applies to 1994~1996 and 2000~2001. These cells are highlighted below and match the aggregate figures above for those same periods.

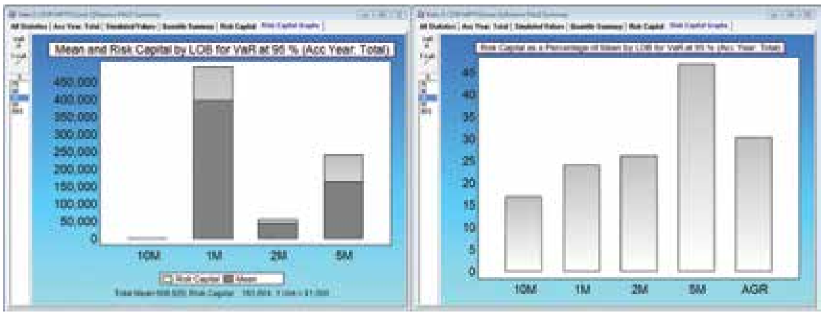


The complete forecast distributions can be analysed by individual accident years and in total – just like any other forecast!





The total reserve distribution is highly skewed; skewness which is primarily driven by the volatility in the Limited 5M layer – especially AY 2001. From the model displays, shown previously, the 2001 year was unusually high - an unfortunate time to have a high limit. Reinsurance at a lower threshold was subsequently taken out post-2001.



Risk capital is primarily allocated to the Lim 1M layer (most years) followed by the Lim 5M layer.

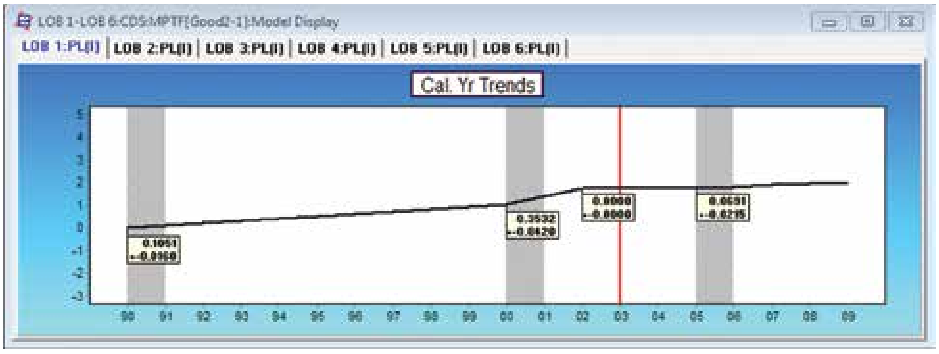
Any combination of layers can be considered for comparison purposes – similarly construction of multiple excess layers can be considered from the perspective of an inward reinsurer.

6.4. Key learnings

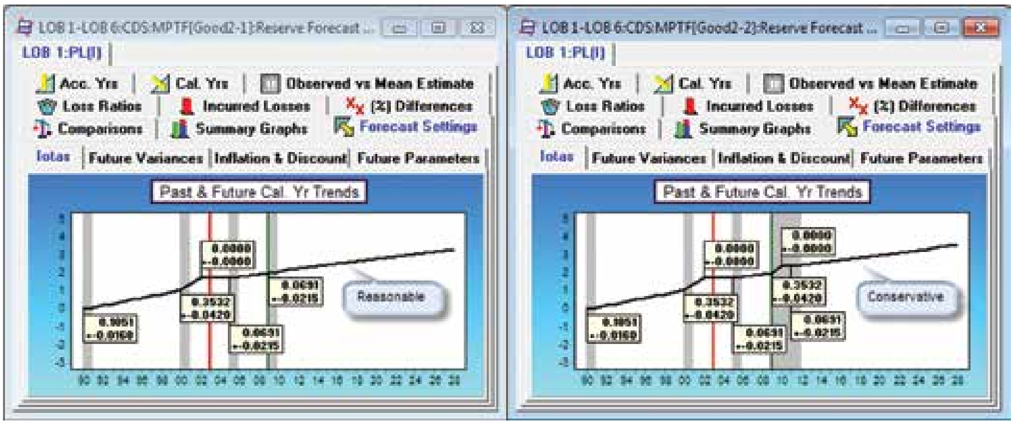
- Adverse development cover can be evaluated against a single LOB or a multitude of LOBs;
- Complex reinsurance structures can be analysed where multiple layers apply for different underwriting years;
- Subsequent updates of reinsurance limits can be evaluated – namely is there any benefit to increasing / decreasing the level of reinsurance for the cedant.

7. Adverse development cover as a means of protection against conservative scenarios

In this case study, we consider two scenarios - a reasonable scenario and a conservative scenario where the conservative scenario adds additional prudence for adverse inflationary trends. Reinsurance can be considered as an option to provide adverse development cover against the adverse trends arising. We illustrate this concept in the context of LOB 1.



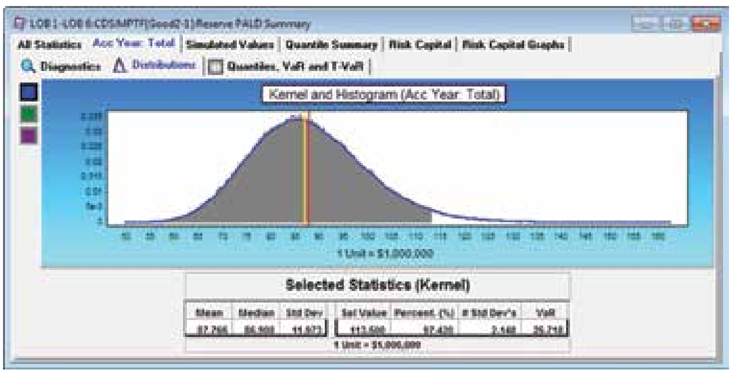
The calendar year trends change several times in the last ten years. A number of scenarios may be considered for the future. The actuaries most reasonable scenario is to continue with the 6.91%+_2.15% calendar year trend until run-off is complete. However, based on their knowledge of the business, there is a small chance (5%) of the 35.3%+_4.2% calendar year trend (previously observed 2000~2002) emerging in the next year, zero the year after, then returning to the 6.91%+-2.15% calendar year trend for the remaining run-off period.



There is a substantial difference in the forecasts arising from these two scenarios. The reasonable scenario estimates the mean of the total loss reserve distribution of 87.8M whereas the conservative scenario places the mean of the total loss reserve distribution at 113.5M. This conservative mean estimate is around 29% higher than the reasonable estimate. The magnitude of the difference is such that it would be unwise to reserve the full conservative mean as there is only a 5% probability of this level of capital being required and the actuarial team states the 87.8M estimate as the best estimate.

An appropriate option under these circumstances is to use the conservative scenario as a basis for purchasing retrospective outward reinsurance. The protection in this scenario is against an adverse calendar year trend arising. Therefore, the most affected years are the recent years. There is likely little advantage in adding retrospective cover to the earliest years.

The insurer has sufficient risk appetite to retain losses up to the 75th percentile of the total loss reserve distribution of the reasonable scenario. What level of adverse development cover is required to maintain the same risk capital appetite against the conservative scenario also at the 75th percentile? What is the most efficient way of realising this cover?



There are at least two options. The first option is to set the attachment points so that the insurer's risk capital is risked first, the second option is that the reinsurance applies first then the insurer's risk capital applies. The second option is what we consider here, although the reinsurance is probably more costly for this option since it applies sooner.

First of all, we observe that the conservative scenario emerging would potentially be catastrophic for the insurer if the reasonable scenario was reserved without any further reinsurance program. The mean total reserve from the conservative scenario is sitting at the 97.4% quantile for the reasonable scenario.

The liability streams for the two scenarios, reasonable and conservative respectively, are as follows:

LOB 1:PL(I) — Calendar Yr Summary

Calendar Yr	Mean Outstanding	Standard Dev.	CV Outstanding	Cum. Means as % of total
2010	51,593	7,911	0.15	58.77
2011	14,393	2,527	0.18	75.17
2012	6,140	1,712	0.28	82.17
2013	3,299	974	0.30	85.92
2014	2,337	688	0.29	88.59
2015	1,765	534	0.30	90.60
2016	1,429	460	0.32	92.22
2017	1,237	433	0.35	93.63
2018	1,067	412	0.39	94.85
2019	916	393	0.43	95.89
2020	782	374	0.48	96.78
2021	671	369	0.55	97.55
2022	588	371	0.63	98.22
2023	481	325	0.67	98.77
2024	383	279	0.73	99.20
2025	291	234	0.80	99.53
2026	208	190	0.91	99.77
2027	137	147	1.08	99.93
2028	64	94	1.47	100.00
Total	87,782	12,001	0.14	100.00

1 Unit = $1,000
Forecast scenario: LOB 1 - Reasonable

LOB 1:PL(I) — Calendar Yr Summary

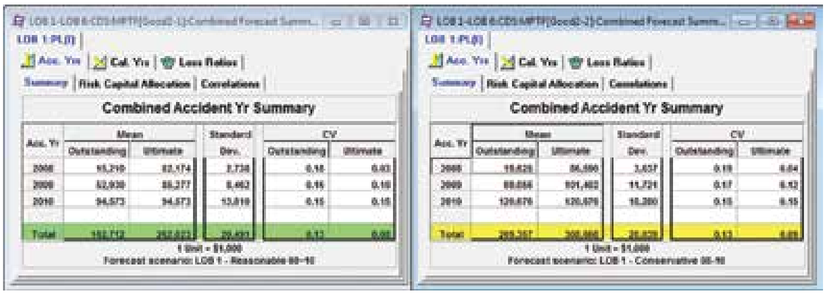
Calendar Yr	Mean Outstanding	Standard Dev.	CV Outstanding	Cum. Means as % of total
2010	68,663	11,306	0.16	60.49
2011	17,842	3,124	0.18	76.20
2012	7,611	2,119	0.28	82.91
2013	4,089	1,206	0.29	86.51
2014	2,897	851	0.29	89.06
2015	2,187	661	0.30	90.99
2016	1,771	570	0.32	92.55
2017	1,633	537	0.36	93.98
2018	1,322	510	0.39	95.07
2019	1,135	487	0.43	96.07
2020	969	463	0.48	96.92
2021	831	458	0.55	97.65
2022	729	460	0.63	98.29
2023	596	402	0.67	98.82
2024	473	346	0.73	99.24
2025	360	289	0.80	99.55
2026	258	235	0.91	99.78
2027	170	183	1.08	99.93
2028	60	117	1.47	100.00
Total	113,518	16,554	0.15	100.00

1 Unit = $1,000
Forecast scenario: LOB 1 - Conservative

It is immediately apparent that the critical differences are in the first few calendar years. This is where the company pays the most money and this is where the high calendar year trend is emerging in the conservative scenario.

An infinite number of possible reinsurance structures could be created to address this scenario. The focus, however, should be on where the primary risks of loss are.

The principle accident years affected by the adverse calendar year trend are the most recent two accident years. Therefore, the outward reinsurance structure likely most optimal from the cedant's perspective is to price reinsurance for only the most recent two accident years (and the next underwriting year as the line is still written).



Combined Accident Yr Summary

Acc. Yr	Mean Outstanding	Mean Ultimate	Standard Dev.	CV Outstanding	CV Ultimate
2008	15,210	82,174	2,738	0.18	0.03
2009	52,930	86,277	8,462	0.16	0.10
2010	94,573	94,573	13,810	0.15	0.15
Total	162,712	262,023	20,491	0.13	0.08

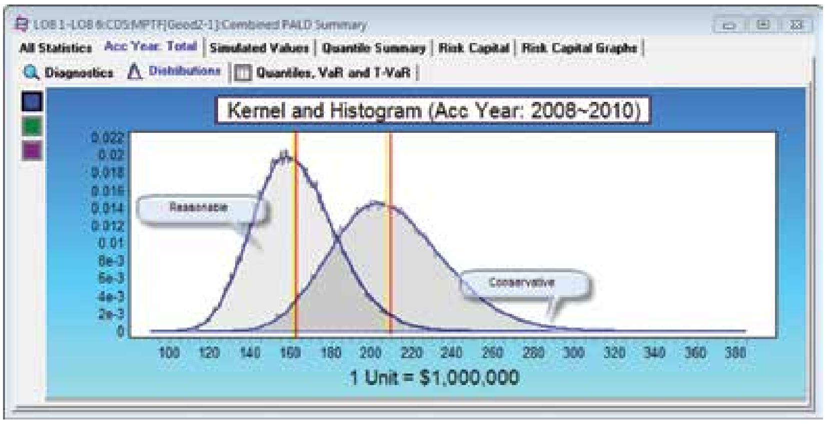
1 Unit = $1,000
Forecast scenario: LOB 1 - Reasonable 08~10

Combined Accident Yr Summary

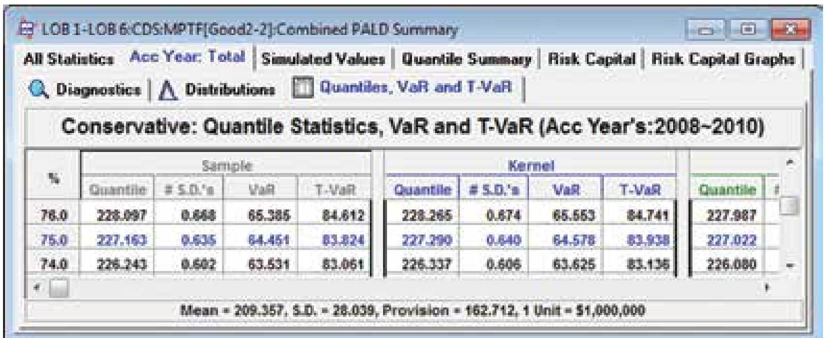
Acc. Yr	Mean Outstanding	Mean Ultimate	Standard Dev.	CV Outstanding	CV Ultimate
2008	19,625	86,590	3,637	0.19	0.04
2009	69,056	101,402	11,724	0.17	0.12
2010	120,676	120,676	18,200	0.15	0.15
Total	209,357	308,668	28,039	0.13	0.09

1 Unit = $1,000
Forecast scenario: LOB 1 - Conservative 08~10

The differences in the mean projections between the reasonable and conservative scenarios is 46.7M; roughly an additional 30% on the mean estimate from the reasonable scenario.



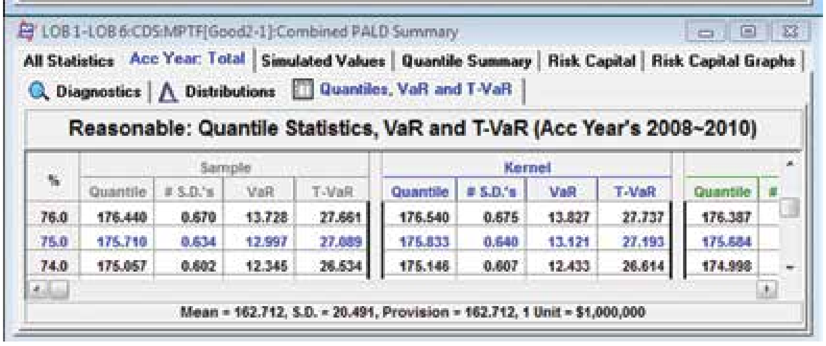
The capital the insurer is prepared to risk for adverse trend development is 13.1M - the losses up to the 75th percentile of the reasonable scenario. The outward adverse development cover for protection against the conservative scenario (severe adverse trends), should be designed so that the V@R at the 75th percentile for the conservative scenario is also 13.1M. Using the strategy where the reinsurance capital is accessed before the insurer's capital, the attachment points used are the reasonable scenario mean for the lower limit (162.7M) and the upper limit given by the 75th percentile less 13.1M (using the Kernel density below: 227.3M - 13.1M = 214.2M).



Conservative: Quantile Statistics, VaR and T-VaR (Acc Year's:2008~2010)

%	Sample Quantile	Sample # S.D.'s	Sample VaR	Sample T-VaR	Kernel Quantile	Kernel # S.D.'s	Kernel VaR	Kernel T-VaR	Quantile
76.0	228.097	0.668	65.385	84.612	228.265	0.674	65.553	84.741	227.987
75.0	227.163	0.635	64.451	83.824	227.290	0.640	64.578	83.938	227.022
74.0	226.243	0.602	63.531	83.061	226.337	0.606	63.625	83.136	226.080

Mean = 209.357, S.D. = 28.039, Provision = 162.712, 1 Unit = $1,000,000



Reasonable: Quantile Statistics, VaR and T-VaR (Acc Year's 2008~2010)

%	Sample Quantile	Sample # S.D.'s	Sample VaR	Sample T-VaR	Kernel Quantile	Kernel # S.D.'s	Kernel VaR	Kernel T-VaR	Quantile
76.0	176.440	0.670	13.728	27.661	176.540	0.675	13.827	27.737	176.387
75.0	175.710	0.634	12.997	27.089	175.833	0.640	13.121	27.193	175.684
74.0	175.057	0.602	12.345	26.534	175.146	0.607	12.433	26.614	174.998

Mean = 162.712, S.D. = 20.491, Provision = 162.712, 1 Unit = $1,000,000

The outward reinsurance table from the reasonable scenario with these attachment points is as follows. This is the most likely scenario.

LOB 1-LOB 6:CDS:MPTF[Good2-1]:Re

All Statistics | Layer Distributions | Insurer's Quantiles, VaR and T-VaR | Reinsurer's Q

Sample-Based Statistics (Incremental)

Calendar	All			Insurer (100%)			Reinsurer (100%)		
Yr	Mean	S.D.	CV	Mean	S.D.	CV	Mean	S.D.	CV
2010	83,959	11,598	0.14	83,959	11,598	0.14	0	0	****
2011	51,973	8,935	0.17	51,355	8,219	0.16	619	3,206	5.18
2012	13,113	2,668	0.20	11,107	4,271	0.38	2,006	4,663	2.32
2013	4,871	1,741	0.36	3,434	2,324	0.68	1,437	2,528	1.76
2014	2,140	914	0.43	1,364	1,132	0.83	776	1,248	1.61
2015	1,300	562	0.43	780	692	0.89	520	789	1.52
2016	849	366	0.43	488	449	0.92	360	525	1.46
2017	632	272	0.43	352	333	0.95	280	397	1.42
2018	549	240	0.44	297	288	0.97	252	351	1.39
2019	480	216	0.45	253	251	0.99	227	313	1.37
2020	419	194	0.46	215	218	1.01	204	277	1.36
2021	403	245	0.61	203	234	1.15	200	292	1.46
2022	391	286	0.73	192	243	1.27	200	312	1.56
2023	382	320	0.84	183	254	1.39	200	330	1.65
2024	335	289	0.86	156	220	1.41	179	299	1.67
2025	294	256	0.87	135	198	1.47	159	261	1.64
2026	259	232	0.90	116	174	1.49	142	236	1.66
2027	227	209	0.92	100	153	1.52	127	214	1.68
2028	144	158	1.10	62	106	1.71	82	154	1.88
2029	70	104	1.49	30	67	2.26	40	93	2.33
Total	162,791	20,467	0.13	154,781	11,216	0.07	8,010	12,345	1.54

Limits: M1=162,791 M2=214,200 M2-M1=51,409
100,000 Simulations. 1 Unit = $1,000

The outward reinsurance has two components, it lowers the exposure of the insurer to adverse development arising from process volatility assuming the reasonable scenario emerges and, additionally, is highly effective for protection against the adverse inflationary trends described by the conservative scenario.

The effectiveness is seen immediately in the comparative outward reinsurance analysis from the conservative scenario (5% likelihood of arising).

LOB 1-LOB 6:CDS:MPTF[Good2-2]:Re

All Statistics | Layer Distributions | Insurer's Quantiles, VaR and T-VaR | Reinsurer's Qu

Sample-Based Statistics (Incremental)

Calendar	All			Insurer (100%)			Reinsurer (100%)		
Yr	Mean	S.D.	CV	Mean	S.D.	CV	Mean	S.D.	CV
2010	111,760	16,848	0.15	111,720	16,707	0.15	40	767	18.98
2011	64,433	11,046	0.17	47,994	11,764	0.25	16,439	16,846	1.02
2012	16,256	3,300	0.20	5,011	6,658	1.33	11,245	6,991	0.62
2013	6,038	2,156	0.36	2,007	3,129	1.56	4,031	3,035	0.75
2014	2,653	1,132	0.43	981	1,524	1.55	1,671	1,436	0.86
2015	1,612	697	0.43	635	961	1.51	976	874	0.89
2016	1,052	453	0.43	434	641	1.48	617	565	0.92
2017	783	337	0.43	335	485	1.45	448	417	0.93
2018	681	298	0.44	300	430	1.43	381	360	0.94
2019	595	268	0.45	270	384	1.43	326	313	0.96
2020	519	240	0.46	241	342	1.42	278	272	0.98
2021	500	303	0.61	237	361	1.53	263	290	1.11
2022	485	354	0.73	236	385	1.63	249	303	1.21
2023	474	396	0.84	235	407	1.73	238	318	1.33
2024	416	358	0.86	211	369	1.75	205	277	1.35
2025	364	317	0.87	188	327	1.74	175	242	1.38
2026	320	287	0.90	169	296	1.76	152	211	1.39
2027	282	260	0.92	151	269	1.78	131	185	1.42
2028	178	196	1.10	98	194	1.98	80	128	1.59
2029	87	130	1.50	48	117	2.45	39	82	2.11
Total	209,486	28,016	0.13	171,501	16,339	0.10	37,985	15,921	0.42

Limits: M1=162,712 M2=214,200 M2-M1=51,488
100,000 Simulations. 1 Unit = $1,000

For the same attachment points, the summary statistics are shown above. The expected losses of the outward reinsurer are substantially higher (the 8M increases to 38M). Similarly, the expected losses of the insurer are substantially higher than the best estimate from the reasonable scenario, but the difference (171.5 - 162.7 = 8.8M) is within the 13M capital the insurer was prepared to allocate to cover adverse development arising from either adverse inflationary trends or process volatility.

7.1. Key learnings

- Adverse development cover can be purchased as means of protection against adverse trends arising from the reasonable forecast assumption;
- Complex reinsurance structures can be analysed when considering reinsurance against adverse inflationary trends emerging.
- Inward reinsurers can evaluate the effect of different economic scenarios against the cedant's forecast assumptions;
- A fair price can be negotiated when both parties have access to the critical information.

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