



**The Actuarial Profession**

making financial sense of the future

**GIRO Conference and Exhibition 2011**  
Jeff Courchene and Mark Shapland



# **Assumption Consistency** Back-testing and other Validation Techniques

12 October 2011

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# BACK-TEST: Monitor and Control Reserving Risk

## Relevant Background

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### Imagine the following reality...

The date is 2 January 2009...

Complete loss data as of 31 December 2008 is available for analysis.

Company A writes 3 homogenous LoBs (CA, PPA, and HO), the triangular history of which is identical to the #3 and #4 writers of each LoB in the USA as of 31 December 2008 (source: Highline Data<sup>\*</sup>).

Company A has an integrated risk management framework, including a reserving risk KPI, based on the realization of paid (and incurred) loss relative to outcomes of a bootstrap model and a pre-defined threshold.

Company A performs a full review of technical provisions for claims annually with segments identical to the homogenous LoBs (Note: more granular than the S2 categories), including an uncertainty analysis.

Management would like to receive the actuary's best estimate of unpaid claim liability as at 31 December 2008 by 20 January 2009 (3 weeks).

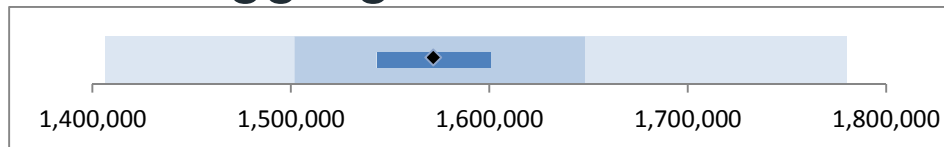
*\* From the data, we can get paid loss, incurred loss, and claim count triangles, as well as ultimate loss selections (for IELRs)*

# BACK-TEST: Monitor and Control Reserving Risk

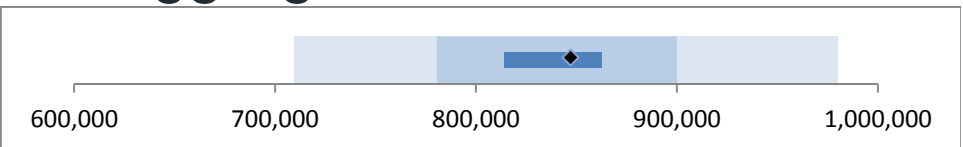
How do annual accruals compare to expectations ( $\Sigma AY < CY$ )?



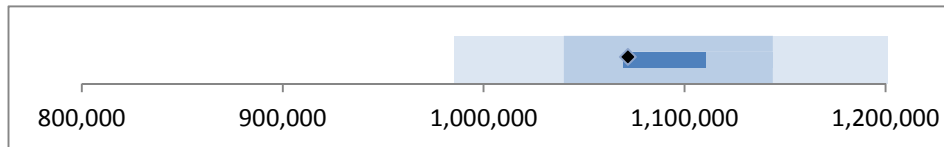
- Aggregate Paid Loss



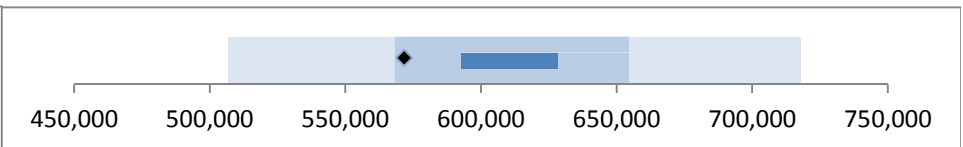
- Aggregate Incurred Loss



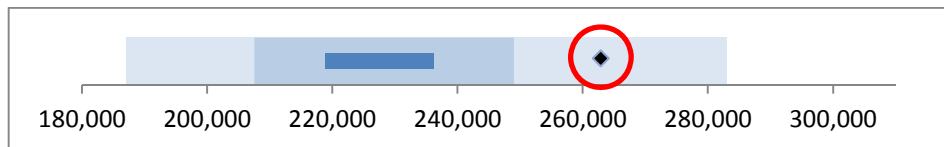
- PPA Paid



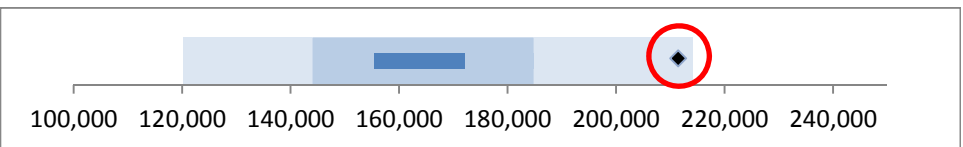
- PPA Incurred



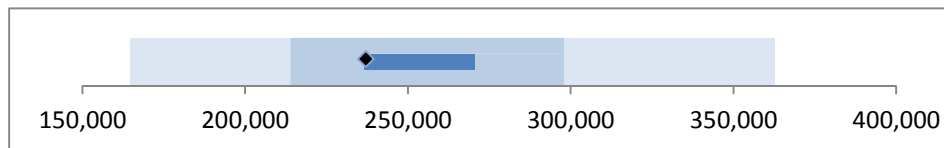
- CA Paid



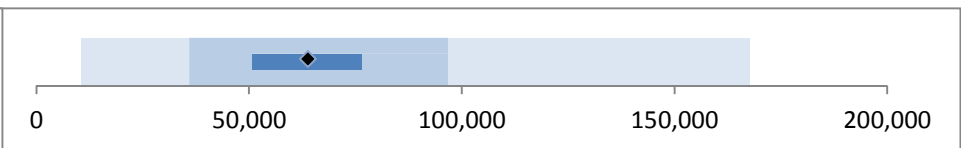
- CA Incurred



- HO Paid



- HO Incurred



# BACK-TEST: Monitor and Control Reserving Risk

How do annual accruals compare to expectations ( $\Sigma AY < CY$ )?


- Aggregate

AY	Age	Actual Paid	Expected Paid	Bootstrap Percentile	Actual Incurred	Expected Incurred	Bootstrap Percentile
1999	120	3,069	3,672	35.4%	1,863	2,130	48.0%
2000	108	5,905	4,268	81.3%	3,145	1,751	81.6%
2001	96	8,986	10,276	32.3%	3,553	6,028	21.1%
2002	84	18,992	20,311	35.5%	9,872	9,977	52.2%
2003	72	51,003	49,291	64.6%	25,942	24,623	62.2%
2004	60	105,067	105,616	47.8%	52,012	51,904	52.8%
2005	48	202,932	197,620	69.1%	106,624	102,833	66.4%
2006	36	334,434	336,607	45.4%	189,908	179,363	76.8%
2007	24	841,484	845,014	47.7%	454,217	460,518	42.3%
2008	12	1,798,138	-		2,528,235	-	
CY 2008		3,370,010			3,375,371		
AY < CY		1,571,872	1,572,674	50.0%	847,136	839,128	59.1%

- Several values near the thresholds*

# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: Aggregate Paid (AY<CY) Output

 Reserve Variability Model  
**2008 Aggregate Exposure**

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**Reserve Variability Model Detail** [Edit](#) [Delete](#) [Clone](#)

Reserve Variability Model Name	2008 Aggregate Exposure	Assumption Owner	<a href="#">Jeff Courchene</a>
Description	Expected Aggregate claims payments during 2008 for exposure periods prior to 2008 based on data generated by claims system as of 12/31/2008 relative to the 12/31/2007 actuarial assumptions		
Assumption Value	50%	Assumption Value Date	12/31/2007
Assumption Minimum	5%	Next Update Due	12/31/2008
Assumption Maximum	95%	Reports to	<a href="#">Mark Shapland</a>

**▼ Realized Value**

Actual Paid	EUR 1,571,872	Actual Incurred	EUR 847,136
Expected Paid	EUR 1,572,840	Expected Incurred	EUR 839,079
Paid Bootstrap Percentile	50.40%	Incurred Bootstrap Percentile	59.30%

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**RVM Values** [New RVM Value](#) [RVM Values Help](#) ?

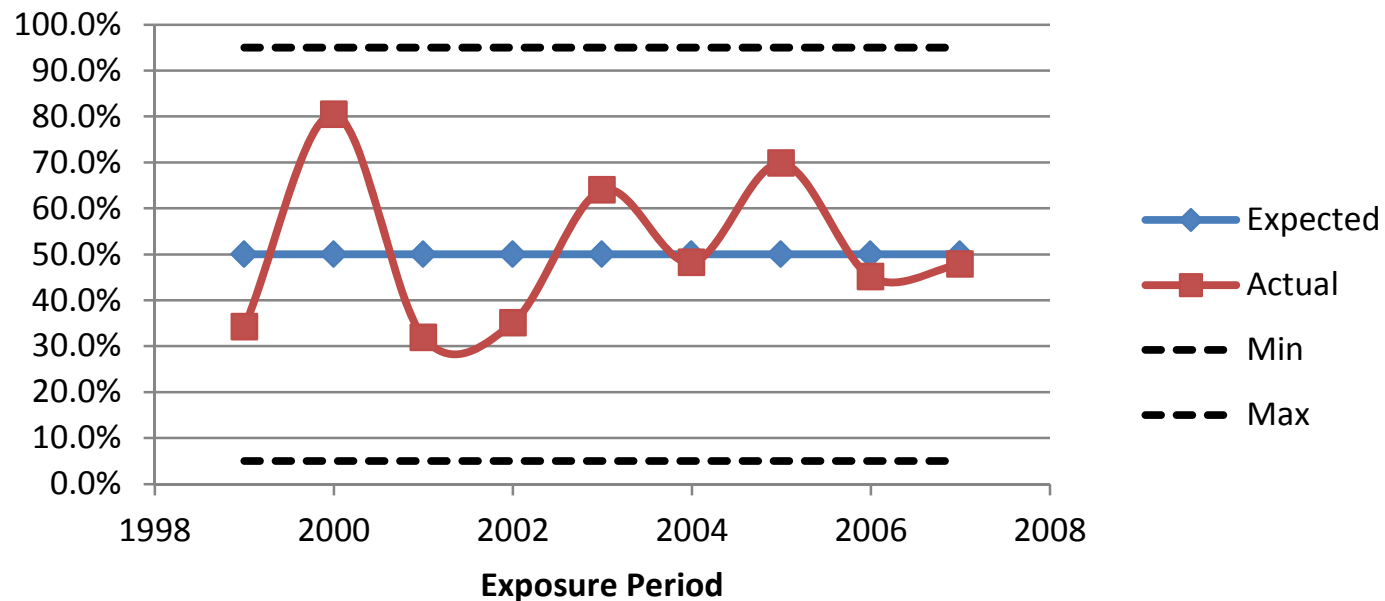
Action	RVM Number	Exposure Period	Age	Paid Actual	Paid Expected	Paid Bootstrap Percentile	Incurred Actual	Incurred Expected	Incurred Bootstrap Percentile
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0035</a>	12/31/1999	120	EUR 3,069	EUR 3,687	34.20	EUR 1,863	EUR 2,140	48.30
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0036</a>	12/31/2000	108	EUR 5,905	EUR 4,298	80.50	EUR 3,145	EUR 1,698	82.00
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0037</a>	12/31/2001	96	EUR 8,986	EUR 10,269	31.90	EUR 3,553	EUR 5,942	21.80
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0038</a>	12/31/2002	84	EUR 18,992	EUR 20,299	35.10	EUR 9,872	EUR 9,947	52.80
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0039</a>	12/31/2003	72	EUR 51,003	EUR 49,330	64.00	EUR 25,942	EUR 24,572	63.30
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0040</a>	12/31/2004	60	EUR 105,067	EUR 105,517	48.20	EUR 52,012	EUR 51,903	52.70
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0041</a>	12/31/2005	48	EUR 202,932	EUR 197,460	69.80	EUR 106,624	EUR 102,705	67.20
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0042</a>	12/31/2006	36	EUR 334,434	EUR 336,802	45.10	EUR 189,908	EUR 179,466	76.30
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0043</a>	12/31/2007	24	EUR 841,484	EUR 845,177	47.80	EUR 454,217	EUR 460,705	42.80

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

# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: Aggregate Paid (AY<CY) Observation

### Realized value relative to assumptions



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

# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: Automated Email to CFO

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2008 Aggregate Paid Claims Accrued for AY<CY

7K

Milliman GRC

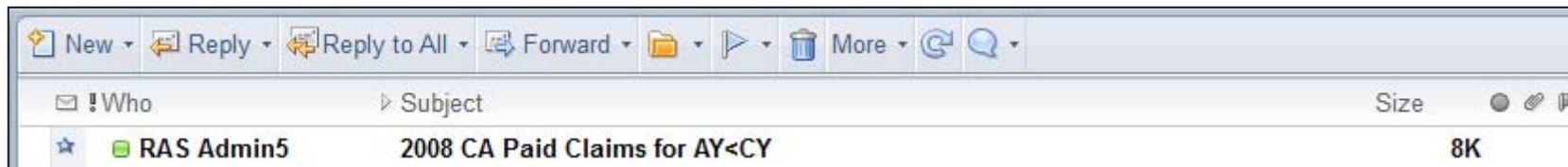
2 January 2009

As CFO, we are required to report to you the results of the Aggregate paid claims data relative to the actuarial assumptions. The 2008 Aggregate claims paid have not breached any thresholds.



# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: Automated Email to Chief Actuary



**Milliman GRC**

**2 January 2009**

TO: Chief Actuary  
CC: CFO, CRO

As Chief Actuary, we are required to report to you that the CA paid claims data, based on the 12/31/2007 actuarial assumptions, have breached at least one 5% / 95% threshold. The Data Quality, Claims Adjustment and Reinsurance departments have been informed. Please review the 2008 paid accruals, the 12/31/2007 actuarial assumptions, and non-actuarial input.

Please determine whether the breach is the result of a misestimated mean, mistestimated uncertainty or due to external circumstances and report your findings to the CFO and CRO.

TO: Chief Actuary  
CC:

Please find below a prioritized listing of deviations from actuarial expectations of paid claims.

Exposure Period	LOB	Paid Actual	Paid Expected	Paid Bootstrap Percentile	25% / 75% Breach	5% / 95% Breach	ABS Paid Deviation
12/31/2006	CA	EUR 75,813	EUR 62,031	97.00%		1	EUR 13,782
12/31/2006	PPA	EUR 234,781	EUR 247,495	17.30%		1	EUR 12,714
12/31/2007	CA	EUR 88,832	EUR 79,300	87.10%		1	EUR 9,532
12/31/2005	CA	EUR 51,020	EUR 44,759	88.70%		1	EUR 6,261
12/31/2003	CA	EUR 14,120	EUR 10,601	93.60%		1	EUR 3,519
12/31/2003	PPA	EUR 33,083	EUR 36,195	22.60%		1	EUR 3,112
12/31/2000	CA	EUR 2,387	EUR 1,068	91.50%		1	EUR 1,319
12/31/2002	HO	EUR -176	EUR 335	9.90%		1	EUR 511
12/31/2003	HO	EUR 3,800	EUR 2,525	79.30%		1	EUR 1,275
12/31/2007	HO	EUR 191,678	EUR 205,787	28.90%		0	EUR 14,109
12/31/2005	PPA	EUR 139,715	EUR 142,369	39.40%		0	EUR 2,654
12/31/2006	HO	EUR 23,840	EUR 26,865	33.30%		0	EUR 3,025
12/31/2002	PPA	EUR 13,765	EUR 15,420	29.00%		0	EUR 1,655
12/31/2004	HO	EUR 5,462	EUR 7,179	32.00%		0	EUR 1,717
12/31/2005	HO	EUR 12,197	EUR 10,412	71.70%		0	EUR 1,785
12/31/2002	CA	EUR 5,403	EUR 4,570	73.80%		0	EUR 833
12/31/2001	PPA	EUR 7,582	EUR 8,226	40.40%		0	EUR 644
12/31/2004	PPA	EUR 75,969	EUR 75,091	56.80%		0	EUR 878
12/31/2007	PPA	EUR 560,974	EUR 559,962	53.50%		0	EUR 1,012
12/31/1999	CA	EUR 543	EUR 571	58.20%		0	EUR 28
12/31/2001	CA	EUR 1,177	EUR 1,637	35.10%		0	EUR 460
12/31/2004	CA	EUR 23,636	EUR 23,242	56.40%		0	EUR 394
12/31/1999	PPA	EUR 2,500	EUR 2,740	45.20%		0	EUR 240
12/31/2000	PPA	EUR 3,485	EUR 2,999	66.80%		0	EUR 486
12/31/2001	HO	EUR 227	EUR 428	56.80%		0	EUR 201
12/31/1999	HO	EUR 26	EUR 382	26.40%		0	EUR 356
12/31/2000	HO	EUR 33	EUR 212	53.20%		0	EUR 179



# BACK-TEST: Monitor and Control Reserving Risk

How do annual accruals compare to expectations ( $\Sigma AY < CY$ )?

- HO

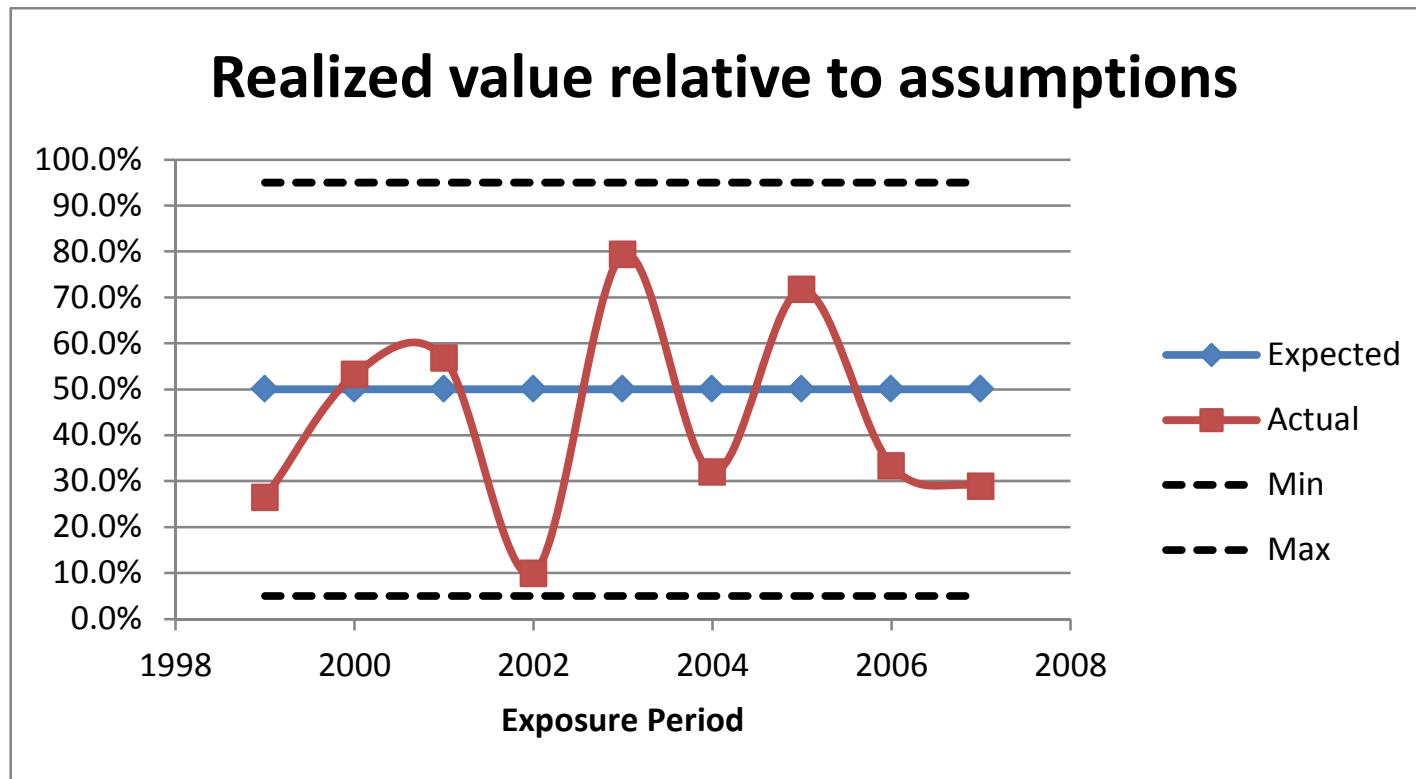
AY	Age	Actual Paid	Expected Paid	Bootstrap Percentile	Actual Incurred	Expected Incurred	Bootstrap Percentile
1999	120	26	382	26.4%	(132)	(55)	37.2%
2000	108	33	212	53.2%	(156)	(60)	37.5%
2001	96	227	428	56.8%	(1,359)	(388)	24.1%
2002	84	(176)	335	9.9%	(1,158)	(335)	23.1%
2003	72	3,800	2,525	79.3%	412	(990)	86.1%
2004	60	5,462	7,179	32.0%	(8)	958	14.2%
2005	48	12,197	10,412	71.7%	1,284	677	82.3%
2006	36	23,840	26,865	33.3%	8,785	10,887	46.7%
2007	24	191,678	205,787	28.9%	56,168	53,709	59.0%
2008	12	934,805	-		1,143,739	-	
CY 2008		1,171,892			1,207,575		
AY < CY		237,087	254,125	25.7%	63,836	64,402	51.7%

- AYs 2002-03 offset each other

- AYs 2001-05 offset each other

# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: HO Paid (AY<CY) Observation



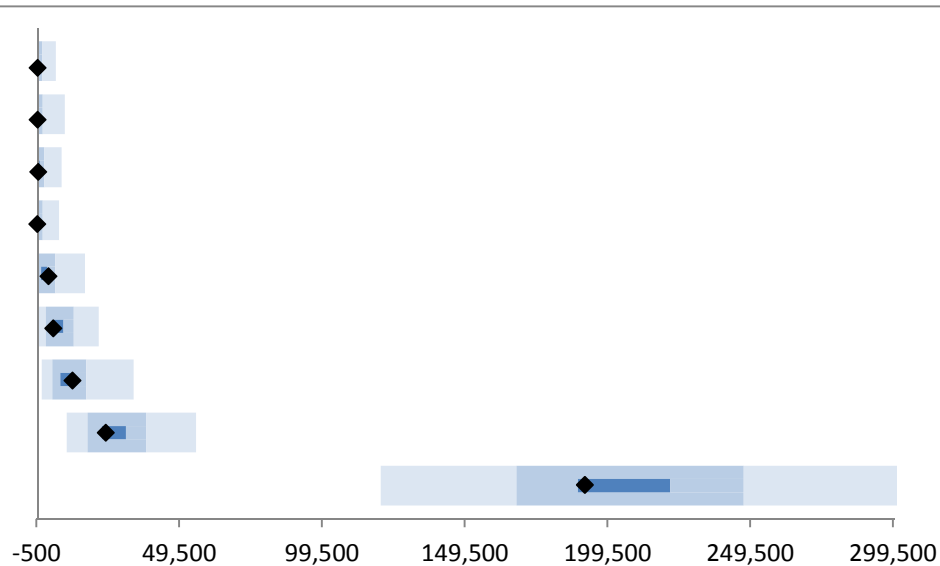
- No thresholds breached.
- Expectations from the model appear unbiased.
- Are the 10th and 80th percentile values surprising, given that we have 9 AY observations?

# BACK-TEST: Monitor and Control Reserving Risk

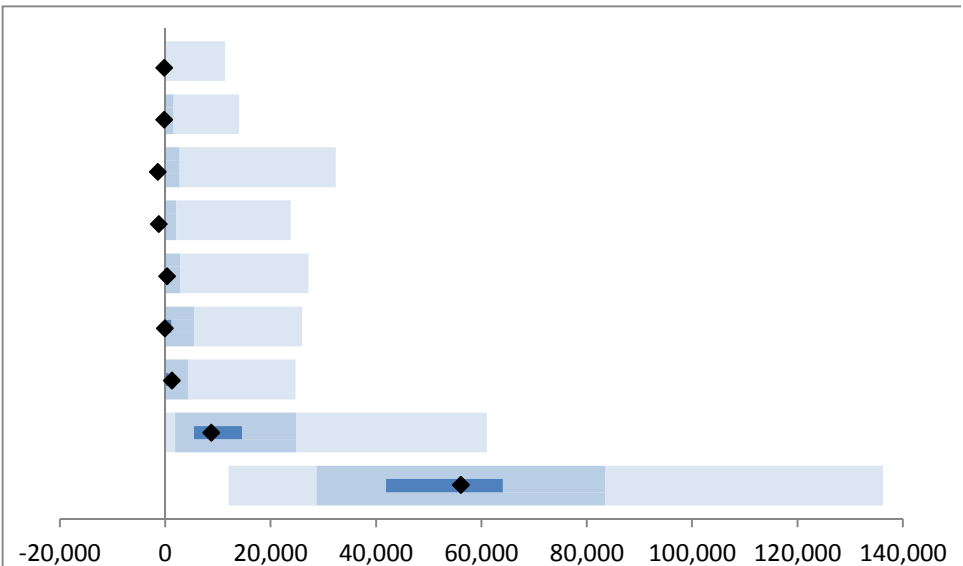
How do annual accruals compare to expectations ( $\Sigma AY < CY$ )?



- HO Paid Loss



- HO Incurred Loss



- AYs 2002-03 offset each other*

- AYs 2001-05 offset each other*

# BACK-TEST: Monitor and Control Reserving Risk

How do annual accruals compare to expectations ( $\Sigma AY < CY$ )?

- PPA

AY	Age	Actual Paid	Expected Paid	Bootstrap Percentile	Actual Incurred	Expected Incurred	Bootstrap Percentile
1999	120	2,500	2,738	45.2%	2,042	2,050	56.8%
2000	108	3,485	2,971	68.0%	2,261	1,279	82.1%
2001	96	7,582	8,165	41.5%	4,061	5,134	34.2%
2002	84	13,765	15,407	28.2%	8,076	8,173	52.5%
2003	72	33,083	36,234	22.1%	16,495	19,592	22.7%
2004	60	75,969	75,199	56.6%	35,496	39,055	26.4%
2005	48	139,715	142,368	38.8%	68,886	72,175	34.3%
2006	36	234,781	247,750	16.7%	119,582	123,554	36.7%
2007	24	560,974	559,917	53.0%	314,895	339,756	12.3%
2008	12	764,210	-		1,205,957	-	
CY 2008		1,836,064			1,777,751		
AY < CY		1,071,854	1,090,749	27.8%	571,794	610,769	6.7%

- *AYs 2003-2007 actuals much less than expected*
- *AY 2007 drives LoB difference*

## Slide 12

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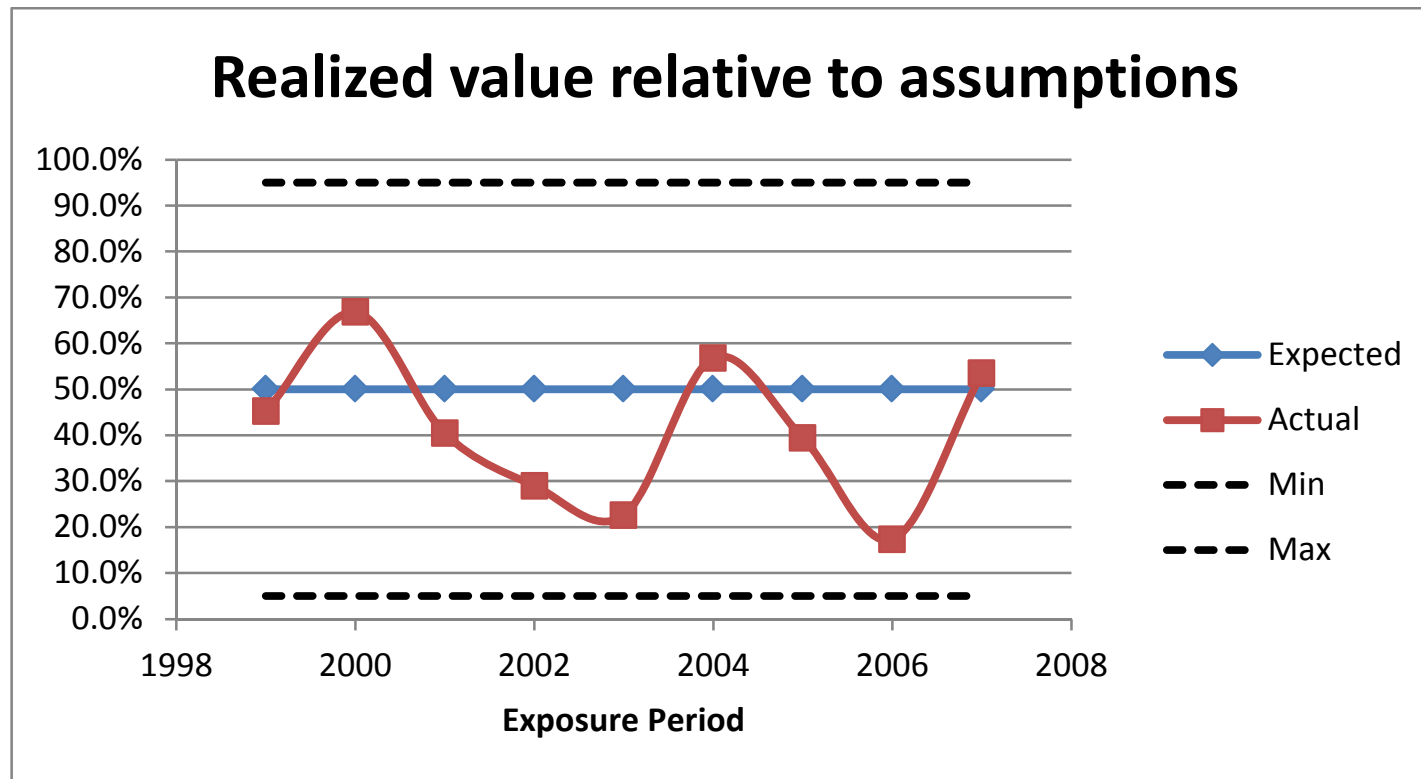
JC1

I do not plan on discussing each of the 3 LoBs, but include all three so we can choose the most interesting one.

Jeff Courchene, 9/9/2011

# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: PPA Paid (AY<CY) Observation



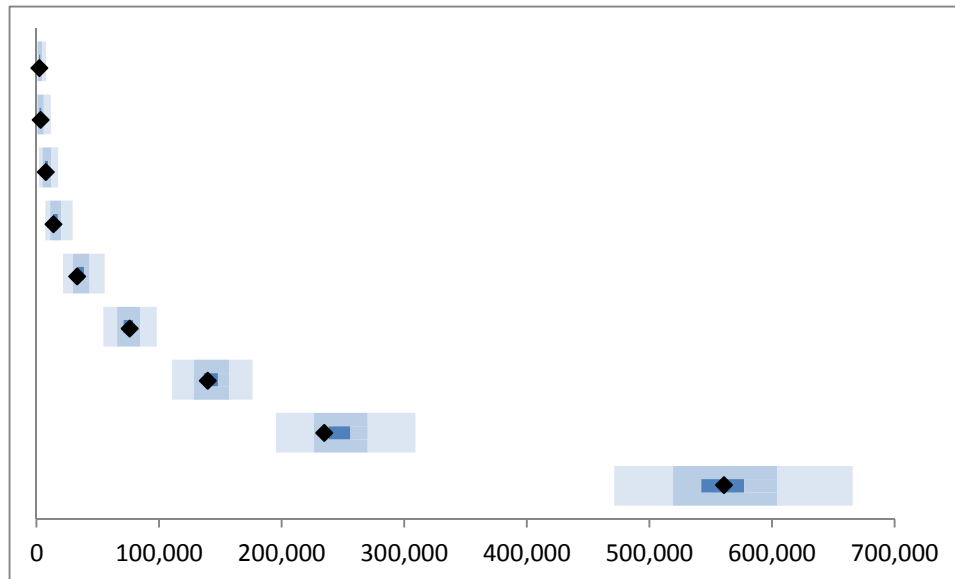
- No thresholds breached
- Not concerned about tail volatility.
- Are the expectations from the model biased low?
- Are two 20th percentile values surprising, given that we have 9 AY observations?

# BACK-TEST: Monitor and Control Reserving Risk

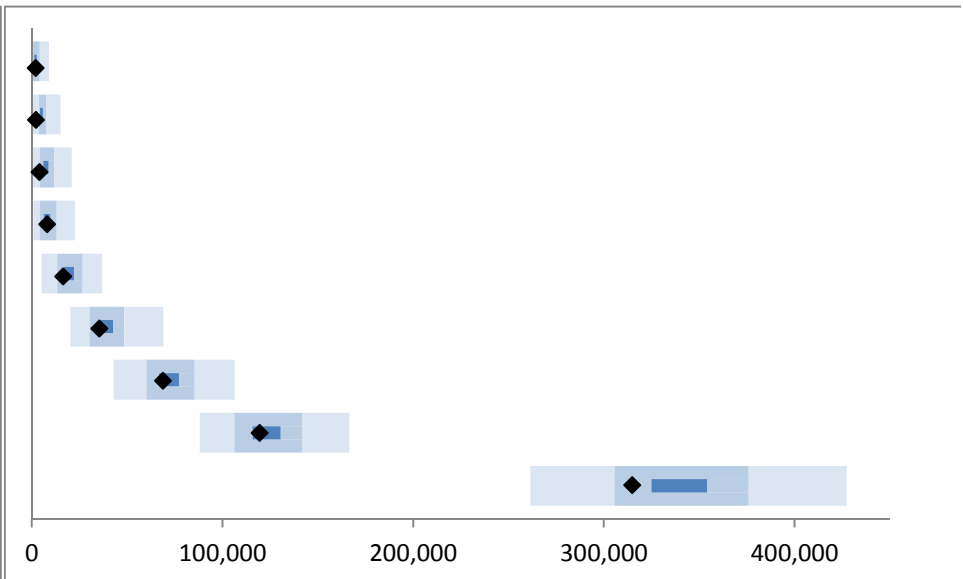
How do annual accruals compare to expectations ( $\Sigma AY < CY$ )?



- PPA Paid Loss



- PPA Incurred Loss




- AYs 2003-2007 actuals much less than expected*
- AY 2007 drives LoB difference*



# BACK-TEST: Integrated ERM Framework


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

 Reserve Variability Model  
**2008 CA Exposure**

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**Reserve Variability Model Detail** [Edit](#) [Delete](#) [Clone](#)

Reserve Variability Model Name: **2008 CA Exposure** 

Assumption Owner: [Jeff Courchene](#)

Description: Expected CA claim payments during 2008 for exposure periods prior to 2008 based on data generated by claims system as of 12/31/2008 relative to the 12/31/2007 actuarial assumptions

Reports to: [Mark Shapland](#)

Assumption Value: 50%      Assumption Value Date: 12/31/2007

Assumption Minimum: 5%      Next Update Due: 12/31/2008

Assumption Maximum: 95%

---

▼ **Realized Value**

Actual Paid: EUR 262,931      Actual Incurred: EUR 211,506

Expected Paid: EUR 227,779      Expected Incurred: EUR 163,972

Paid Bootstrap Percentile: 99.60%      Incurred Bootstrap Percentile: 99.90%

[Edit](#) [Delete](#) [Clone](#)

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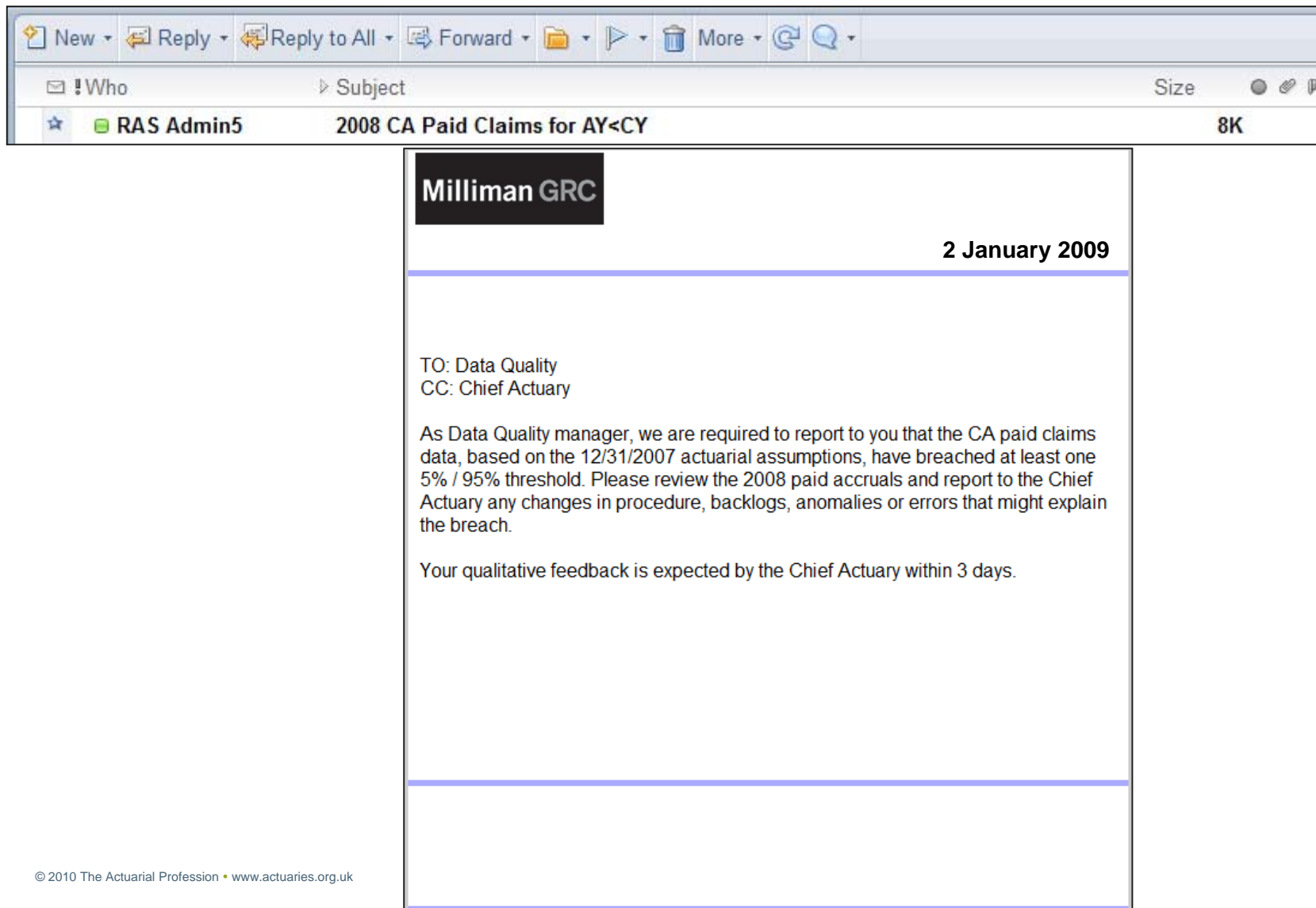
**RVM Values** [New RVM Value](#) [RVM Values Help](#) ?

Action	RVM Number	Exposure Period	Age	Paid Actual	Paid Expected	Paid Bootstrap Percentile	Incurred Actual	Incurred Expected	Incurred Bootstrap Percentile
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0025</a>	12/31/1999	120	EUR 543	EUR 571	58.20	EUR -47	EUR 157	0.10
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0026</a>	12/31/2000	108	EUR 2,387	EUR 1,068	91.50	EUR 1,040	EUR 507	81.10
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0027</a>	12/31/2001	96	EUR 1,177	EUR 1,637	35.10	EUR 851	EUR 1,206	42.40
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0028</a>	12/31/2002	84	EUR 5,403	EUR 4,570	73.80	EUR 2,954	EUR 2,088	79.10
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0029</a>	12/31/2003	72	EUR 14,120	EUR 10,601	93.60	EUR 9,035	EUR 6,005	92.50
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0030</a>	12/31/2004	60	EUR 23,636	EUR 23,242	56.40	EUR 16,524	EUR 11,893	94.70
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0031</a>	12/31/2005	48	EUR 51,020	EUR 44,759	88.70	EUR 36,454	EUR 29,853	91.30
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0032</a>	12/31/2006	36	EUR 75,813	EUR 62,031	97.00	EUR 61,541	EUR 44,846	99.00
<a href="#">Edit</a>   <a href="#">Del</a>	<a href="#">RVM-0033</a>	12/31/2007	24	EUR 88,832	EUR 79,300	87.10	EUR 83,154	EUR 67,417	96.00

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

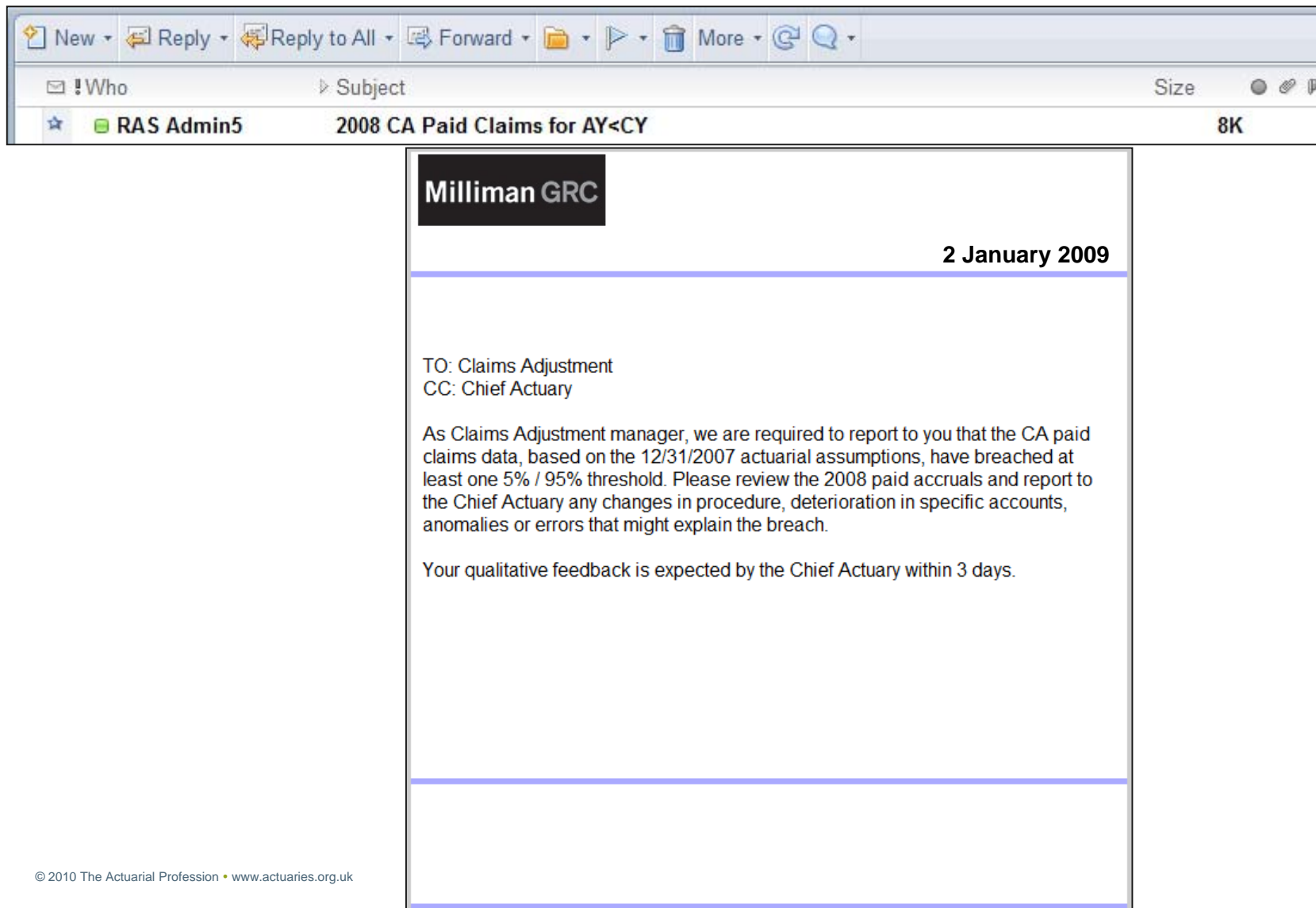
# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: Automated Email to Data Quality



# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: Automated Email to Claims Adjusters



# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: Automated Email to Reinsurance Dept.

The screenshot shows an email client window with a toolbar at the top containing icons for New, Reply, Reply to All, Forward, a folder icon, a flag icon, a trash icon, and a More dropdown menu. Below the toolbar is a header bar with columns for Who, Subject, and Size. The email is from RAS Admin5 (marked with a star) with the subject '2008 CA Paid Claims for AY<CY' and a size of 8K.

**Milliman GRC**

**2 January 2009**

TO: Reinsurance Recovery  
CC: Chief Actuary

As Reinsurance Recovery manager, we are required to report to you that the CA paid claims data, based on the 12/31/2007 actuarial assumptions, have breached at least one 5% / 95% threshold. Please review the 2008 paid accruals and report to the Chief Actuary any changes in expected recoverable, backlogs, anomalies or errors that might explain the breach.

Your qualitative feedback is expected by the Chief Actuary within 3 days.

# BACK-TEST: Monitor and Control Reserving Risk

How do annual accruals compare to expectations ( $\Sigma AY < CY$ )?

- CA

AY	Age	Actual Paid	Expected Paid	Bootstrap Percentile	Actual Incurred	Expected Incurred	Bootstrap Percentile
1999	120	543	577	57.5%	(47)	152	0.2%
2000	108	2,387	1,043	91.8%	1,040	503	81.9%
2001	96	1,177	1,636	35.6%	851	1,193	43.6%
2002	84	5,403	4,540	74.1%	2,954	2,064	79.5%
2003	72	14,120	10,630	93.5%	9,035	6,013	92.5%
2004	60	23,636	23,300	56.2%	16,524	11,898	95.0%
2005	48	51,020	44,746	88.8%	36,454	29,808	91.6%
2006	36	75,813	62,082	96.9%	61,541	44,977	99.0%
2007	24	88,832	79,335	87.0%	83,154	67,322	95.9%
2008	12	99,123	-		178,539	-	
CY 2008		362,054			390,045		
AY < CY		262,931	227,890	99.6%	211,506	163,930	99.9%

- AYs 2002-07 are driving high #s

- Need to check IELRs, LDFs, weight

- AYs 2002-07 are driving high #s

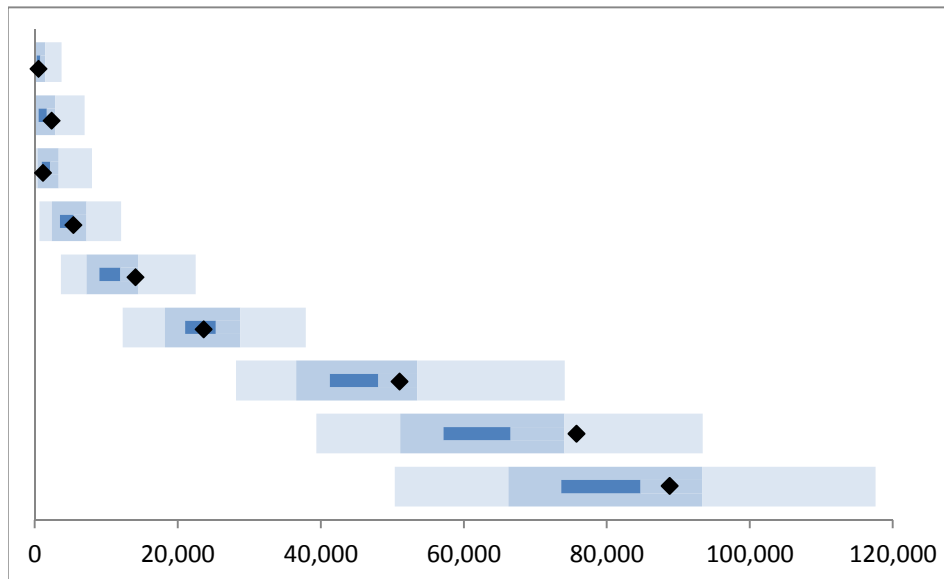
- Need to check IELRs, LDFs, weight

# BACK-TEST: Monitor and Control Reserving Risk

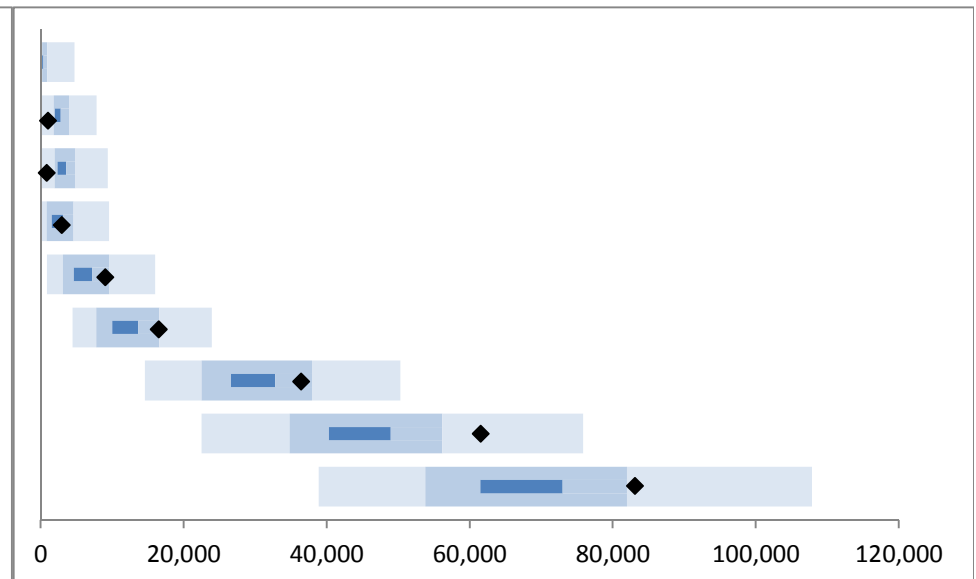
How do annual accruals compare to expectations ( $\Sigma AY < CY$ )?



- CA Paid Loss



- CA Incurred Loss

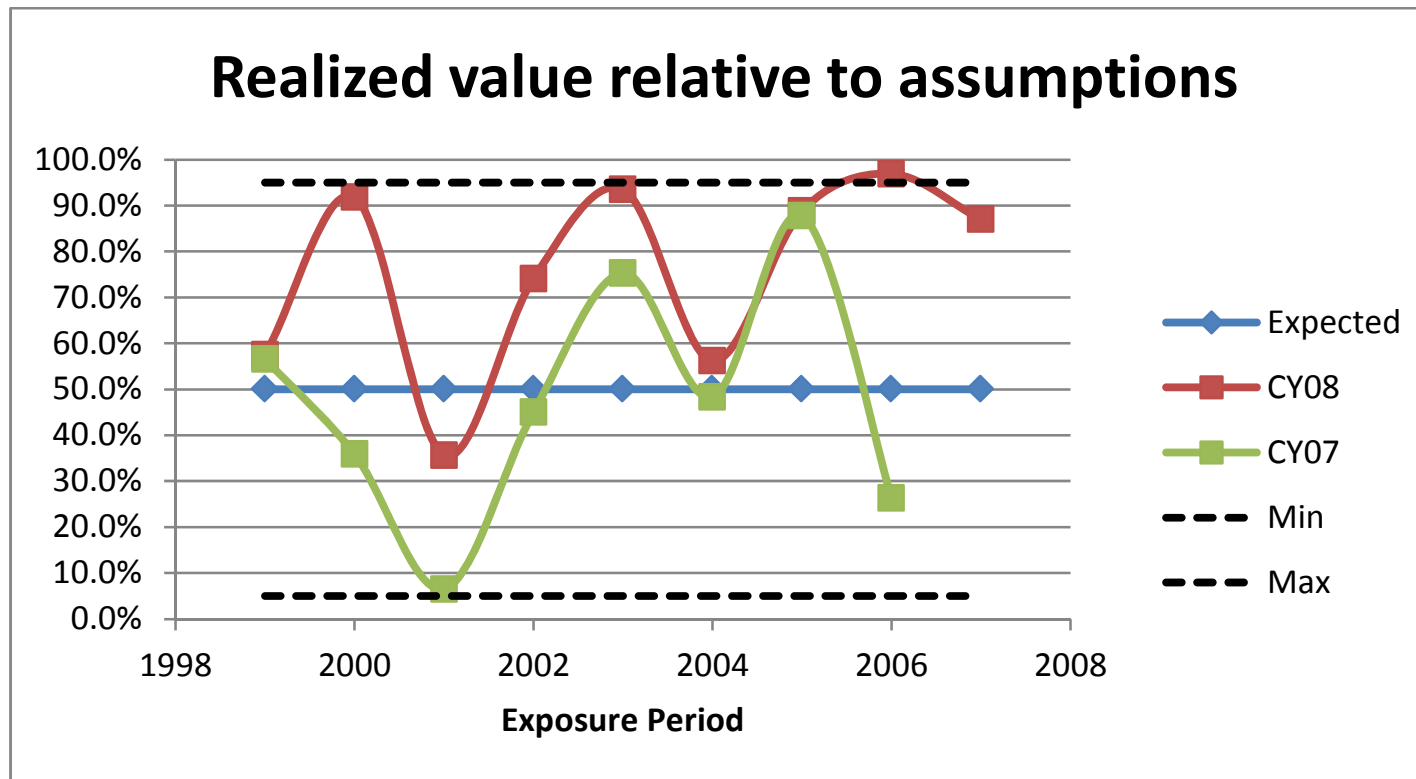


- AYs 2002-07 are driving high #s
  - Need to check IELRs, LDFs, weight

- AYs 2002-07 are driving high #s
  - Need to check IELRs, LDFs, weight

# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: Aggregate Paid (AY<CY) Observation



- Threshold breached
- Are the expectations from the model biased low?
- Are we aware of all internal process change?
- Are we underestimating tail volatility?



# BACK-TEST: Monitor and Control Reserving Risk

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

	Number			Percentage		
	25<X<75	5<X<95	<5 or >95	25<X<75	5<X<95	<5 or >95
HO	13	20	-	65.0%	100.0%	0.0%
PPA	14	20	-	70.0%	100.0%	0.0%
CA	5	14	6	25.0%	70.0%	30.0%
Agg	16	20	-	80.0%	100.0%	0.0%
Total	48	74	6	60.0%	92.5%	7.5%

- *Overall actual results are consistent with expectations*
  - *Includes both AY and Total ( $\Sigma AY < CY$ ) outcomes*
  - *CA could be problematic:*
  - *Width of distribution or some other assumption?*

# BACK-TEST: Monitor and Control Reserving Risk

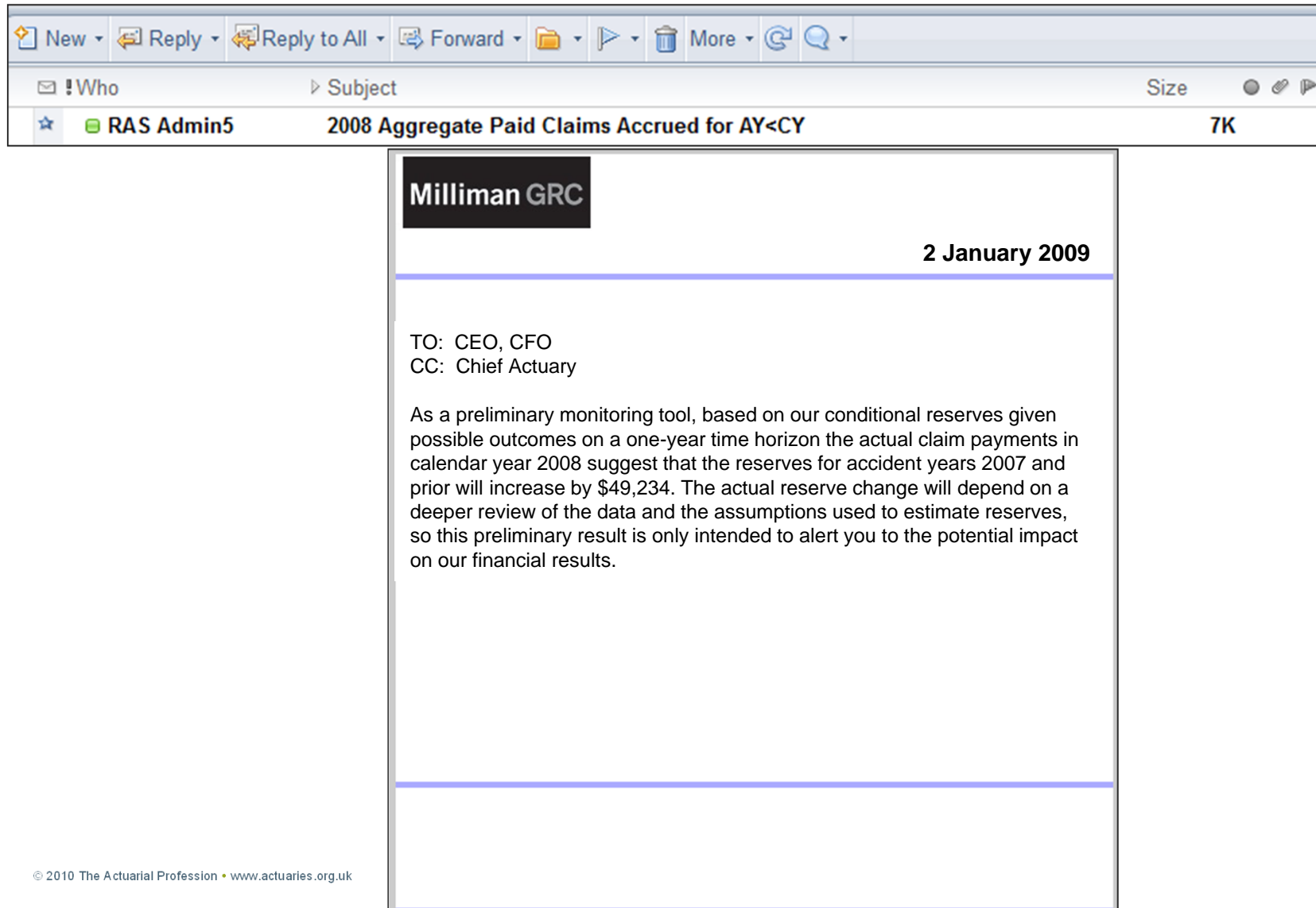
## One-year time horizon reserve changes ( $\Sigma AY < CY$ )?

AY	CA			PPA			HO			Total Change
	Expected Reserve	Conditional Reserve	Change	Expected Reserve	Conditional Reserve	Change	Expected Reserve	Conditional Reserve	Change	
1999	613	547	(67)	2,737	2,493	(245)	392	25	(367)	(678)
2000	(146)	2,194	2,340	6,210	6,874	664	979	744	(235)	2,769
2001	2,500	1,533	(967)	9,566	8,940	(626)	1,559	1,511	(49)	(1,642)
2002	3,205	4,927	1,722	19,331	17,337	(1,994)	2,013	114	(1,899)	(2,171)
2003	5,828	12,825	6,997	36,672	33,136	(3,535)	2,897	4,499	1,602	5,064
2004	19,494	20,176	682	73,732	74,597	865	6,005	4,315	(1,690)	(143)
2005	44,250	57,573	13,323	156,541	153,517	(3,024)	12,219	14,416	2,197	12,496
2006	80,777	113,108	32,331	319,636	303,909	(15,727)	25,577	22,449	(3,129)	13,475
2007	146,195	171,586	25,391	587,371	588,683	1,313	65,979	59,340	(6,639)	20,065
2008										
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 2005-07 should also drive reserves up*
  - *Most of this increase is driven by CA*

# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: Automated Email to CEO & CFO



New ▾ Reply ▾ Reply to All ▾ Forward ▾ More ▾

Who Subject Size

★ RAS Admin5 2008 Aggregate Paid Claims Accrued for AY<CY 7K

**Milliman GRC**

**2 January 2009**

TO: CEO, CFO  
CC: Chief Actuary

As a preliminary monitoring tool, based on our conditional reserves given possible outcomes on a one-year time horizon the actual claim payments in calendar year 2008 suggest that the reserves for accident years 2007 and prior will increase by \$49,234. The actual reserve change will depend on a deeper review of the data and the assumptions used to estimate reserves, so this preliminary result is only intended to alert you to the potential impact on our financial results.

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# Agenda

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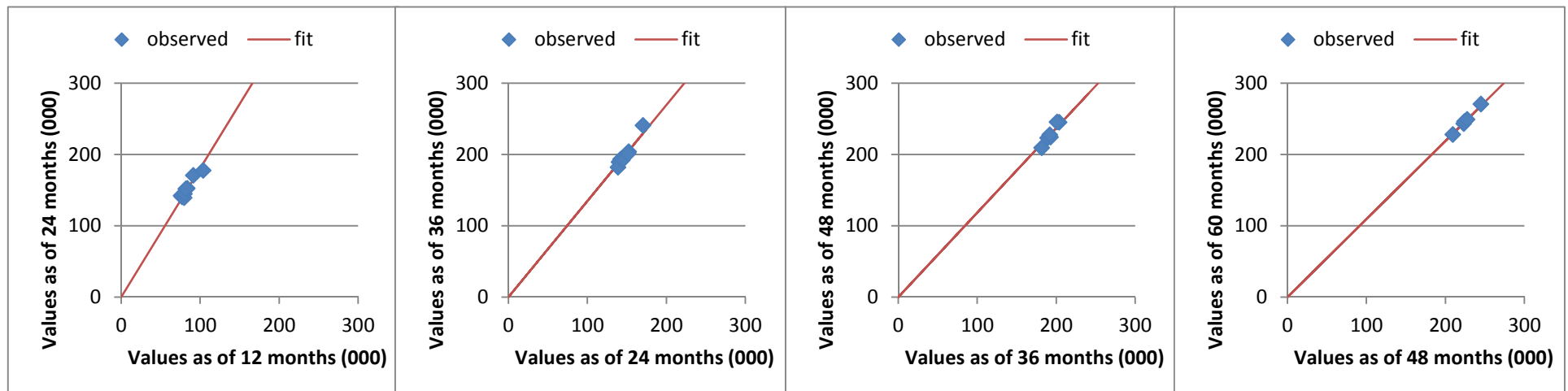
- ✓ Using back-testing to monitor and control reserving risk
- ✓ Integrated ERM framework
- How did we get there?
  - Best estimate and validation
  - Uncertainty and corresponding validation
  - Assumption consistency
    - Method weights
    - Shifting of mean
  - Setting thresholds for action
  - Defining controls to support the actuarial function
- Available validation guidance (CEIOPS 33/09 & Lloyd's)

# Best Estimate & Validation as of 31 December 07

Assumptions: Commercial Auto (CA) – Paid Loss Triangle

AY	<u>12</u>	<u>24</u>	<u>36</u>	<u>48</u>	<u>60</u>	<u>72</u>	<u>84</u>	<u>96</u>	<u>108</u>	<u>120</u>	Tail
1998											1.004
1999	77,401	140,425	189,316	223,326	243,182	250,182	254,305	256,672	257,689		
2000	76,085	142,122	193,196	224,406	246,220	257,226	263,698	264,871			
2001	79,850	139,041	181,905	209,366	228,012	237,792	240,300				
2002	80,323	144,482	192,134	227,723	249,165	259,339					
2003	83,919	152,487	203,761	245,150	270,525						
2004	82,001	151,768	201,189	245,541							
2005	91,514	170,696	240,652								
2006	103,957	177,709									
2007	105,547										
AYLWA	1.805	1.347	1.184	1.095	1.039	1.018	1.007	1.004	1.002	1.002	1.000
CDF	3.385	1.875	1.392	1.176	1.074	1.033	1.015	1.008	1.004	1.002	1.000
BF Unpaid	0.705	0.467	0.282	0.149	0.069	0.032	0.015	0.008	0.004	0.002	0.000

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

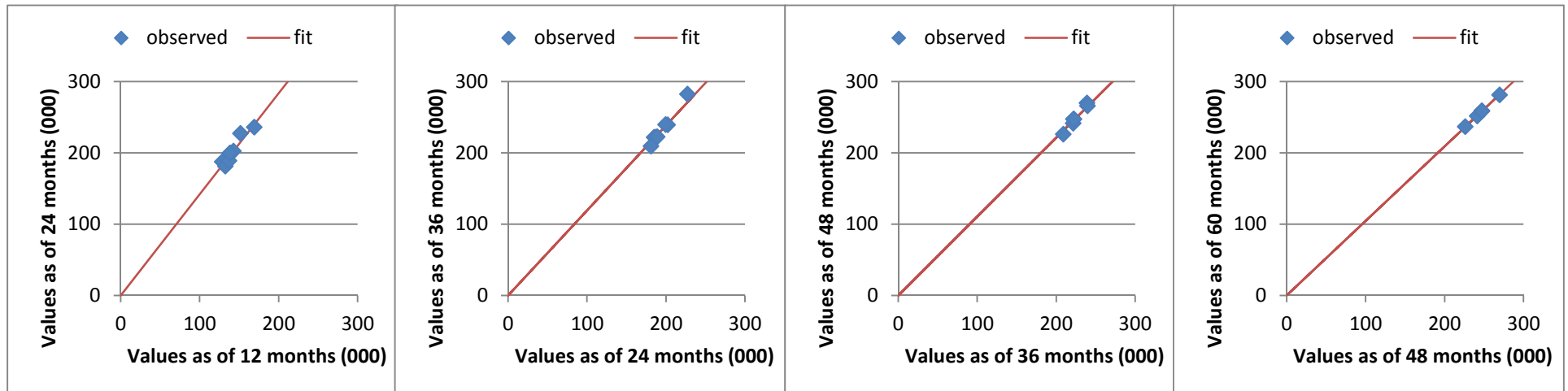


# Best Estimate & Validation as of 31 December 07

Assumptions: Commercial Auto (CA) – Incurred Loss Triangle

AY	12	24	36	48	60	72	84	96	108	120	Tail
1998											1.001
1999	133,521	185,161	221,635	241,420	251,646	255,508	256,596	258,041	258,524		
2000	128,727	187,403	222,093	247,345	258,712	265,636	269,558	270,758			
2001	132,567	181,263	209,262	226,237	236,863	241,107	242,171				
2002	137,295	188,962	222,624	247,335	258,856	265,496					
2003	142,862	202,363	239,239	269,940	281,376						
2004	138,650	199,791	239,719	266,101							
2005	151,778	227,353	282,394								
2006	169,171	235,983									
2007	177,611										
AYLWA	1.418	1.193	1.106	1.045	1.022	1.008	1.005	1.002	1.001	1.000	1.000
CDF	2.029	1.431	1.200	1.085	1.038	1.016	1.008	1.003	1.001	1.000	1.000
BF Unported	0.507	0.301	0.166	0.078	0.037	0.016	0.008	0.003	0.001	0.000	0.000

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



# Best Estimate & Validation as of 31 December 07

Assumptions: Commercial Auto (CA) – AY Independence

*Mack Assumption:  $\{c(i, 1), \dots, c(i, n)\}$  &  $\{c(j, 1), \dots, c(j, n)\}$  are independent for  $i \neq j$*

CY LDFs		Paid Loss	AY	24 / 12	36 / 24	48 / 36	60 / 48	72 / 60	84 / 72	96 / 84	108 / 96
Small	Large										
1	0	1999		1.814	1.348	1.180	1.089	1.029	1.016	1.009	1.004
0	2	2000		1.868	1.359	1.162	1.097	1.045	1.025	1.004	
2	1	2001		1.741	1.308	1.151	1.089	1.043	1.011		
4	0	2002		1.799	1.330	1.185	1.094	1.041			
3	2	2003		1.817	1.336	1.203	1.104				
1	3	2004		1.851	1.326	1.220					
1	5	2005		1.865	1.410						
4	3	2006		1.709							
Median				1.816	1.336	1.182	1.094	1.042	1.016	1.007	1.004

CY LDFs		Incurred Loss	AY	24 / 12	36 / 24	48 / 36	60 / 48	72 / 60	84 / 72	96 / 84	108 / 96
Small	Large										
1	0	1999		1.387	1.197	1.089	1.042	1.015	1.004	1.006	1.002
0	2	2000		1.456	1.185	1.114	1.046	1.027	1.015	1.004	
2	0	2001		1.367	1.154	1.081	1.047	1.018	1.004		
3	1	2002		1.376	1.178	1.111	1.047	1.026			
3	1	2003		1.416	1.182	1.128	1.042				
2	4	2004		1.441	1.200	1.110					
1	6	2005		1.498	1.242						
4	2	2006		1.395							
Median				1.406	1.185	1.111	1.046	1.022	1.004	1.005	1.002



# Best Estimate & Validation as of 31 December 07

Assumptions: Commercial Auto (CA) – IELR (used in BF) and weights

AY	Paid CL ULR	Incurred CL ULR	Management IELR	Selected ULR	AY	Paid CL	Incurred CL	Incurred BF	Incurred BF
1999	73.2%	73.2%	73.3%	73.2%	1999	50.0%	50.0%		
2000	76.0%	77.3%	77.4%	76.7%	2000	50.0%	50.0%		
2001	64.5%	64.5%	64.6%	64.5%	2001	50.0%	50.0%		
2002	62.8%	63.2%	63.2%	63.0%	2002	50.0%	50.0%		
2003	60.4%	60.7%	60.8%	60.6%	2003	50.0%	50.0%		
2004	53.2%	53.2%	53.4%	53.2%	2004	50.0%	50.0%		
2005	57.9%	58.5%	58.5%	58.2%	2005	25.0%	25.0%	25.0%	25.0%
2006	54.5%	55.3%	54.7%	54.9%	2006			50.0%	50.0%
2007	57.3%	57.7%	52.9%	54.7%	2007			50.0%	50.0%

- Optimism Regarding AY 2007 ULR
  - In this example, based on published figures (selected ultimate)
  - IELR is an important assumption which requires additional validation
    - Based on renewal study performed by Underwriting?
    - Based on Actuarial analysis of average rate achieved?
  - Sensitivity tests confirm that this assumption is only a partial explanation

# Best Estimate & Validation as of 31 December 07

## Implied Expectations: Commercial Auto (CA) – Incurred CL

CL Incurred - Cumulative

	12	24	36	48	60	72	84	96	108	120	132
1998	0	0	0	0	0	0	0	0	0	0	0
1999	133,521	185,161	221,635	241,420	251,646	255,508	256,596	258,041	258,524	258,835	258,835
2000	128,727	187,403	222,093	247,345	258,712	265,636	269,558	270,758	271,265	271,591	271,591
2001	132,567	181,263	209,262	226,237	236,863	241,107	242,171	243,388	243,844	244,137	244,137
2002	137,295	188,962	222,624	247,335	258,856	265,496	267,612	268,957	269,460	269,784	269,784
2003	142,862	202,363	239,239	269,940	281,376	287,437	289,727	291,183	291,729	292,079	292,079
2004	138,650	199,791	239,719	266,101	278,016	284,004	286,267	287,706	288,245	288,592	288,592
2005	151,778	227,353	282,394	312,374	326,361	333,390	336,047	337,736	338,368	338,775	338,775
2006	169,171	235,983	281,496	311,381	325,323	332,330	334,978	336,662	337,293	337,698	337,698
2007	177,611	251,767	300,325	332,208	347,083	354,559	357,385	359,181	359,853	360,286	360,286

CL Incurred - Cumulative - paid expectations

	12	24	36	48	60	72	84	96	108	120	132
1998	0	0	0	0	0	0	0	0	0	0	0
1999	77,401	140,425	189,316	223,326	243,182	250,182	254,305	256,672	257,689	258,261	258,835
2000	77,363	144,510	196,442	228,177	250,357	261,548	268,129	269,322	270,389	270,989	271,591
2001	79,901	139,130	182,021	209,500	228,158	237,944	240,454	242,097	243,056	243,596	244,137
2002	80,875	145,476	193,456	229,289	250,879	261,123	265,714	267,530	268,590	269,187	269,784
2003	84,382	153,329	204,886	246,504	272,019	282,702	287,673	289,639	290,786	291,432	292,079
2004	81,986	151,740	201,151	245,495	268,771	279,326	284,237	286,180	287,314	287,952	288,592
2005	92,539	172,608	243,347	288,185	315,508	327,899	333,664	335,944	337,275	338,025	338,775
2006	105,354	180,097	242,574	287,269	314,505	326,856	332,603	334,876	336,203	336,950	337,698
2007	106,428	192,144	258,799	306,484	335,541	348,719	354,850	357,276	358,691	359,488	360,286

CL Incurred - Incremental - paid expectations

	12	24	36	48	60	72	84	96	108	120	132
1998	0	0	0	0	0	0	0	0	0	0	0
1999	77,401	63,024	48,891	34,010	19,856	7,000	4,123	2,367	1,017	572	574
2000	77,363	67,147	51,932	31,734	22,181	11,191	6,581	1,193	1,067	601	602
2001	79,901	59,229	42,891	27,479	18,658	9,786	2,510	1,643	959	540	541
2002	80,875	64,600	47,980	35,834	21,589	10,244	4,591	1,816	1,060	597	598
2003	84,382	68,947	51,557	41,618	25,515	10,683	4,971	1,966	1,148	646	647
2004	81,986	69,754	49,412	44,344	23,275	10,555	4,911	1,942	1,134	638	640
2005	92,539	80,069	70,739	44,838	27,323	12,391	5,766	2,280	1,331	749	751
2006	105,354	74,743	62,476	44,695	27,236	12,351	5,747	2,273	1,327	747	748
2007	106,428	85,716	66,655	47,685	29,058	13,178	6,132	2,425	1,416	797	798

$$E[CPL_{i,j} | CIL_{i,j}] = CPL_{i,j} \times \frac{CIL_{i,ULT}}{CPL_{i,ULT}}$$

# Best Estimate & Validation as of 31 December 07

## Implied Expectations: Commercial Auto (CA)

AY	Expected Paid Losses during CY 2008				
	PCL	ICL	PBF	IBF	Weighted
1999	572	572	573	573	572
2000	1,049	1,067	1,068	1,086	1,058
2001	1,642	1,643	1,647	1,648	1,643
2002	4,560	4,591	4,590	4,621	4,576
2003	10,624	10,683	10,695	10,750	10,654
2004	23,280	23,275	23,355	23,346	23,278
2005	44,341	44,838	44,779	45,145	44,776
2006	61,648	62,476	61,823	62,374	62,098
2007	85,007	85,716	78,521	80,114	79,317
AY < CY	232,723	234,862	227,052	229,656	227,972

- Each method produces a different expectation of paid (incurred) loss.
- 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.
- This can be material for young AYs

AY	Expected Incurred Losses during CY 2008				
	PCL	ICL	PBF	IBF	Weighted
1999	155	155	156	156	155
2000	498	507	499	507	503
2001	1,217	1,217	1,219	1,220	1,217
2002	2,101	2,116	2,101	2,115	2,108
2003	6,027	6,061	6,037	6,067	6,044
2004	11,917	11,915	11,960	11,956	11,916
2005	29,648	29,980	29,698	29,941	29,817
2006	44,910	45,513	44,640	45,037	44,839
2007	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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# Uncertainty and Corresponding Validation

Assumptions: Commercial Auto (CA) – General

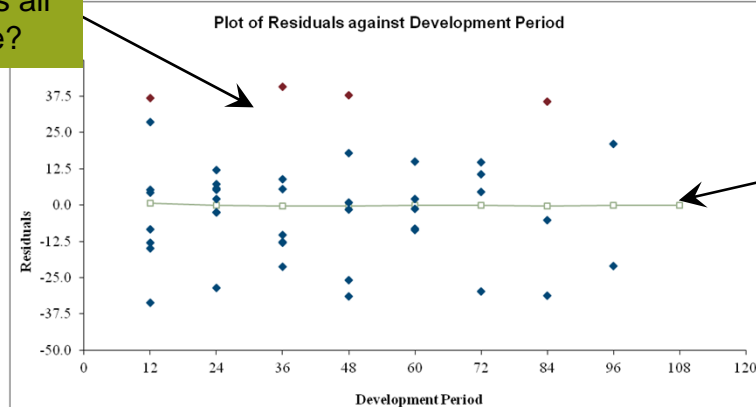
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- Non-zero average of residuals
  - Assumed to be a characteristic of the dataset (not remove)
- Long term average LDFs
  - No validated reason to use shorter term averages (e.g. 5YLWA)
  - In this example, 100% consistent with calculation of Best Estimate
    - If deterministic analysis uses a „picker approach“ (to reflect observable trends), need to validate each „pick“ and consider shifting output of uncertainty model.
- Heteroecthesious data
  - We use symmetrical triangles (e.g. AY x AY)
  - Exposures are complete at interim valuation dates and have not significantly changed over time (e.g. not observe rapid growth)
- 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

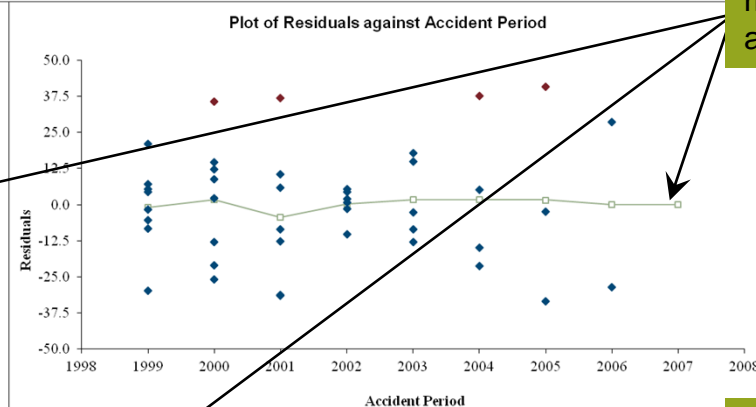
# Uncertainty and Corresponding Validation

Assumptions: Commercial Auto (CA) – Paid Loss Diagnostics

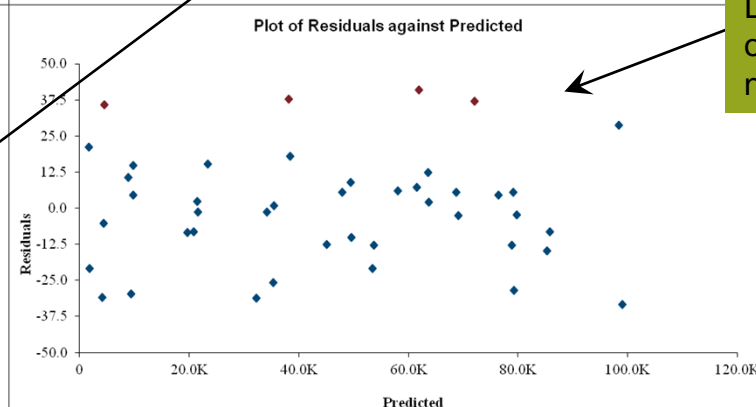
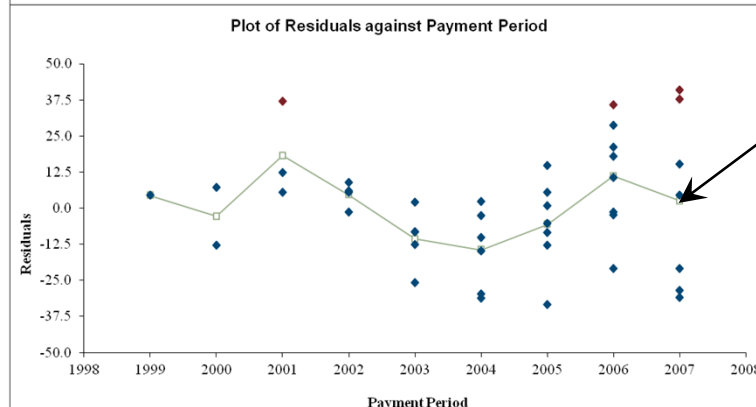
Are the variances all the same?



Does the model explain all the trends?



Do you have only random noise left?

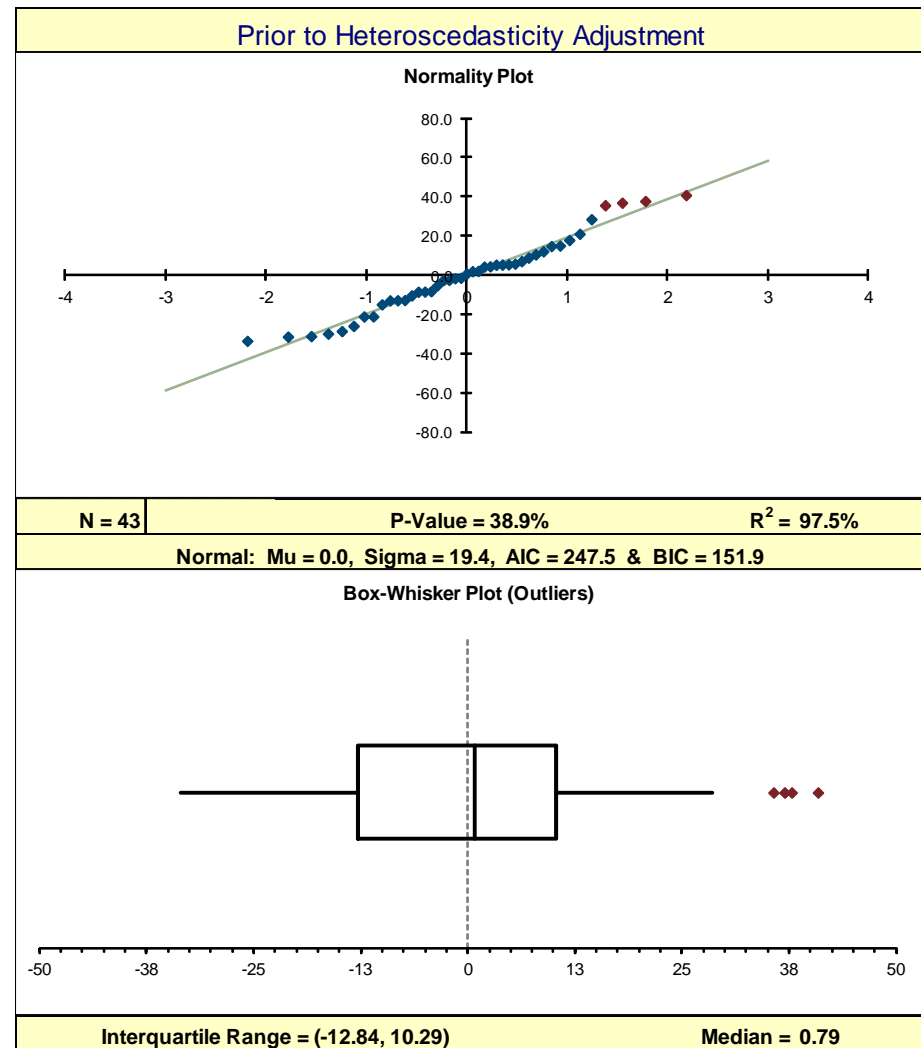


Paid Tail (108-ult) = 1.0044, Std Dev = 0.0005 (extrapolated 2 years with decay = 0.5)

# Uncertainty and Corresponding Validation

Assumptions: Commercial Auto (CA) – Paid Loss Diagnostics

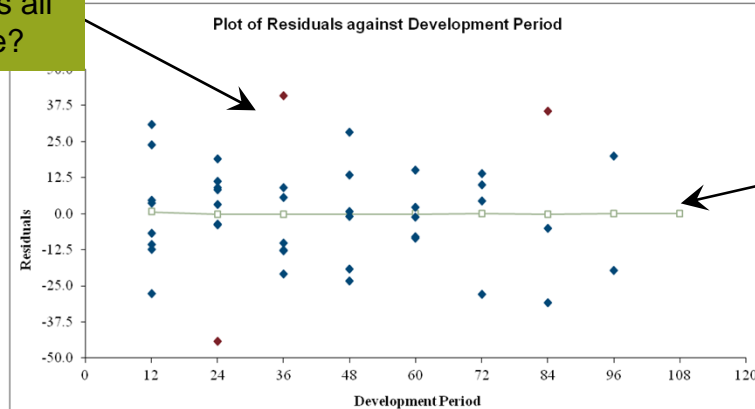
- All positive outliers could indicate skewness.
- Normality still good though.
- We can still check heteroscedasticity.



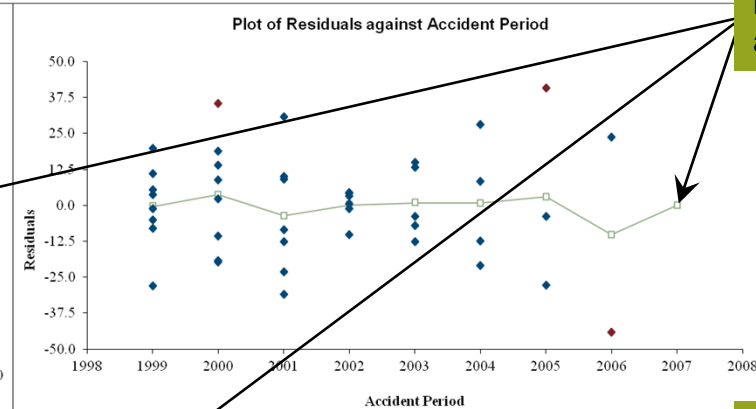
# Uncertainty and Corresponding Validation

Assumptions: Commercial Auto (CA) – Paid Loss Diagnostics

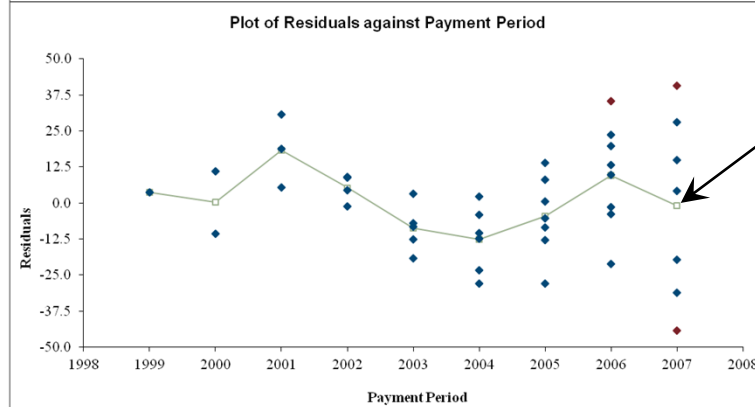
Are the variances all the same?



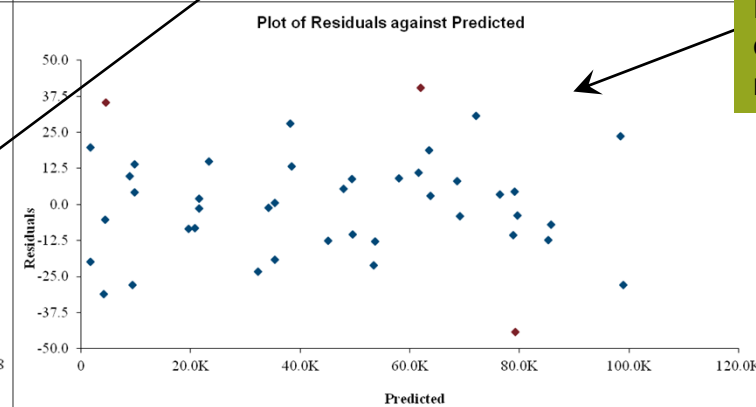
Does the model explain all the trends?



✓ Yes



Do you have only random noise left?



✓ Yes

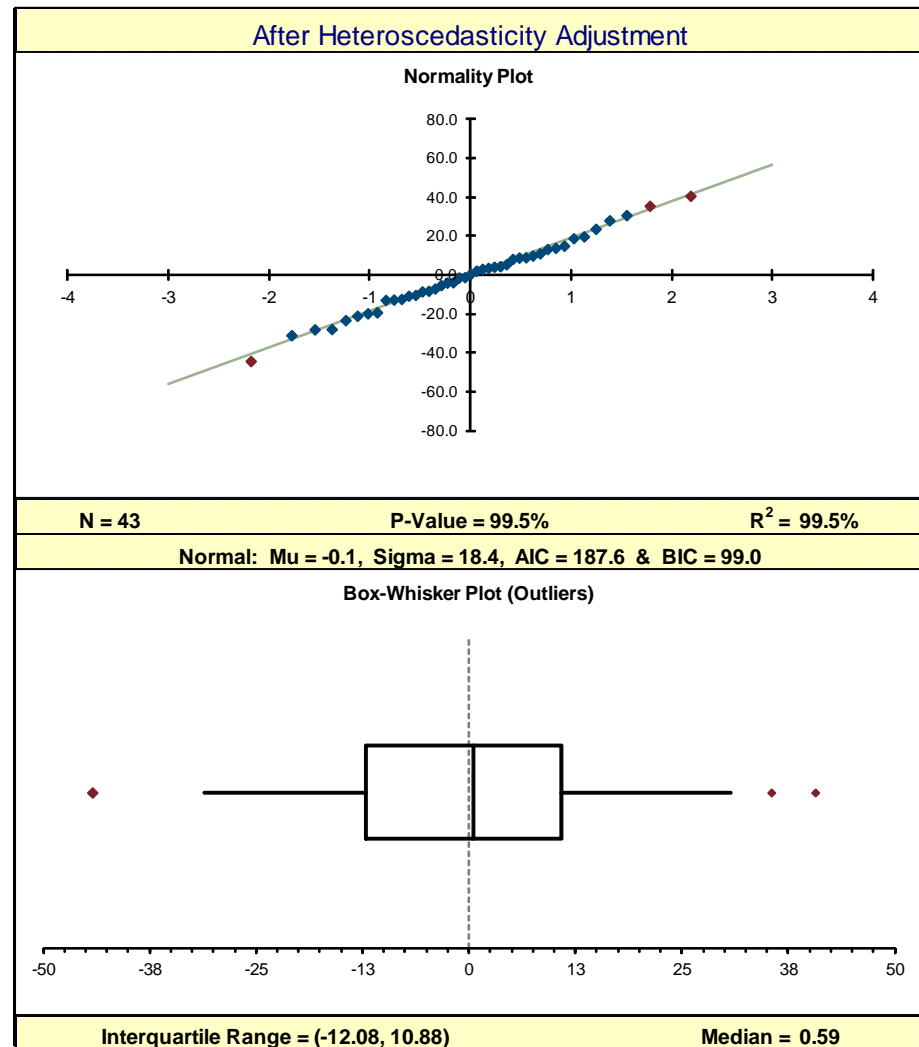
Did adjusting for heteroscedasticity improve the model?



# Uncertainty and Corresponding Validation

Assumptions: Commercial Auto (CA) – Incurred Loss Diagnostics

- Residuals now more symmetrical
- Normality greatly improved
- AIC and BIC also improved



# Uncertainty and Corresponding Validation

Assumptions: Commercial Auto (CA) – BF and weights

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

AY	Coefficient of Variation				
	Chain Ladder (Unshifted)		IELR CoV	BF (Unshifted)	
	Paid	Incurred		Paid	Incurred
1999	55.9%	56.5%	0.0%	78.1%	78.5%
2000	49.4%	48.9%	0.0%	56.0%	56.5%
2001	38.0%	37.3%	0.0%	40.5%	40.9%
2002	24.4%	24.3%	0.0%	25.7%	25.0%
2003	16.1%	15.3%	0.0%	16.1%	15.9%
2004	11.3%	10.1%	0.0%	10.4%	10.4%
2005	8.1%	6.9%	0.0%	6.9%	7.0%
2006	7.2%	6.2%	0.0%	5.1%	5.5%
2007	7.6%	6.6%	0.0%	4.0%	4.7%
Total	4.9%	4.0%		3.1%	3.2%

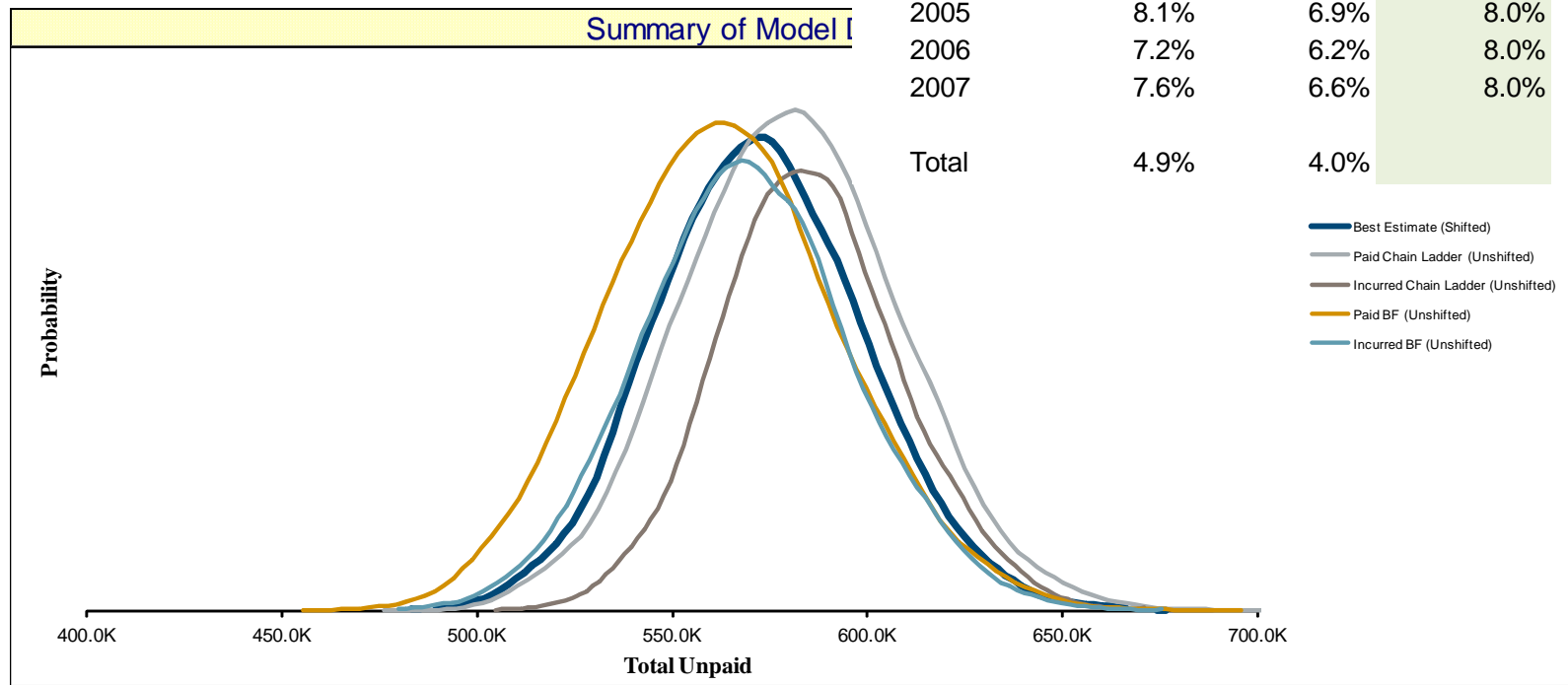
In this case, the use of the BF reduces variability of the resulting distribution

# Uncertainty and Corresponding Validation

Assumptions: Commercial Auto (CA) – BF and weights

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

AY	Coefficient of Variation				
	Chain Ladder (Unshifted)		IELR CoV	BF (Unshifted)	
	Paid	Incurred		Paid	Incurred
1999	55.9%	56.5%	8.0%	79.8%	78.6%
2000	49.4%	48.9%	8.0%	57.0%	56.5%
2001	38.0%	37.3%	8.0%	41.9%	42.1%
2002	24.4%	24.3%	8.0%	26.9%	26.8%
2003	16.1%	15.3%	8.0%	17.9%	17.6%
2004	11.3%	10.1%	8.0%	13.2%	12.9%
2005	8.1%	6.9%	8.0%	10.6%	10.0%
2006	7.2%	6.2%	8.0%	9.6%	8.5%
2007	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

# Uncertainty and Corresponding Validation

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

User-Selected Rank Correlation Matrix				
Line of Business	CA	PPA	HO	
CA	1.00	0.33	0.00	
PPA	0.33	1.00	0.00	
HO	0.00	0.00	1.00	
T-Dist DoF:	13.00			

MLE Copula Rank Correlation of Residuals prior to Hetero Adjustment - Paid				
Line of Business	CA	PPA	HO	
CA	1.00	0.33	0.03	
PPA	0.33	1.00	-0.13	
HO	0.03	-0.13	1.00	
T-Dist DoF:	13.00			

P-Values of MLE Copula Rank Correlation of Residuals prior to Hetero Adjustment - Paid				
Line of Business	CA	PPA	HO	
CA	0.00	0.06	0.80	
PPA	0.06	0.00	0.33	
HO	0.80	0.33	0.00	

# Assumption Consistency

We validated our model last year! How did we miss the mark for paid?

- Choice of 2007 IELR?
  - Management: 52.9%
  - Incurred CL: 57.7%
  - Paid CL: 57.3%
- Missed CY trend?
- Heteroscedasticity?
- Weighting Models?
- Shifting mean of distribution?

AY	Age	Actual Paid	Expected Paid	Bootstrap Percentile
1999	120	543	577	57.5%
2000	108	2,387	1,043	91.8%
2001	96	1,177	1,636	35.6%
2002	84	5,403	4,540	74.1%
2003	72	14,120	10,630	93.5%
2004	60	23,636	23,300	56.2%
2005	48	51,020	44,746	88.8%
2006	36	75,813	62,082	96.9%
2007	24	88,832	79,335	87.0%
2008	12	99,123	-	

CY 2008	362,054		
AY<CY	262,931	227,890	99.6%

# Assumption Consistency

How did we miss the mark so badly for paid losses? 2007 IELR

- 2007 IELR
  - No longer 52.9%
  - Used 57.5%

AY	Age	Actual Paid	Initial Expected	Initial Percentile	Alternative Expected	Alternative Percentile
1999	120	543	577	57.5%	566	57.8%
2000	108	2,387	1,043	91.8%	1,064	91.4%
2001	96	1,177	1,636	35.6%	1,639	35.2%
2002	84	5,403	4,540	74.1%	4,569	73.3%
2003	72	14,120	10,630	93.5%	10,650	93.1%
2004	60	23,636	23,300	56.2%	23,359	54.8%
2005	48	51,020	44,746	88.8%	44,662	89.3%
2006	36	75,813	62,082	96.9%	62,032	97.1%
2007	24	88,832	79,335	87.0%	85,452	66.2%
2008	12	99,123	-			

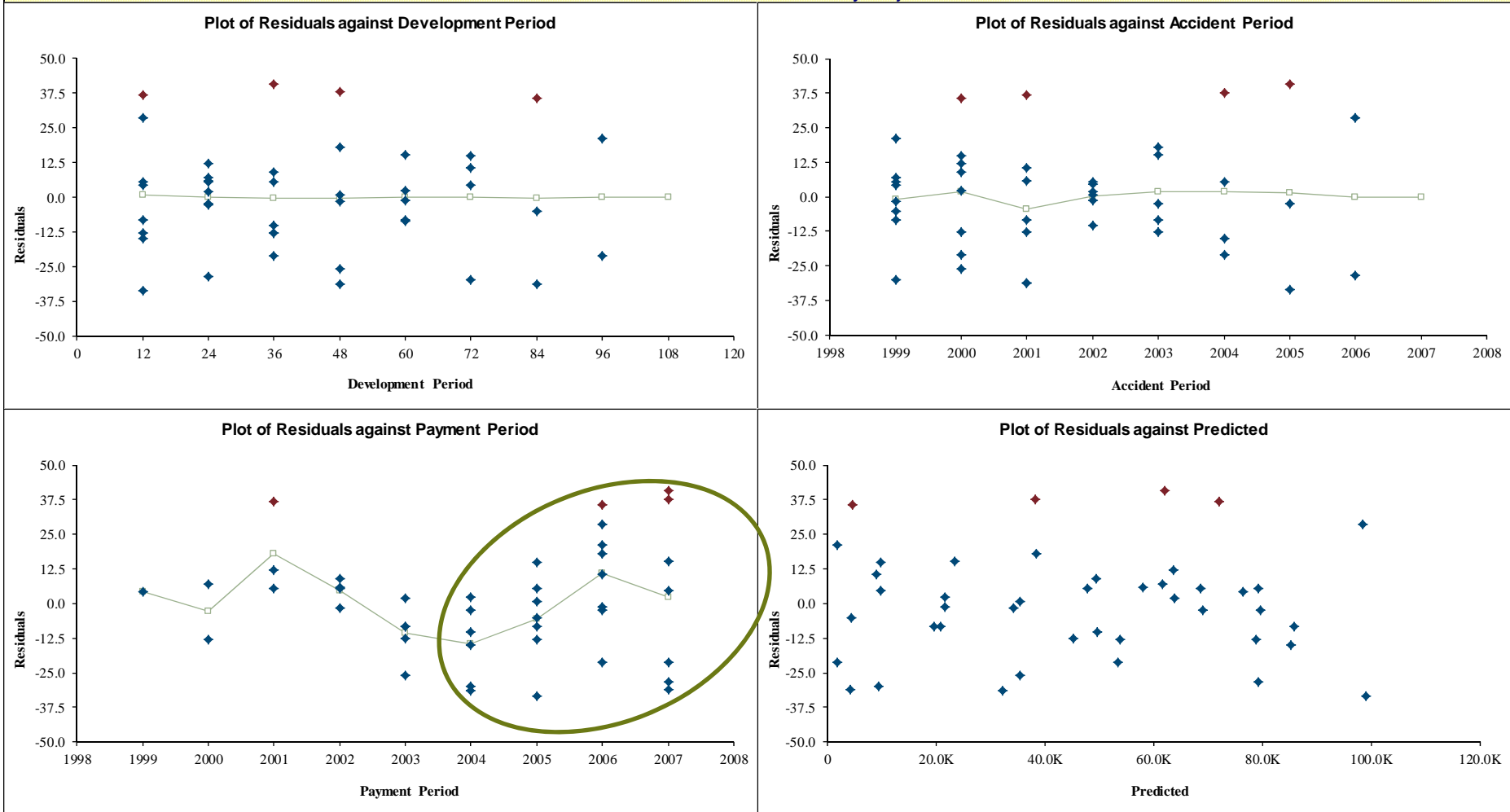
CY 2008	362,054					
AY<CY	262,931	227,890	99.6%	233,994	98.5%	

- Explains AY 2007 deviation only.
- Still breach LoB threshold

# Assumption Consistency

How did we miss the mark so badly for paid losses? **CY Trend**

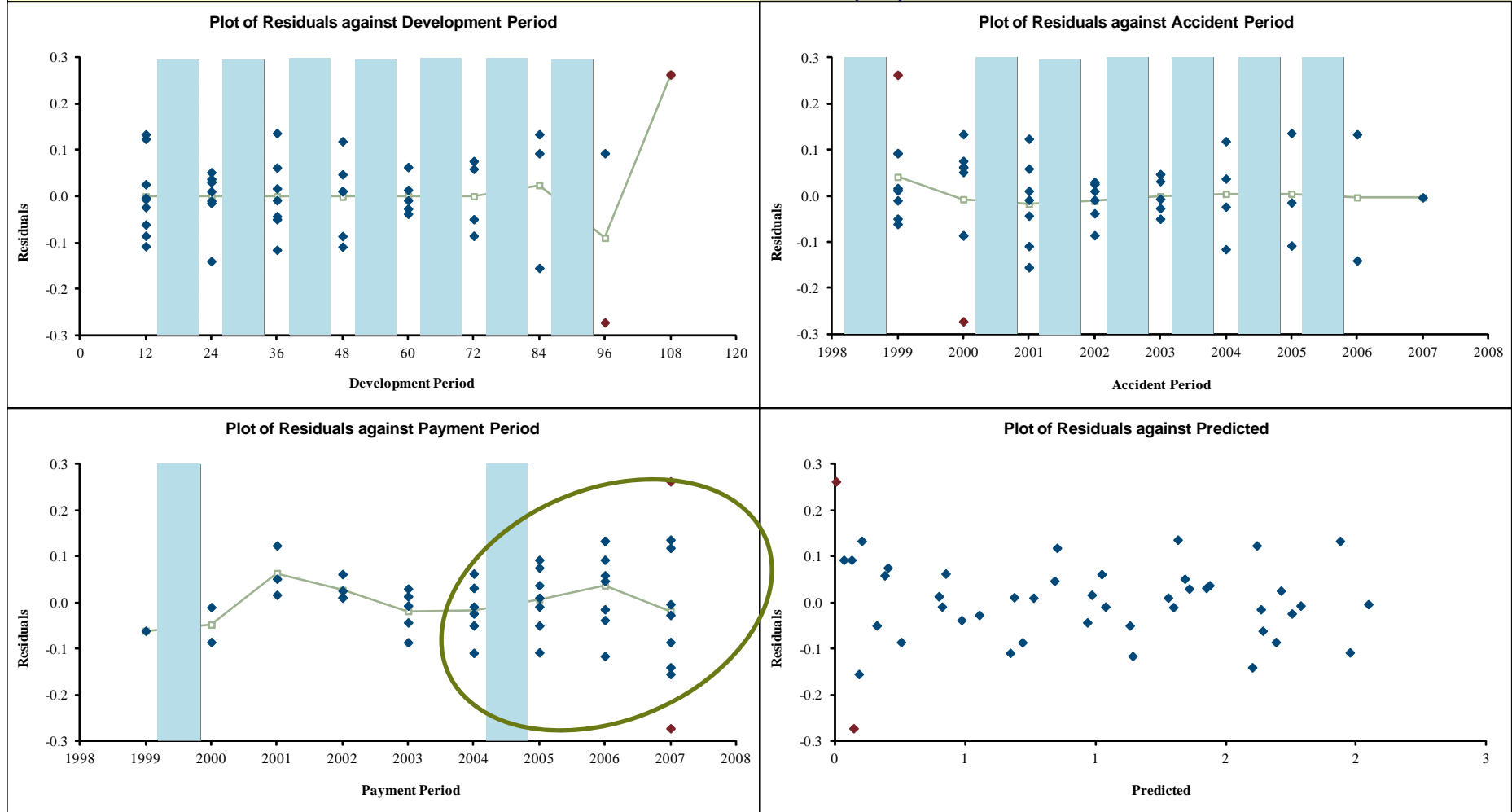
Plot of Residuals Prior to Heteroscedasticity Adjustment - Paid Loss



# Assumption Consistency

New GLM model with CY Trends: 1.9% 1999-2004, 3.6% 2004-2007+

Plot of Residuals Prior to Heteroscedasticity Adjustment - Paid Loss





# BACK-TEST: Monitor and Control Reserving Risk

How do annual accruals compare to expectations ( $\Sigma AY < CY$ )?

AY	Age	Actual Paid	ODP Paid Model		GLM Paid Model	
			Expected Paid	Bootstrap Percentile	Expected Paid	Bootstrap Percentile
1999	120	543	577	57.5%	62	96.1%
2000	108	2,387	1,043	91.8%	2,021	65.2%
2001	96	1,177	1,636	35.6%	2,868	12.6%
2002	84	5,403	4,540	74.1%	6,989	25.3%
2003	72	14,120	10,630	93.5%	14,810	43.8%
2004	60	23,636	23,300	56.2%	26,680	23.4%
2005	48	51,020	44,746	88.8%	49,173	63.1%
2006	36	75,813	62,082	96.9%	64,678	94.5%
2007	24	88,832	79,335	87.0%	87,876	55.5%
2008	12	99,123				
CY 2008		362,054				
AY < CY		262,931	227,890	99.6%	255,155	68.5%

- Adding CY Trend parameter to model improves fit & results

# Assumption Consistency

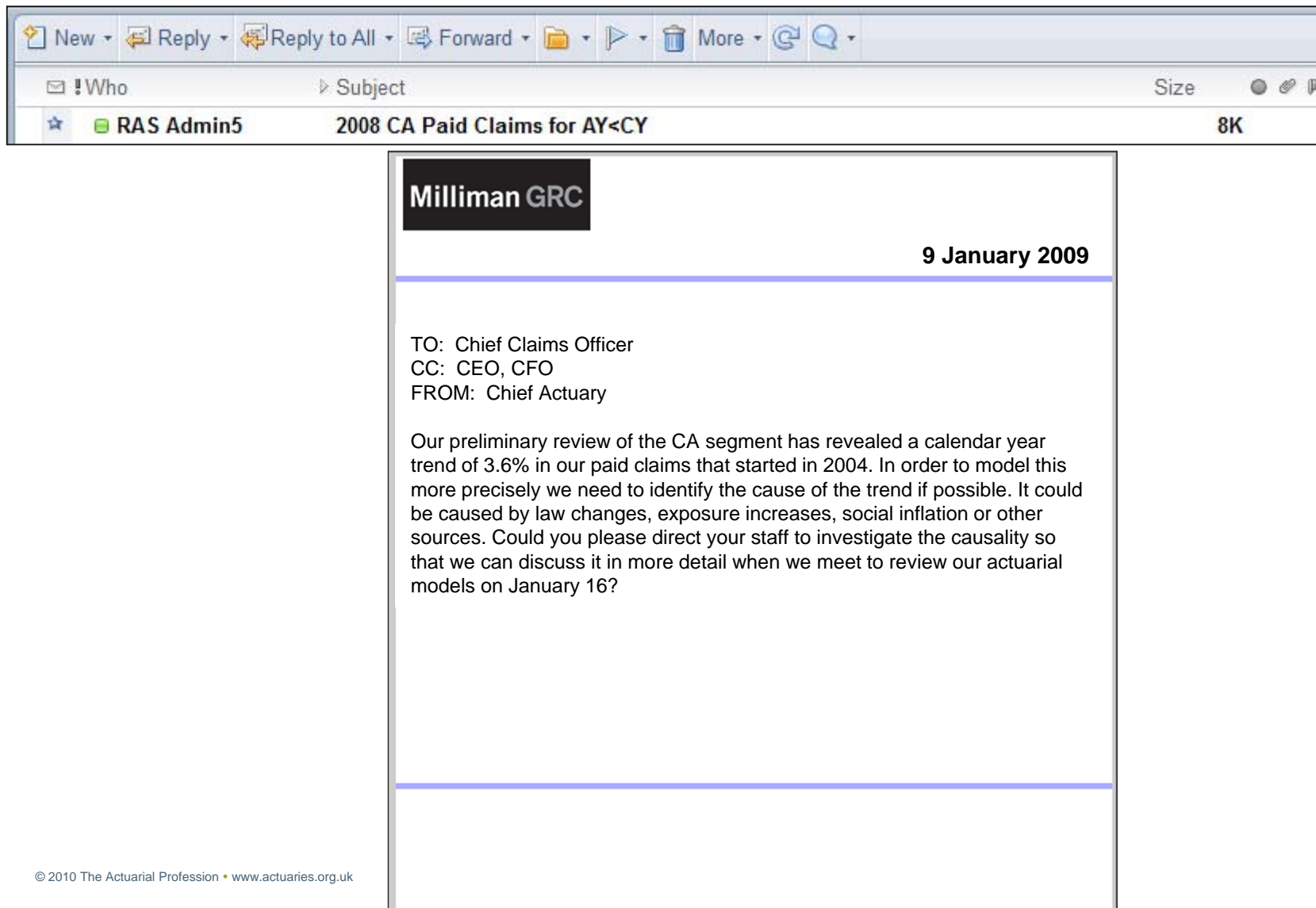
How did we miss the mark so badly for paid losses? **Mack Model**

AY	Mack Model Calculations					Actual Paid	Percentile
	Reserve	Standard Deviation	CoV	Expected Paid CY 08	Std Dev CY 2008		
1999	1,146	188	16.4%	1,146	188	543	0.0%
2000	2,232	644	28.9%	1,049	615	2,387	96.3%
2001	3,681	1,207	32.8%	1,642	1,046	1,177	39.0%
2002	8,603	2,548	29.6%	4,560	2,199	5,403	72.6%
2003	19,950	3,441	17.2%	10,624	2,152	14,120	93.6%
2004	43,104	3,838	8.9%	23,280	1,727	23,636	59.6%
2005	94,371	8,325	8.8%	44,341	7,177	51,020	83.0%
2006	155,511	11,761	7.6%	61,648	8,335	75,813	94.6%
2007	251,758	16,702	6.6%	85,007	11,349	88,832	65.5%
Total	580,356	26,820	4.6%	233,297			

- Similar to „Shifted“ paid CL
- Must decompose Mack formula
- Variance assumptions disconnected from mean assumptions
- Often seen in industry
  - NOTE: Under this scenario, low 2007 IELR may not get attention

# BACK-TEST: Integrated ERM Framework

## Non-Life Reserving Risk KPI: Follow up Email to Management



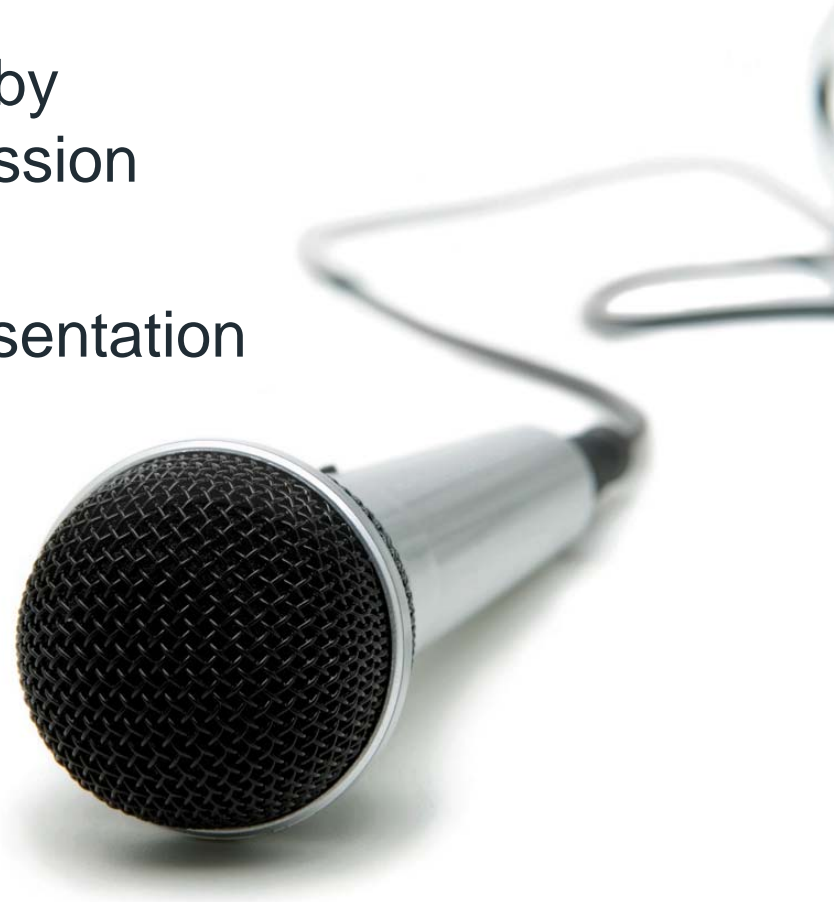
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# Questions or Comments?

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Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

The views expressed in this presentation are those of the presenter.



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# Appendix

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# Available Guidance (CEIOPS 33/09 & Lloyd's)

## Purpose of Validation

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- Demonstrate appropriate levels of BE element of TP
- Demonstrate applicability and relevance of methods applied
  - Appropriate for nature, scale & complexity of business
- Compare BE and assumptions with experience (back-testing)
  - Validation that the history is a good indicator of the future
  - Posterior validation of expert judgment
  - Identify significant deviations (actual vs. predicted)
    - Postulate explanation: randomness, systematic effect, assumption or parameter error
  - Enhance understanding of FCF emergence and calculations
  - Support for application of method(s)

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# Available Guidance (CEIOPS 33/09 & Lloyd's)

## Requirements of Validation & Back Testing

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- Responsibility of actuarial function
  - Independent of those directly involved in setting TP
- Sufficient granularity (ideally level of homogeneous risks)
- At least once yearly
  - And where indications of substantial changes
  - And in response to significant changes in external environment, assumptions and results of goodness of fit

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# Available Guidance (CEIOPS 33/09 & Lloyd's)

## Scope of Validation & Back Testing

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- Separately for gross/ceded and claim/premium provisions
  - Lloyd's: Expect back-testing to be conducted undiscounted and (likely) gross on a Solvency II line of business
- All relevant and material assumptions
  - Consistent from year to year (no arbitrary changes)
  - Testing of expert judgment
  - Appropriateness of underlying data (complete and accurate)
- Documentation at a level consistent with materiality
- Peer-review



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# Available Guidance (CEIOPS 33/09 & Lloyd's)

## Common validation approaches

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- Percentiles and residual analysis (outliers/clusters)
- Diagnostics
- Stress / scenario testing (non-linearity, uncertainty, tail of distribution) and reverse stress testing (survival scenarios)
- Sensitivity analyses (changes in parameters, benchmarking, impact of changes in cover, deductibles or external factors)