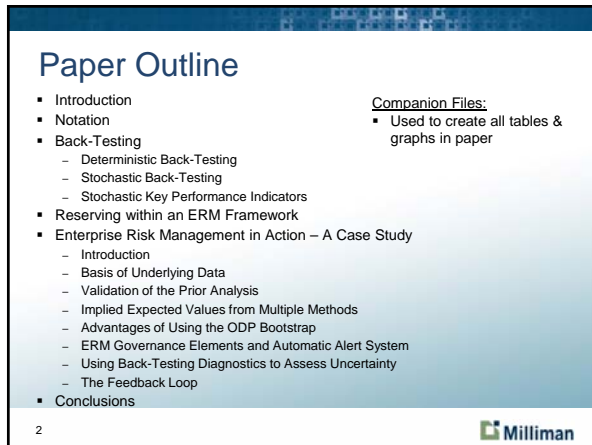
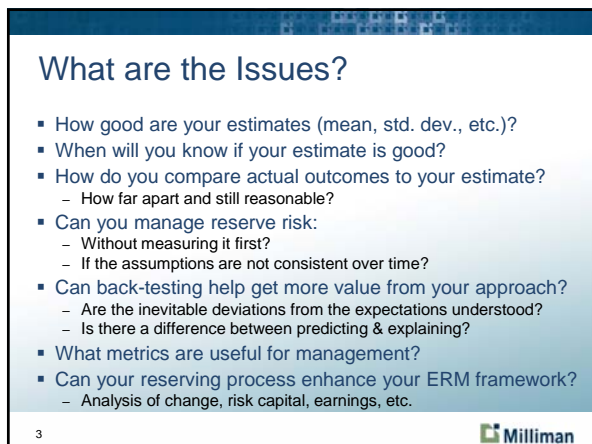


The Actuary & Enterprise Risk Management: Integrating Reserve Variability







The Actuary & Enterprise Risk Management: Integrating Reserve Variability

Drivers of Change

- IFRS 4 (Insurance Contracts) Phase II
 - Building Block, Risk Adjustment, Disclosure
- Solvency II
 - Quantification, Validation, Governance
- NAIC Model Audit Rule
 - Internal Data, Process, Reporting Validation
- Own Risk Solvency Assessment (ORSA)
 - Model Act Fall, 2012 ⇒ Effective 1/1/15

4



Integrated ERM Framework

- Conduct deterministic analysis to get a best estimate (BE) or central estimate
- Conduct stochastic modeling of unpaid claim liabilities
 - Multiple models weighted to address model risk
- Set threshold for action based on deviation from expected
 - Strategic allocation of actuarial talent during high pressure season
- Automatically notify key personnel of unusual values at an early stage of the reserving process
 - Facilitate prompt investigation of potential data inaccuracies
 - Make changes to the assumption set as needed, maintaining consistency of approach

5



Deterministic Back-Testing

- Key Question: Is outcome better or worse than expected?
- Point estimate is sole source of “Expectation” from which to test deviations
- Expectation can be expressed as cumulative or incremental
- Multiple methods requires *consistency of expectations*
- Focused more on **direction** and **magnitude** of outcome than **significance**
- Can include “ranges” (e.g., weighted, method or possible), but still more about direction and magnitude than significance

6



The Actuary & Enterprise Risk Management: Integrating Reserve Variability

Deterministic Back-Testing

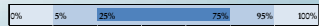
Sample Insurance Company Consolidation of All Segments							
Deterministic Actual vs. Expected as of December 31, 2015							
AY	Age	Actual Paid	Expected Paid	Difference	Actual Incurred	Expected Incurred	Difference
2006	120	3,069	3,701	(632)	1,863	2,158	(295)
2007	108	5,905	7,405	(1,500)	3,145	2,794	351
2008	96	8,986	10,073	(1,087)	3,553	6,142	(2,589)
2009	84	18,992	19,027	(35)	9,872	11,285	(1,413)
2010	72	51,003	47,151	3,852	25,942	26,873	(931)
2011	60	105,067	103,127	1,940	52,012	54,534	(2,522)
2012	48	202,932	194,479	8,453	106,624	106,020	604
2013	36	334,434	325,644	8,790	189,908	192,143	(2,235)
2014	24	841,484	833,793	7,691	454,217	479,073	(24,856)
2015	12	1,798,138			2,528,235		
Totals		3,370,010			3,370,374		
AY=CY		1,571,872	1,544,400	27,471	847,136	881,022	(33,886)

7



Stochastic Back-Testing

- Key Question: Is outcome **significantly** different than expected?
- Distribution of possible outcomes is source of "Expectation" from which to test deviations
- Expectation can be expressed as cumulative or incremental
- Multiple models encourages *assumption consistency*
Focused on **significance** of outcome
- Distribution can be used to pre-define KPI thresholds



8



Stochastic Back-Testing

- Assess materiality of difference (A - E)
 - Expected (distributional) vs. Actual (one observation)
- Caveats:
 - Model assumptions require validation and should address model risk
 - Does not address AY=CY. New exposures have been earned!
 - Works well for gross, but net (or R/I recoveries) requires more effort
 - Works best for high frequency segments
 - May need to "shift" mean of resulting distribution to replicate BE
 - Paid ODP Bootstrap may underestimate reserve risk



9



The Actuary & Enterprise Risk Management: Integrating Reserve Variability

Reserving Within an ERM Framework

- ERM components include: governance, strategy, identification, assessment, measurement, response, monitoring, and reporting
- ERM does not change how actuarial function manages reserving risk
- Rather, ERM formalizes the governance around the actuarial process:
 - Clear assignment of risk ownership;
 - Auditable controlling of both the model(s) and conclusions;
 - Metrics used to identify deviations from prior expectations;
 - Efficient allocation of actuarial resources;
 - Assess whether deviations are mean estimation error, variance estimation error, or random error;
 - Key performance indicators that management can use; and
 - Expanded discussion with parties outside of the actuarial function

13



Imagine the following...

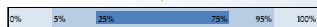
- The date is 4 January 2016
- Complete loss data is available as of 31 December 2015
- Company writes 3 homogenous lines of business (CA, PPA, and HO), with triangular data going back to Accident Year 2006 (source: SNL Financial)
- Company performs a full review of unpaid claim liabilities annually, including an uncertainty analysis using multiple models to address model risk

14



Imagine the following...

- Company has an integrated risk management framework, including reserving risk Key Performance Indicators (KPIs), based on the realization of incremental paid (and incurred) loss relative to outcomes of their models and pre-defined thresholds

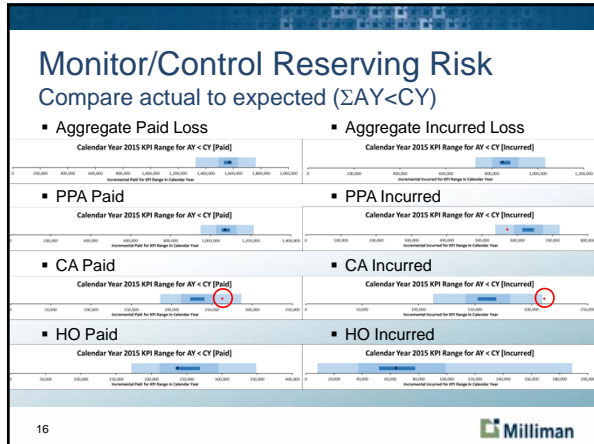


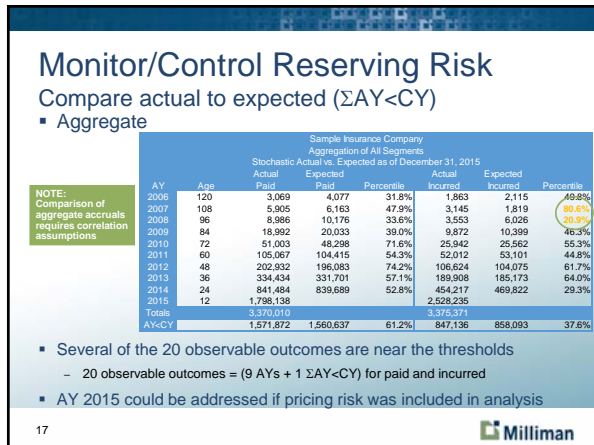
- Management would like to receive the actuary's best estimate as of 31 December 2015 by 27 January 2016 (3 weeks)

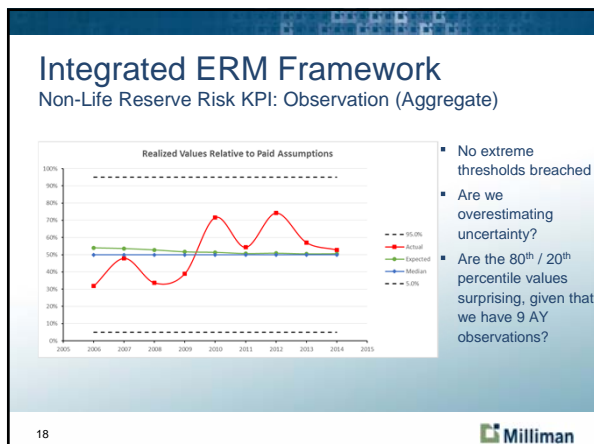
15



The Actuary & Enterprise Risk Management: Integrating Reserve Variability







The Actuary & Enterprise Risk Management: Integrating Reserve Variability

Integrated ERM Framework

Non-Life Reserve Risk KPI: Observation (Aggregate)

- No extreme thresholds breached
- Are we overestimating uncertainty?
- Are the 80th / 20th percentile values surprising, given that we have 9 AY observations?

18

Integrated ERM Framework

Non-Life Reserve Risk KPI: Aggregate Paid

Stochastic Model Detail

Model Name: 2013 Aggregation of All Segments Exposure
 Assumption Owner: Chief Actuary
 Owner: [Name]
 Assumption Value: 1,211,872
 Assumption Minimum: 50%
 Assumption Maximum: 200%

Realized Value: Paid Actual @ 1,211,872
 Paid Threshold @ 1,212,887
 Paid Percentile @ 61.2%

Segment	Assumed	Expected	Incurred	Percentile	Assumed	Expected	Incurred	Percentile
001	1,211,872	1,211,872	1,211,872	61.2%	1,211,872	1,211,872	1,211,872	61.2%

19

Integrated ERM Framework

Automated E-Mail to the CEO

Dear CEO,

We are required to report to you the results of the Aggregate Paid and Incurred claims data relative to the actuarial assumptions and thresholds. The 2013 Aggregate paid and incurred claims have not breached any thresholds.

20

The Actuary & Enterprise Risk Management: Integrating Reserve Variability


Monitor/Control Reserving Risk

Do outcomes tell us something? ($\Sigma AY < CY$)

Sample Insurance Company
Summary of Threshold Activity by Segment as of December 31, 2015

	Number						Percentage					
	25% < X < 75%		5% < X < 95%		5% > X > 95%		25% < X < 75%		5% < X < 95%		5% > X > 95%	
	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected	Actual
PPA	10	14	18	18	2	2	50.0%	70.0%	90.0%	90.0%	10.0%	10.0%
CA	10	5	18	14	2	6	50.0%	25.0%	90.0%	70.0%	10.0%	30.0%
HD	10	12	18	20	2	0	50.0%	60.0%	90.0%	100.0%	10.0%	0.0%
ACC	10	18	18	20	2	0	50.0%	90.0%	90.0%	100.0%	10.0%	0.0%
Total	40	48	72	72	8	8	50.0%	61.3%	90.0%	90.0%	10.0%	10.0%


- Overall actual results are consistent with expectations
 - Includes both AY and Total ($\Sigma AY < CY$) outcomes (20 outcomes each)
 - Comparison of aggregate accruals requires correlation assumptions
 - Includes both LoB and Aggregate outcomes (80 outcomes total)
 - CA could be problematic
 - Internal process (data quality / claims adjusting / reinsurance)
 - Width of distribution or some other modeling assumption
 - Random occurrence

21 

Monitor/Control Reserving Risk

One-year time horizon reserve changes ($\Sigma AY < CY$)


- Given the actual losses paid in CY 2015, we can obtain a preliminary estimate of the amount by which reserves for AY 2014 and prior (or $\Sigma AY < CY$) will change
 - All the necessary information is contained within the prior deterministic analysis and uncertainty analysis (does not require an update with new data)
 - Provides an early warning of impact on financial results
 - Provides a measure of the performance of the actuarial function

22 

Monitor/Control Reserving Risk

One-year time horizon reserve changes ($\Sigma AY < CY$)

- Calculate, separately for each LOB:
 - "Conditional Reserve @ 31 December 2015" = Nth Percentile
 - Example: If CY Paid fell into the 15th percentile of the distribution of expected CY Paid, the Conditional Reserve would be the 15th percentile of the distribution of reserves @ 31 December 2015
 - "Expected Reserve @ 31 December 2015" = Expected Reserve @ 31 December 2014 less CY 2015 Paid
 - This is the reserve @ 31 December 2015 if we did not change Ultimates at all
 - Difference between Conditional Reserve and Expected Reserve represents the estimated reserve change

23 

The Actuary & Enterprise Risk Management: Integrating Reserve Variability

Integrated ERM Framework

Non-Life Reserve Risk KPI: Observation (LOB: CA)

- Threshold breached
- Are expectations from the 2014 model biased low?
Check 2013

29

Integrated ERM Framework

Non-Life Reserve Risk KPI: Observation (LOB: CA)

- Threshold breached
- Are expectations from the 2014 model biased low?
Check 2013
- Are we aware of all internal process changes?
- Are we underestimating uncertainty?

29

Integrated ERM Framework

Automated E-Mail to the Chief Actuary

Dear Chief Actuary,

We are required to report to you, based on the 12/31/2014 actuarial assumptions and the 5%/5% thresholds, that there are two Private Passenger Auto breaches, six Commercial Auto breaches and zero Homeowners breaches. The Data Quality, Claims Adjustment and Reinsurance departments have also been informed. Please review the 2015 paid accruals, the 12/31/2014 actuarial assumptions, and non-actuarial input.

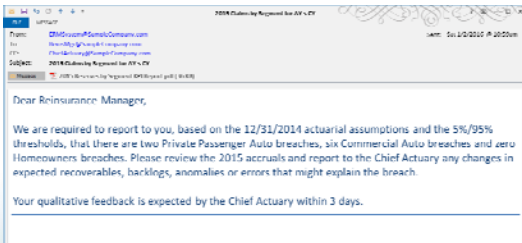
Please determine if the breach is the result of a misestimated mean, misestimated variability or due to external circumstances and report your findings to the CEO and CRO.


30

The Actuary & Enterprise Risk Management: Integrating Reserve Variability

Integrated ERM Framework


Automated E-Mail to the Reinsurance Department



34 

Validation as of 31 December 2014


- We validated last year
- Why so far off the mark?
- Need systematic review of assumptions

35 

Validation as of 31 December 2014

Assumptions: Each requiring validation

- Long term average LDFs?
 - No validated reason to use shorter term averages (e.g., WA of last 5)
 - In this example, model is 100% consistent with calculation of BE
 - If deterministic analysis uses a "picker approach" (to reflect observable trends), need to validate each "pick" and consider shifting output of stochastic uncertainty model.
- Accident year independence?
- Heteroecthesious data (i.e., non-uniform exposures)?
 - We use symmetrical triangles (e.g., AY x AY)
 - Exposures are complete (not at interim valuation date) and have not significantly changed over time (e.g., no rapid growth)
- Exposure Growth?

36 

The Actuary & Enterprise Risk Management: Integrating Reserve Variability

Validation as of 31 December 2014

Assumptions: Each requiring validation

- Heteroscedasticity
 - Residuals assumed to be identically distributed with a mean of zero
 - Residuals by development period more variable than others?
- Gamma used for Process Variance
- IELRs & CoVs used in BF Models
- Weighting of models
- Shifting mean of distribution
- Missed CY trend?

37

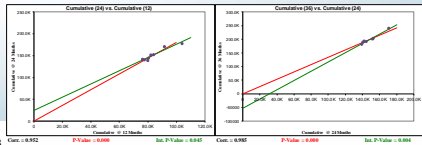


Validation as of 31 December 2014

Assumptions: LDF Validation (Paid)

AY	12	24	36	48	60	72	84	96	108
2006	77,401	140,425	189,316	223,326	243,182	250,182	254,305	256,672	257,689
2007	76,085	143,122	193,196	224,406	246,220	257,226	263,698	264,871	
2008	79,850	139,041	181,905	209,366	228,012	237,792	240,300		
2009	80,323	144,482	192,134	227,723	249,165	259,339			
2010	83,919	152,487	203,761	245,150	270,255				
2011	82,001	151,768	201,189	245,541					
2012	81,514	170,686	240,652						
2013	103,957	177,709							
2014	155,587								
ATA	1.805	1.347	1.184	1.095	1.039	1.018	1.007	1.004	1.002
CDF	3.385	1.875	1.302	1.176	1.074	1.033	1.015	1.008	1.004
Unpaid	0.705	0.467	0.282	0.149	0.069	0.032	0.015	0.008	0.004

Assumption: $E[c(w,d+1)|c(w,1), \dots, c(w,d)] = c(w,d) \times F(d)$



38

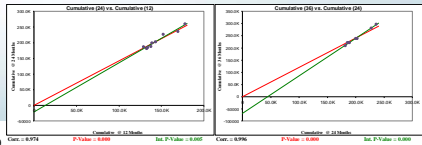


Validation as of 31 December 2014

Assumptions: LDF Validation (Incurred)

AY	12	24	36	48	60	72	84	96	108
2006	133,521	185,161	221,635	241,420	251,646	255,908	256,596	258,041	258,524
2007	128,727	187,403	222,093	247,345	258,712	265,636	269,558	270,758	
2008	132,867	181,263	208,262	228,227	236,863	241,107	242,171		
2009	137,285	188,922	222,624	247,335	258,856	265,996			
2010	142,852	202,363	239,239	269,940	281,376				
2011	138,650	199,791	239,719	266,101					
2012	151,778	227,353	282,394						
2013	160,171	235,983							
2014	177,611								
ATA	1.418	1.193	1.106	1.045	1.022	1.008	1.005	1.002	1.001
CDF	2.029	1.431	1.200	1.085	1.038	1.016	1.008	1.003	1.001
Unpaid	0.907	0.301	0.166	0.078	0.037	0.016	0.008	0.003	0.001

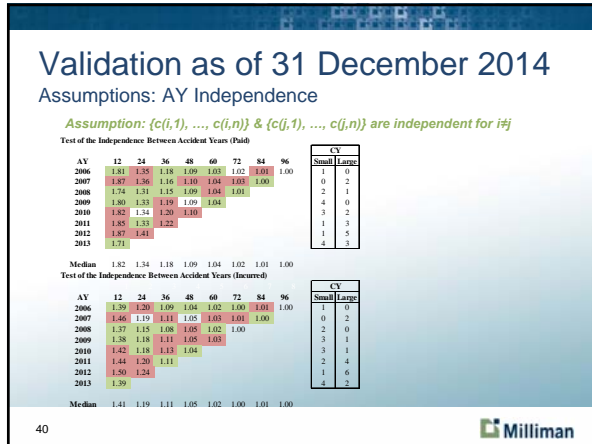
Assumption: $E[c(w,d+1)|c(w,1), \dots, c(w,d)] = c(w,d) \times F(d)$

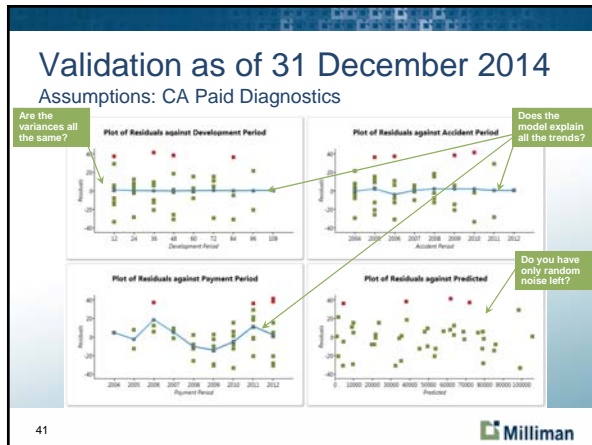


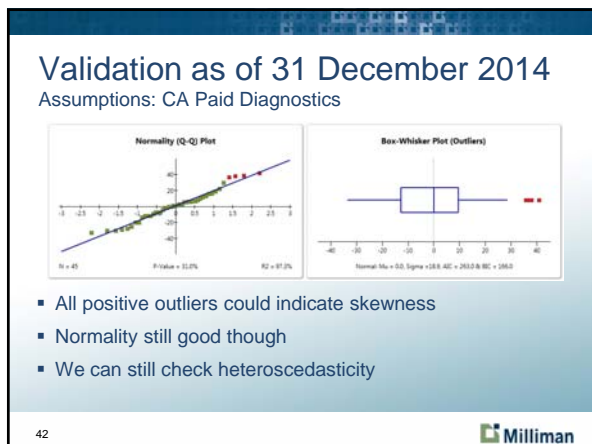
39



The Actuary & Enterprise Risk Management: Integrating Reserve Variability








The Actuary & Enterprise Risk Management: Integrating Reserve Variability

Validation as of 31 December 2014

Assumptions: BF Initial Expected Loss Ratio

- Choice of 2014 IELR?
 - Management: 52.9%
 - Incurred CL: 57.7%
 - Paid CL: 57.3%

Sample Insurance Company Commercial Auto				
AY	Paid CL ULR	Inc CL ULR	Management IELR	Selected ULR
2006	73.2%	73.2%	73.3%	73.2%
2007	76.0%	77.3%	77.4%	76.7%
2008	64.5%	64.5%	64.6%	64.5%
2009	62.8%	63.2%	63.2%	63.0%
2010	60.4%	60.7%	60.8%	60.8%
2011	53.2%	53.2%	53.4%	53.2%
2012	57.9%	58.5%	58.5%	58.2%
2013	54.5%	55.3%	54.7%	54.9%
2014	57.3%	57.7%	52.9%	54.7%


43 

Validation as of 31 December 2014

Assumptions: BF IELR and Weights

AY	Age	Calculation of Weighted Ultimate as of December 31, 2014				Weights by Method				Weighted Ultimate
		Paid CL	Inc CL	Paid BF	Inc BF	Paid CL	Inc CL	Paid BF	Inc BF	
2006	108	258,835	258,835	258,837	258,836	50.0%	50.0%	0.0%	0.0%	258,835
2007	96	287,103	271,591	267,143	271,592	50.0%	50.0%	0.0%	0.0%	289,247
2008	84	243,981	244,137	243,991	244,141	50.0%	50.0%	0.0%	0.0%	244,059
2009	72	267,942	269,794	267,999	269,783	50.0%	50.0%	0.0%	0.0%	268,863
2010	60	290,476	292,079	290,608	292,092	50.0%	50.0%	0.0%	0.0%	291,277
2011	48	288,645	288,592	288,785	288,669	50.0%	50.0%	0.0%	0.0%	288,618
2012	36	335,033	338,775	335,956	338,702	25.0%	25.0%	25.0%	25.0%	337,114
2013	24	333,220	337,698	333,662	336,635	0.0%	0.0%	50.0%	50.0%	335,149
2014	12	357,305	360,286	338,097	344,963	0.0%	0.0%	50.0%	50.0%	341,825
Total		2,192,806	2,198,893	2,192,072	2,198,893					2,201,876

- Optimism Regarding AY 2014 ULR
 - In this example, IELR based on published figures (selected ultimate)
 - IELR is an important assumption which requires additional validation
 - Consider renewal study performed by Underwriting
 - Consider actuarial analysis of average rate achieved
 - Sensitivity tests confirm that this assumption is only a partial explanation


44 

Validation as of 31 December 2014

Assumptions: BF Initial Expected Loss Ratio

- 2014 IELR
 - No longer 52.9%
 - Used 57.5%
- Explains AY 2014 deviation only
- Still breach LoB threshold

AY	Age	Actual Paid	Initial Expected	Initial Percentile	Alternative Expected	Alternative Percentile
2004	120	543	577	57.5%	566	57.8%
2005	108	2,387	1,043	91.8%	1,064	91.4%
2006	96	1,177	1,636	35.6%	1,639	35.2%
2007	84	5,403	4,540	74.1%	4,569	73.3%
2008	72	14,120	10,630	93.5%	10,650	93.1%
2009	60	23,636	23,300	56.2%	23,359	54.8%
2010	48	51,020	44,746	88.8%	44,662	89.3%
2011	36	75,813	62,082	96.9%	62,032	97.1%
2012	24	88,832	79,335	87.0%	85,452	96.2%
2013	12	99,123	-	-	-	-
CY 2013		362,054	-	-	-	-
AY < CY		262,931	227,890	99.6%	233,994	98.5%

45 

The Actuary & Enterprise Risk Management: Integrating Reserve Variability


Validation as of 31 December 2014

Assumptions: BF Coefficient of Variation

- BF models
 - IELR consistent with BE
 - CoV (IELR) = 8%
- Weights identical to BE

AY	Coefficient of Variation			BF (Unshifted)	
	Oran Ladder (Unshifted) Paid	Unshifted Incurred	IELR CoV	Paid	Incurred
2004	55.9%	56.5%	8.0%	79.8%	78.6%
2005	49.4%	48.9%	8.0%	57.0%	56.5%
2006	38.0%	37.3%	8.0%	41.9%	42.1%
2007	24.4%	24.3%	8.0%	26.9%	26.8%
2008	16.1%	15.3%	8.0%	17.9%	17.6%
2009	11.3%	10.1%	8.0%	13.2%	12.9%
2010	8.1%	6.9%	8.0%	10.6%	10.0%
2011	7.2%	6.2%	8.0%	9.6%	8.5%
2012	7.6%	6.6%	8.0%	9.1%	7.9%
Total	4.9%	4.0%		5.3%	4.8%

In this case, the use of the BF adds variability to the resulting distribution

46 


Validation as of 31 December 2014

Assumptions: BF Coefficient of Variation (Alternative)

- BF models
 - IELR consistent with BE
 - CoV (IELR) = 0%
- Weights identical to BE

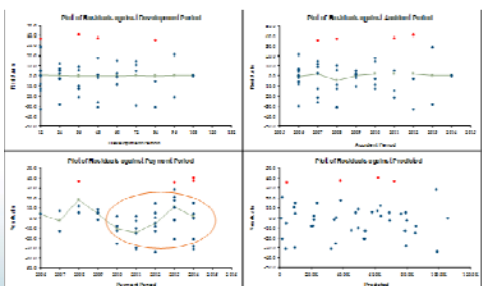
AY	Coefficient of Variation			BF (Unshifted)	
	Oran Ladder (Unshifted) Paid	Unshifted Incurred	IELR CoV	Paid	Incurred
2004	55.9%	56.5%	0.0%	78.1%	78.5%
2005	49.4%	48.9%	0.0%	56.0%	56.5%
2006	38.0%	37.3%	0.0%	40.5%	40.9%
2007	24.4%	24.3%	0.0%	25.7%	25.0%
2008	16.1%	15.3%	0.0%	16.1%	15.9%
2009	11.3%	10.1%	0.0%	10.4%	10.4%
2010	8.1%	6.9%	0.0%	6.9%	7.0%
2011	7.2%	6.2%	0.0%	5.1%	5.5%
2012	7.6%	6.6%	0.0%	4.0%	4.7%
Total	4.9%	4.0%		3.1%	3.2%


In this case, the use of the BF reduces variability of the resulting distribution

47 

Validation as of 31 December 2014

We validated last year. Why so far off? **CY Trend**



48 

The Actuary & Enterprise Risk Management: Integrating Reserve Variability

New GLM model with CY Trend:

No Trend for 2006-2011 and 7.3%/6.4% for 2011-2014+

49

Monitor/Control Reserving Risk

Impact of change in prior assumption ($\Sigma AY < CY$)

Sample Insurance Company Commercial Auto							
AY	Age	Stochastic Actual vs. Expected as of December 31, 2015		Percentile	Actual		Percentile
		Actual	Expected		Incurred	Expected	
2006	120	543	432	69.4%	(47)	228	2.0%
2007	108	2,387	942	96.6%	1,040	516	86.5%
2008	96	1,177	2,117	14.0%	851	1,181	37.9%
2009	84	5,403	5,001	64.1%	2,954	2,665	64.7%
2010	72	14,120	12,100	82.3%	9,035	6,669	89.8%
2011	60	23,636	27,514	11.8%	16,524	13,869	84.2%
2012	48	51,020	46,010	87.6%	36,454	31,896	87.7%
2013	36	75,813	66,910	94.9%	61,541	50,020	98.5%
2014	24	98,832	88,362	54.1%	63,154	78,164	77.8%
2015	12	99,123			178,539		
Totals		362,054			300,045		
AY < CY		262,931	249,388	86.0%	211,506	185,218	98.7%

- Adding CY trend parameter to model improves fit & results?
 - GLM model also adjusted for exposures
 - Statistics comparable, some better, some not as good

50

Integrated ERM Framework

Manual E-Mail to the Claims Officer

51

The Actuary & Enterprise Risk Management: Integrating Reserve Variability

Validation as of 31 December 2014
Assumptions: Correlation by Segment

- Measurement:
 - Use of rank or pairwise correlation of paid residuals
 - Could have used incurred residuals
- Evaluation:
 - P-value is the probability of obtaining a test statistic at least as extreme as the one that was actually observed, assuming that the null hypothesis is true.
 - Could have used incurred residuals
 - Could have used residuals after heteroscedasticity adjustment
 - Can validate by tracking over time

	PPA	CA	HO
PPA	1.000	0.276	-0.142
CA	0.276	1.000	0.027
HO	-0.142	0.027	1.000

	PPA	CA	HO
PPA	0.000	0.066	0.362
CA	0.066	0.000	0.960
HO	0.362	0.960	0.000

In this case, the calculated correlation is not significantly different from zero.

	PPA	CA	HO
PPA	1.000	0.276	0.000
CA	0.276	1.000	0.000
HO	0.000	0.000	1.000

Any Final Questions?

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