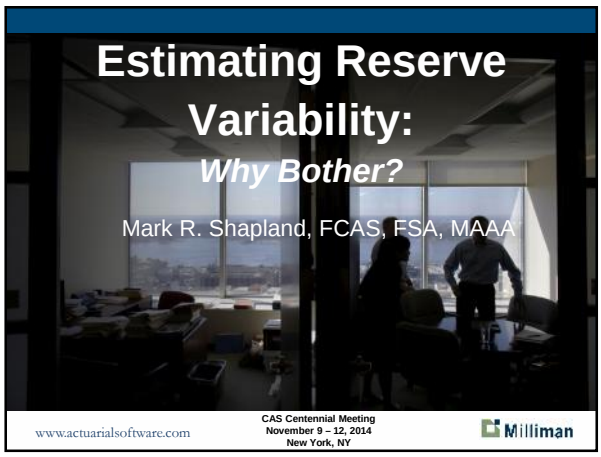
Estimating Reserve Variability: Why Bother?



What are the Issues?

- How good are your estimates (mean, std. dev., etc.)?
- When will you know if your estimate is good?
- How do you compare actual outcomes to your estimate?
  - How far apart and still reasonable?
- Can you manage reserve risk:
  - Without measuring it first?
  - If the assumptions are not consistent over time?
- Will retrospective testing improve your processes?
  - Are the inevitable deviations from the expectations understood?
  - Is there a difference between predicting & explaining?
- What metrics are useful for management?
- Should we integrate reserving into ERM?
  - Analysis of change, risk capital, earnings, etc.

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Drivers of Change

- International Accounting Standards (IFRS)
  - 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

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Estimating Reserve Variability: Why Bother?

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

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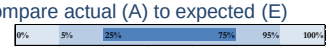
Back Testing

- Goal: Compare actual (A) to expected (E)



- Deriving E requires assumption consistency
- 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
  - May need to "shift" mean of resulting distribution to replicate BE

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What can be measured without an uncertainty analysis?

		Actual	Expected		Actual	Expected
AY	Age	Paid	Paid		Incurred	Incurred
2004	120	543	577		(47)	152
2005	108	2,387	1,043		1,040	503
2006	96	1,177	1,636		851	1,193
2007	84	5,403	4,540		2,954	2,064
2008	72	14,120	10,630		9,035	6,013
2009	60	23,636	23,300		16,524	11,898
2010	48	51,020	44,746		36,454	29,808
2011	36	75,813	62,082		61,541	44,977
2012	24	88,832	79,335		83,154	67,322
2013	12	99,123	-		178,539	-
CY 2013		362,054			390,045	
AY<CY		262,931	227,890		211,506	163,930

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Estimating Reserve Variability: Why Bother?

Imagine the following…

- The date is 2 January 2014
- Complete loss data is available as of 31 December 2013
- Company A writes 3 homogenous lines of business (CA, PPA, and HO), with triangular data going back to Accident Year 2004 (source: SNL Financial)
- Company A performs a full review of unpaid claim liabilities annually, including an uncertainty analysis using multiple models to address model risk

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Imagine the following…

- Company A has an integrated risk management framework, including reserving risk Key Performance Indicators (KPIs), based on the realization of 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 2013 by 23 January 2014 (3 weeks)

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Monitor/Control Reserving Risk

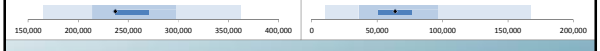
Compare actual to expected (ΣAY<CY)

- Aggregate Paid Loss
- Aggregate Incurred Loss

- PPA Paid
- PPA Incurred

- CA Paid
- CA Incurred

- HO Paid
- HO Incurred



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Estimating Reserve Variability: Why Bother?

Monitor/Control Reserving Risk

Compare actual to expected (ΣAY<CY)

- Aggregate

AY	Age	Actual Paid	Expected Paid	Modeled Percentile	Actual Incurred	Expected Incurred	Modeled Percentile
2004	120	3,069	3,672	35.4%	1,863	2,130	48.0%
2005	108	5,905	4,268	81.3%	3,145	1,751	81.6%
2006	96	8,986	10,276	32.3%	3,553	6,028	21.1%
2007	84	18,992	20,311	35.5%	9,872	9,977	52.2%
2008	72	51,003	49,291	64.6%	25,942	24,623	62.2%
2009	60	105,067	105,616	47.8%	52,012	51,904	52.8%
2010	48	202,932	197,620	69.1%	106,624	102,833	66.4%
2011	36	334,434	336,607	45.4%	189,908	179,363	76.8%
2012	24	841,484	845,014	47.7%	454,217	460,518	42.3%
2013	12	1,798,138	-		2,528,235	-	
CY 2013		3,370,010			3,375,371		
AY<CY		1,571,872	1,572,674	50.0%	847,136	839,128	59.1%

NOTE: Comparison of aggregate accruals requires correlation assumptions

- Several of the 20 observable outcomes are near the thresholds
  - 20 observable outcomes = (9 AYs + 1 ΣAY<CY) for paid and incurred
- AY 2013 could be addressed if pricing risk was included in analysis

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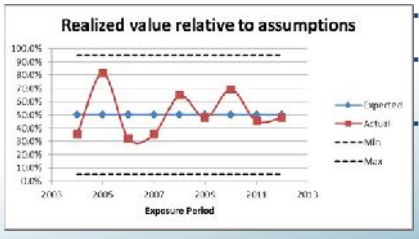
Integrated ERM Framework

Non-Life Reserve Risk KPI: Observation (Aggregate)



- No thresholds breached
- Are we overestimating uncertainty?
- Is the 80th percentile value surprising, given that we have 9 AY observations?

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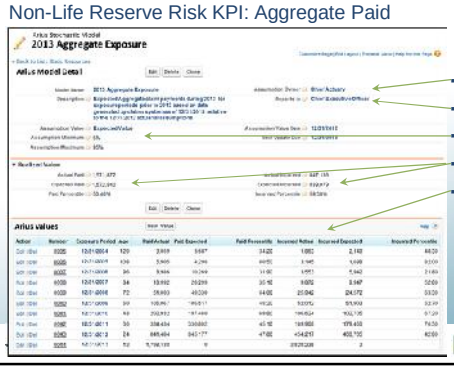
Integrated ERM Framework

Non-Life Reserve Risk KPI: Aggregate Paid



- Risk Owner
- Risk Reviewer
- Thresholds
- Realized Values
- AY / UY Details

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Estimating Reserve Variability: Why Bother?

Integrated ERM Framework

Automated E-Mail to the CFO

Monitor/Control Reserving Risk

Do outcomes tell us something? (ΣAY<CY)

	Number						Percentage					
	25<X<75		5<X<95		<5 or >95		25<X<75		5<X<95		<5 or >95	
HO	10	13	18	20	2	0	50.0%	65.0%	90.0%	100.0%	10.0%	0.0%
PPA	10	14	18	20	2	0	50.0%	70.0%	90.0%	100.0%	10.0%	0.0%
CA	10	**5**	18	**14**	2	**6**	50.0%	**25.0%**	90.0%	**70.0%**	10.0%	**30.0%**
Agg	10	16	18	20	2	0	50.0%	80.0%	90.0%	100.0%	10.0%	0.0%
Total	40	48	72	74	8	6	50.0%	60.0%	90.0%	92.5%	10.0%	7.5%

- Overall actual results are consistent with expectations
  - Includes both AY and Total (ΣAY<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

Monitor/Control Reserving Risk

One-year time horizon reserve changes (ΣAY<CY)

- Given the actual losses paid in CY 2013, we can obtain a preliminary estimate of the amount by which reserves for AY 2012 and prior (or 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

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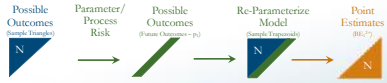
Estimating Reserve Variability: Why Bother?

Monitor/Control Reserving Risk

One-year time horizon reserve changes (ΣAY<CY)

- Calculate, separately for each LOB:
  - "Conditional Reserve @ 31 December 2013" = 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 2013
  - "Expected Reserve @ 31 December 2013" = Expected Reserve @ 31 December 2012 less CY 2013 Paid
    - This is the reserve @ 31 December 2013 if we did not change Ultimates at all
  - Difference between Conditional Reserve and Expected Reserve represents the estimated reserve change

Monitor/Control Reserving Risk

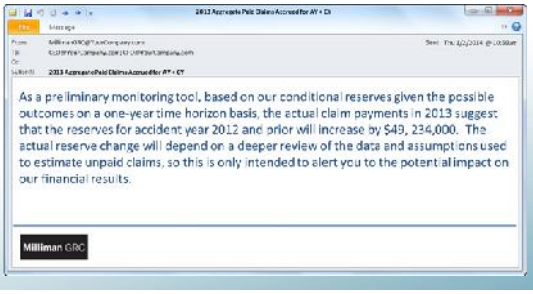
One-year time horizon reserve changes (ΣAY<CY)

	CA			PPA			HO			
	Expected	Conditional		Expected	Conditional		Expected	Conditional		Total
AY	Reserve	Reserve	Change	Reserve	Reserve	Change	Reserve	Reserve	Change	Change
2004	613	547	(67)	2,737	2,493	(245)	392	25	(367)	(678)
2005	(146)	2,194	2,340	6,210	6,874	664	979	744	(235)	2,769
2006	2,500	1,533	(967)	9,566	8,940	(626)	1,559	1,511	(49)	(1,642)
2007	3,205	4,927	1,722	19,331	17,337	(1,994)	2,013	114	(1,899)	(2,171)
2008	5,828	12,825	6,997	36,672	33,136	(3,535)	2,897	4,499	1,602	5,064
2009	19,494	20,176	682	73,732	74,597	865	6,005	4,315	(1,690)	(143)
2010	44,250	57,573	13,323	156,541	153,517	(3,024)	12,219	14,416	2,197	12,496
2011	80,777	113,108	32,331	319,636	303,909	(15,727)	25,577	22,449	(3,129)	13,475
2012	146,195	171,586	25,391	587,371	588,683	1,313	65,979	59,340	(6,639)	20,065
2013										
AY<CY	302,716	384,469	81,754	1,211,797	1,189,486	(22,310)	117,621	107,412	(10,209)	49,234

- AYs 2010-12 should also drive reserves up
  - Most of this increase is driven by CA

Integrated ERM Framework

Automated E-Mail to the CEO/CFO



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Estimating Reserve Variability: Why Bother?

Monitor/Control Reserving Risk

- Focus on Commercial Auto (CA)

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Monitor/Control Reserving Risk

Compare CA actual to expected (ΣAY<CY)

- CA

AY	Age	Actual Paid	Expected Paid	Modeled Percentile	Actual Incurred	Expected Incurred	Modeled Percentile
2004	120	543	577	57.5%	(47)	152	0.2%
2005	108	2,387	1,043	91.8%	1,040	503	81.9%
2006	96	1,177	1,636	35.6%	851	1,193	43.6%
2007	84	5,403	4,540	74.1%	2,954	2,064	79.5%
2008	72	14,120	10,630	93.5%	9,035	6,013	92.5%
2009	60	23,636	23,300	56.2%	16,524	11,898	95.0%
2010	48	51,020	44,746	88.8%	36,454	29,808	91.6%
2011	36	75,813	62,082	96.9%	61,541	44,977	99.0%
2012	24	88,832	79,335	87.0%	83,154	67,322	95.9%
2013	12	99,123	-		178,539	-	
CY 2013		362,054			390,045		
AY<CY		262,931	227,890	99.6%	211,506	163,930	99.9%

- AYs 2007-12 are driving high #s
  - Need to check assumptions (i.e., IELRs, LDFs, weights, etc.)

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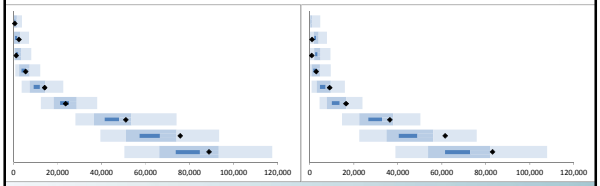
Monitor/Control Reserving Risk

Compare CA actual to expected (ΣAY<CY)

- CA Paid
- CA Incurred



- AYs 2007-12 are driving high #s
  - Need to check all assumptions

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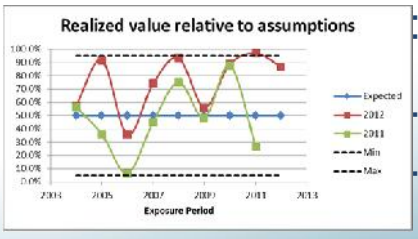
Estimating Reserve Variability: Why Bother?

Integrated ERM Framework

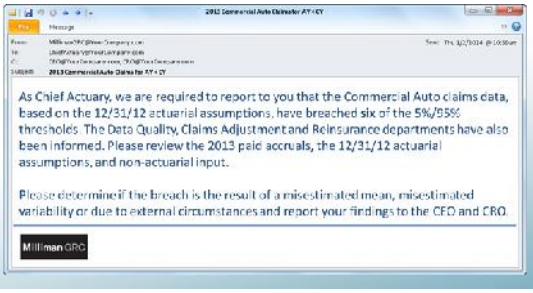
Non-Life Reserve Risk KPI: Observation (LOB: CA)



- Threshold breached
- Are expectations from the 2012 model biased low? Check 2011
- Are we aware of all internal process changes?
- Are we underestimating uncertainty?

Integrated ERM Framework

Automated E-Mail to the Chief Actuary



2013 Commercial Auto Claims for AY<CY

As Chief Actuary, we are required to report to you that the Commercial Auto claims data, based on the 12/31/12 actuarial assumptions, have breached six of the 5%/95% thresholds. The Data Quality, Claims Adjustment and Reinsurance departments have also been informed. Please review the 2013 paid accruals, the 12/31/12 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 CFO and CRO.

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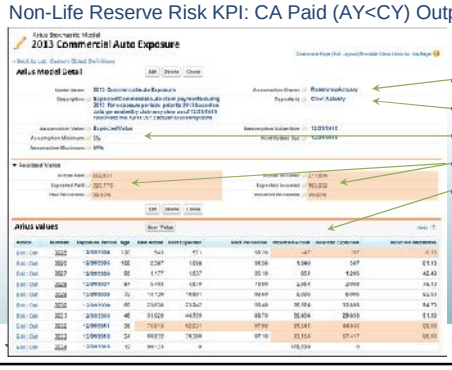
Integrated ERM Framework

Non-Life Reserve Risk KPI: CA Paid (AY<CY) Output



- Risk Owner
- Risk Reviewer
- Thresholds
- Realized Values
- AY / UY Details

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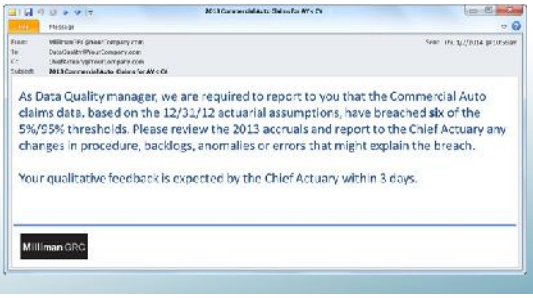
Estimating Reserve Variability: Why Bother?

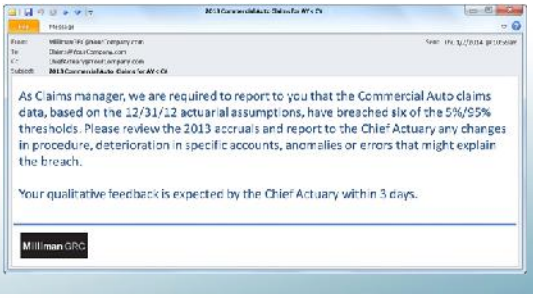
Integrated ERM Framework

Automated E-Mail to Data Quality Department



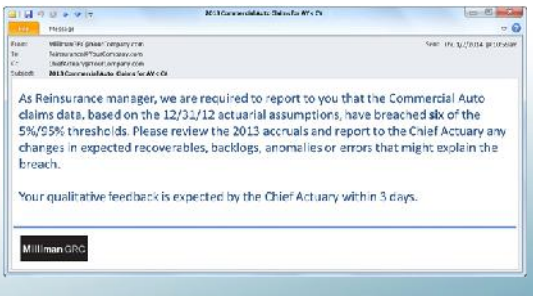
Integrated ERM Framework

Automated E-Mail to Claims Department



Integrated ERM Framework

Automated E-Mail to the Reinsurance Department



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Estimating Reserve Variability: Why Bother?

Assumption Consistency

We validated last year. Why so far off the mark?

- Choice of 2012 IELR?
  - Management: 52.9%
  - Incurred CL: 57.7%
  - Paid CL: 57.3%
- Heteroscedasticity?
- Shifting mean of distribution?
- Missed CY trend?

AY	Age	Actual Paid	Expected Paid	Model Percentile
2004	120	543	577	57.5%
2005	108	2,387	1,043	91.8%
2006	96	1,177	1,636	35.6%
2007	84	5,403	4,540	74.1%
2008	72	14,120	10,630	93.5%
2009	60	23,636	23,300	56.2%
2010	48	51,020	44,746	88.8%
2011	36	75,813	62,082	96.9%
2012	24	88,832	79,335	87.0%
2013	12	99,123	-	
CY 2013		362,054		
AY<CY		262,931	227,890	99.6%

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Validation as of 31 December 2012

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
- IELRs used in the BF Method
- 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)

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Validation as of 31 December 2012

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
- Coefficient of Variation of the IELRs used in BF Method
- Weighting of methods

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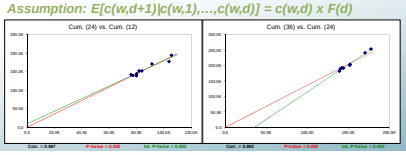
Estimating Reserve Variability: Why Bother?

Validation as of 31 December 2012

Assumptions: CA Paid Loss Triangle

Year	12	24	36	48	60	72	84	96	108	120
2004	77,401	140,425	189,316	223,326	243,182	250,182	254,305	256,672	257,689	258,232
2005	76,085	142,122	193,196	224,406	246,220	257,226	263,698	264,871	267,258	
2006	79,850	139,041	181,905	209,366	228,012	237,792	240,300	241,477		
2007	80,323	144,482	192,134	227,723	249,165	259,339	264,742			
2008	83,919	152,487	203,761	245,150	270,525	284,645				
2009	82,001	151,768	201,189	245,541	269,177					
2010	91,514	170,696	240,652	291,672						
2011	103,957	177,709	253,522							
2012	105,547	194,379								
2013	99,123									
LDF	1.810	1.359	1.189	1.095	1.042	1.018	1.006	1.007	1.002	1.002
CDF	3.456	1.909	1.405	1.182	1.079	1.036	1.017	1.011	1.004	1.002

Assumption: E[c(w,d+1)|c(w,1),…,c(w,d)] = c(w,d) x F(d)

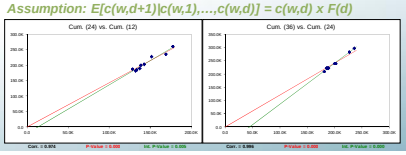


Validation as of 31 December 2012

Assumptions: CA Incurred Loss Triangle

Year	12	24	36	48	60	72	84	96	108	120
2004	133,521	185,161	221,635	241,420	251,646	255,508	256,596	258,041	258,524	258,477
2005	128,727	187,403	222,093	247,345	258,712	265,636	269,558	270,758	271,798	
2006	132,567	181,263	209,262	226,237	236,863	241,107	242,171	243,022		
2007	137,295	188,962	222,624	247,335	258,856	265,496	268,450			
2008	142,862	202,363	239,239	269,940	281,376	290,411				
2009	138,650	199,791	239,719	266,101	282,625					
2010	151,778	227,353	282,394	318,848						
2011	169,171	235,983	297,524							
2012	177,611	260,765								
2013	178,539									
LDF	1.424	1.203	1.110	1.048	1.024	1.009	1.005	1.003	1.000	1.001
CDF	2.075	1.457	1.211	1.091	1.041	1.017	1.008	1.004	1.001	1.001

Assumption: E[c(w,d+1)|c(w,1),…,c(w,d)] = c(w,d) x F(d)



Validation as of 31 December 2012

Implied Expectations: Use of Paid and Incurred

- Each method produces a different expectation of paid (incurred) loss.

Note: The difference between the expectation from various models can be material for young AYs

- The mean of the distribution used in the back test of paid (incurred) loss should be consistent with the paid (incurred) loss inherent in the selected ultimate.

Expected Paid Losses during CY 2013					
AY	PCL	ICL	PBF	BF	Weighted
2004	572	572	573	573	572
2005	1,049	1,067	1,068	1,086	1,058
2006	1,642	1,643	1,647	1,648	1,643
2007	4,560	4,591	4,590	4,621	4,576
2008	10,624	10,683	10,695	10,750	10,654
2009	23,280	23,275	23,355	23,346	23,278
2010	44,341	44,838	44,779	45,145	44,776
2011	61,648	62,476	61,823	62,374	62,098
2012	85,007	85,716	78,521	80,114	79,317
AY<CY	232,723	234,862	227,052	229,656	227,972

Expected Incurred Losses during CY 2013					
AY	PCL	ICL	PBF	BF	Weighted
2004	155	155	156	156	155
2005	498	507	499	507	503
2006	1,217	1,217	1,219	1,220	1,217
2007	2,101	2,116	2,101	2,115	2,108
2008	6,027	6,061	6,037	6,067	6,044
2009	11,917	11,915	11,960	11,956	11,916
2010	29,648	29,980	29,698	29,941	29,817
2011	44,910	45,513	44,640	45,037	44,839
2012	73,543	74,156	66,582	67,932	67,257
AY<CY	170,016	171,620	162,892	164,931	163,856

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Estimating Reserve Variability: Why Bother?

Validation as of 31 December 2012

Assumptions: AY Independence

Assumption: {c(i,1), …, c(i,n)} & {c(j,1), …, c(j,n)} are independent for i≠j

CY LDFs Small	CY LDFs Large	Paid Loss AY	24 / 12	36 / 24	48 / 36	60 / 48	72 / 60	84 / 72	96 / 84	108 / 96
1	0	2004	1.814	1.348	1.180	1.089	1.029	1.016	1.009	1.004
0	2	2005	1.868	1.359	1.162	1.097	1.045	1.025	1.004	
2	1	2006	1.741	1.308	1.151	1.089	1.043	1.011		
4	0	2007	1.799	1.330	1.185	1.094	1.041			
3	2	2008	1.817	1.336	1.203	1.104				
1	3	2009	1.851	1.326	1.220					
1	5	2010	1.865	1.410						
4	3	2011	1.709							
		Median	1.816	1.336	1.182	1.094	1.042	1.016	1.007	1.004

CY LDFs Small	CY LDFs Large	Incurred Loss AY	24 / 12	36 / 24	48 / 36	60 / 48	72 / 60	84 / 72	96 / 84	108 / 96
1	0	2004	1.387	1.197	1.089	1.042	1.015	1.004	1.006	1.002
0	2	2005	1.456	1.185	1.114	1.046	1.027	1.015	1.004	
2	0	2006	1.367	1.154	1.081	1.047	1.018	1.004		
3	1	2007	1.376	1.178	1.111	1.047	1.026			
3	1	2008	1.416	1.182	1.128	1.042				
2	4	2009	1.441	1.200	1.110					
1	6	2010	1.498	1.242						
4	2	2011	1.395							
		Median	1.406	1.185	1.111	1.046	1.022	1.004	1.005	1.002

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Validation as of 31 December 2012

Assumptions: Exposures

- Exposures have grown slowly since 2006

AY	Exposures
2004	48,886
2005	47,449
2006	45,935
2007	46,224
2008	47,132
2009	47,358
2010	48,855
2011	50,167
2012	51,644
Total	433,650

AY	Age	Actual Paid	Initial Expected	Initial Percentile	Alternative Expected	Alternative Percentile
2004	120	543	577	57.5%	574	58.5%
2005	108	2,387	1,043	91.8%	1,060	91.5%
2006	96	1,177	1,636	35.6%	1,639	35.3%
2007	84	5,403	4,540	74.1%	4,554	73.2%
2008	72	14,120	10,630	93.5%	10,677	93.5%
2009	60	23,636	23,300	56.2%	23,272	56.0%
2010	48	51,020	44,746	88.8%	44,745	88.7%
2011	36	75,813	62,082	96.9%	61,999	96.8%
2012	24	88,832	79,335	87.0%	79,473	86.4%
2013	12	99,123	-			
CY 2013		362,054				
AY<CY		262,931	227,890	99.6%	227,994	99.5%

- Re-ran simulation with exposure-adjusted data; minimal impact

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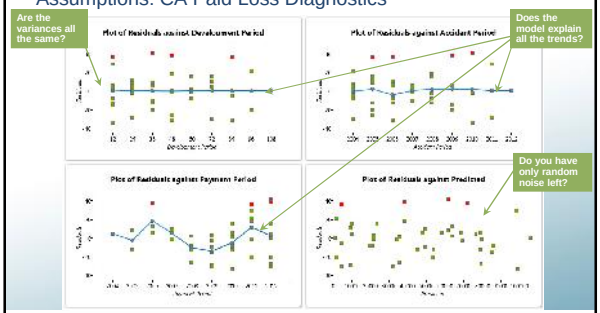
Validation as of 31 December 2012

Assumptions: CA Paid Loss Diagnostics



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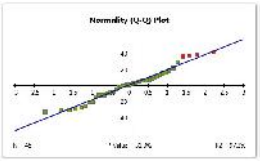
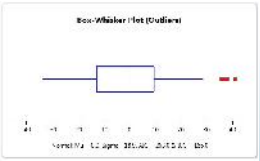
Estimating Reserve Variability: Why Bother?

Validation as of 31 December 2012

Assumptions: CA Paid Loss Diagnostics





- All positive outliers could indicate skewness
- Normality still good though
- We can still check heteroscedasticity

Validation as of 31 December 2012

Assumptions: Process Variance

- Assumed a Gamma distribution
- Switching to Normal distribution had minimal impact

AY	Age	Actual Paid	Initial Expected	Initial Percentile	Alternative Expected	Alternative Percentile
2004	120	543	577	57.5%	577	47.0%
2005	108	2,387	1,043	91.8%	1,048	92.2%
2006	96	1,177	1,636	35.6%	1,652	32.1%
2007	84	5,403	4,540	74.1%	4,550	72.4%
2008	72	14,120	10,630	93.5%	10,622	93.6%
2009	60	23,636	23,300	56.2%	23,260	55.4%
2010	48	51,020	44,746	88.8%	44,694	89.1%
2011	36	75,813	62,082	96.9%	62,102	97.2%
2012	24	88,832	79,335	87.0%	79,251	87.3%
2013	12	99,123	-			
CY 2013		362,054				
AY<CY		262,931	227,890	99.6%	227,754	99.6%

Validation as of 31 December 2012

Assumptions: CA BF and Weighting

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

	Coefficient of Variation				
	Chain Ladder (Unshifted)		IELR	BF (Unshifted)	
AY	Paid	Incurred	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

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Estimating Reserve Variability: Why Bother?

Validation as of 31 December 2012

Assumptions: CA BF and Weighting (*Alternative*)

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

	Coefficient of Variation				
	Chain Ladder (Unshifted)		IELR	BF (Unshifted)	
AY	Paid	Incurred	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

Validation as of 31 December 2012

Assumptions: CA IELR (for BF) and Weights

AY	Paid CL ULR	Incurred CL ULR	Management IELR	Selected ULR	AY	Paid CL	Incurred CL	Incurred BF	Incurred BF
2004	73.2%	73.2%	73.3%	73.2%	2004	50.0%	50.0%		
2005	76.0%	77.3%	77.4%	76.7%	2005	50.0%	50.0%		
2006	64.5%	64.5%	64.6%	64.5%	2006	50.0%	50.0%		
2007	62.8%	63.2%	63.2%	63.0%	2007	50.0%	50.0%		
2008	60.4%	60.7%	60.8%	60.6%	2008	50.0%	50.0%		
2009	53.2%	53.2%	53.4%	53.2%	2009	50.0%	50.0%		
2010	57.9%	58.5%	58.5%	58.2%	2010	25.0%	25.0%	25.0%	25.0%
2011	54.5%	55.3%	54.7%	54.9%	2011			50.0%	50.0%
2012	57.3%	57.7%	52.9%	54.7%	2012			50.0%	50.0%

- Optimism Regarding AY 2012 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

Assumption Consistency

We validated last year. Why so far off? IELR

- 2012 IELR
  - No longer 52.9%
  - Used 57.5%
- Explains AY 2012 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	25,636	25,300	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	66.2%
2013	12	99,123	-			
CY 2013		362,054				
AY<CY		262,931	227,890	99.6%	233,994	98.5%

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Estimating Reserve Variability: Why Bother?

Assumption Consistency

We validated last year. Why so far off? Heteroscedasticity

- Minimal impact
- Still breach LoB thresholds

AY	Age	Actual Paid	Initial Expected	Initial Percentile	Alternative Expected	Alternative Percentile
2004	120	543	577	57.5%	574	61.4%
2005	108	2,387	1,043	91.8%	1,051	88.3%
2006	96	1,177	1,636	35.6%	1,646	37.4%
2007	84	5,403	4,540	74.1%	4,544	73.0%
2008	72	14,120	10,630	93.5%	10,664	91.1%
2009	60	23,636	23,300	56.2%	23,228	56.7%
2010	48	51,020	44,746	88.8%	44,751	82.9%
2011	36	75,813	62,082	96.9%	62,034	96.5%
2012	24	88,832	79,335	87.0%	79,373	89.1%
2013	12	99,123	-			
CY 2013		362,054				
AY<CY		262,931	227,890	99.6%	227,864	99.3%

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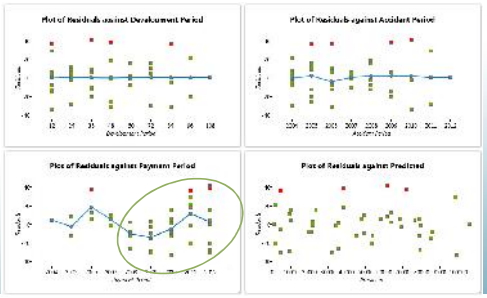
Assumption Consistency

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



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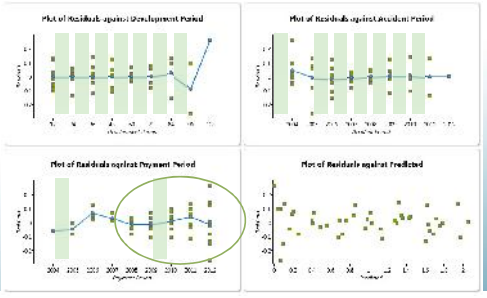
New GLM model with CY Trend:

1.9% Trend for 2004-2009 and 3.6% for 2009-2012+



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Estimating Reserve Variability: Why Bother?

Monitor/Control Reserving Risk

Impact of change in prior assumption (ΣAY<CY)

			ODP Paid Model		GLM Paid Model	
AY	Age	Actual Paid	Expected Paid	Bootstrap Percentile	Expected Paid	Bootstrap Percentile
2004	120	543	577	57.5%	62	96.1%
2005	108	2,387	1,043	91.8%	2,021	65.2%
2006	96	1,177	1,636	35.6%	2,868	12.6%
2007	84	5,403	4,540	74.1%	6,989	25.3%
2008	72	14,120	10,630	93.5%	14,810	43.8%
2009	60	23,636	23,300	56.2%	26,680	23.4%
2010	48	51,020	44,746	88.8%	49,173	63.1%
2011	36	75,813	62,082	96.9%	64,678	94.5%
2012	24	88,832	79,335	87.0%	87,876	55.5%
2013	12	99,123				
CY 2013		362,054				
AY<CY		262,931	227,890	99.6%	255,155	68.5%

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

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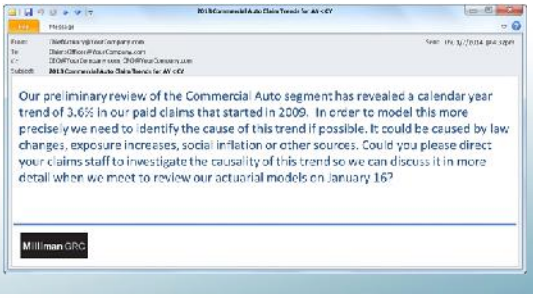
Integrated ERM Framework

Manual E-Mail to the Claims Officer



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Assumption Consistency

We validated last year. Why so far off?

Mack Model

Variance assumptions disconnected from BE assumptions

	Mack Model Calculations						
AY	Reserve	Standard Deviation	CoV	Expected Paid CY 13	Std Dev CY 2013	Actual Paid	Percentile
2004	1,146	188	16.4%	1,146	188	543	0.0%
2005	2,232	644	28.9%	1,049	615	2,387	96.3%
2006	3,681	1,207	32.8%	1,642	1,046	1,177	39.0%
2007	8,603	2,548	29.6%	4,560	2,199	5,403	72.6%
2008	19,950	3,441	17.2%	10,624	2,152	14,120	93.6%
2009	43,104	3,838	8.9%	23,280	1,727	23,636	59.6%
2010	94,371	8,325	8.8%	44,341	7,177	51,020	83.0%
2011	155,511	11,761	7.6%	61,648	8,335	75,813	94.6%
2012	251,758	16,702	6.6%	85,007	11,349	88,832	65.5%
Total	580,356	26,820	4.6%	233,297	19,185	262,931	93.3%

- Similar to using a "Shifted" paid Chain Ladder
- Often seen in industry, but under this scenario:
  - Management's low 2012 IELR may not get attention
  - Recent CY trends may not get attention

Must decompose Mack formula and make distribution assumption

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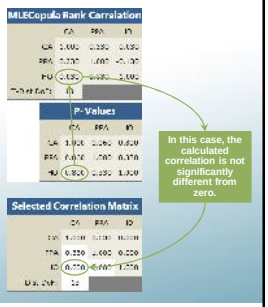
Estimating Reserve Variability: Why Bother?

Validation as of 31 December 2012

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



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Any Final Questions?

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