Disrupting the Actuarial Function?

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Monograph Outline

- Introduction
- Notation
- Back-Testing
  - Deterministic Back-Testing
  - Stochastic Back-Testing
  - Stochastic Key Performance Indicators
- Reserving within an ERM Framework
- Enterprise Risk Management in Action – A Case Study
  - Introduction
  - Basis of Underlying Data
  - Validation of the Prior Analysis
  - Implied Expected Values from Multiple Methods
  - Advantages of Using the ODP Bootstrap
  - ERM Governance Elements and Automatic Alert System
  - Using Back-Testing Diagnostics to Assess Uncertainty
  - The Feedback Loop
- Conclusions

Companion Files:
- Used to create all tables & graphs in paper


Polling Questions

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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?
- Can back-testing help get more value from your approach?
  - Are the inevitable deviations from the expectations understood?
  - Is there a difference between predicting & explaining?
- What metrics are useful for management?
- Can your reserving process enhance your ERM framework?
  - Analysis of change, risk capital, earnings, etc.

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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

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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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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

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Deterministic Back-Testing

Sample Insurance Company
Consolidation of All Segments
Deterministic Actual vs. Expected as of December 31, 2021

AY	Age	Actual Paid	Expected Paid	Difference	Actual Incurred	Expected Incurred	Difference
2012	120	3,069	3,701	(632)	1,863	2,158	(295)
2013	108	5,905	7,405	(1,500)	3,145	2,794	351
2014	96	8,986	10,073	(1,087)	3,553	6,142	(2,589)
2015	84	18,992	19,027	(35)	9,872	11,285	(1,413)
2016	72	51,003	47,151	3,852	25,942	26,873	(931)
2017	60	105,067	103,127	1,940	52,012	54,534	(2,522)
2018	48	202,932	194,479	8,453	106,624	106,020	604
2019	36	334,434	325,644	8,790	189,908	192,143	(2,235)
2020	24	841,484	833,793	7,691	454,217	479,073	(24,856)
2021	12	1,798,138			2,528,235		
Totals		3,370,010			3,375,371		
AY<CY		1,571,872	1,544,400	27,471	847,136	881,022	(33,886)

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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

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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!
  - Triangle models used primarily, but some situations my require something else
  - May need to "shift" mean of resulting distribution to replicate BE
  - Paid ODP Bootstrap may underestimate reserve risk
  - Works better for high frequency segments

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Stochastic Back-Testing

Sample Insurance Company
Aggregation of All Segments
Stochastic Actual vs. Expected as of December 31, 2021

AY	Age	Actual Paid	Expected Paid	Percentile	Actual Incurred	Expected Incurred	Percentile
2012	120	3,069	4,077	31.8%	1,863	2,115	49.8%
2013	108	5,905	6,163	47.9%	3,145	1,819	80.6%
2014	96	8,986	10,176	33.6%	3,553	6,026	20.9%
2015	84	18,992	20,033	39.0%	9,872	10,399	46.3%
2016	72	51,003	48,298	71.6%	25,942	25,562	55.3%
2017	60	105,067	104,415	54.3%	52,012	53,101	44.8%
2018	48	202,932	196,083	74.2%	106,624	104,075	61.7%
2019	36	334,434	331,701	57.1%	189,908	185,173	64.0%
2020	24	841,484	839,689	52.8%	454,217	469,822	29.3%
2021	12	1,798,138			2,528,235		
Totals		3,370,010			3,375,371		
AY<CY		1,571,872	1,560,637	61.2%	847,136	858,093	37.6%

Note: Total Unpaid by AY is same for Deterministic and Stochastic, but incremental expectation is different.

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Consistency of Expectations

- Starts with assumption consistency between & among methods
- Weighting of estimates to address model risk is partial acceptance or rejection of various assumptions
- Shifting is also a partial acceptance or rejection of assumptions
- Future expectation for each data element (e.g., incremental paid) is therefore a weighted average of that element from each model given weight
- This is true for both deterministic and stochastic analysis
- **IN CONTRAST:** A single model approach for variance (e.g., use Mack) is at best a partial rejection of assumptions used for mean, and at worst involves using ***completely different*** assumptions compared to the mean.

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Reserving Within an ERM Framework

- ERM is a continuous process;
- ERM adopts a holistic view to risk and assesses risk from the perspective of the company's aggregate position as well as from a standalone perspective;
- ERM is concerned with all risks, including those that are unquantifiable or difficult to quantify;
- ERM considers uncertainty from both a positive and negative viewpoint;
- ERM aims to achieve greater value for all stakeholders by assisting in achieving an appropriate risk-reward balance; and
- ERM considers both the short-term and the long-term aspects of risk

Source: IAA. 2016. *Actuarial Aspects of ERM for Insurance Companies*

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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

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Imagine the following…

- The date is 4 January 2022
- Complete loss data is available as of 31 December 2021
- Company writes 3 homogenous lines of business (CA, PPA, and HO), with triangular data going back to Accident Year 2012 (source: SNL Financial)
- Company performs a full review of unpaid claim liabilities annually, including an uncertainty analysis using multiple models to address model risk

Imagine the following…

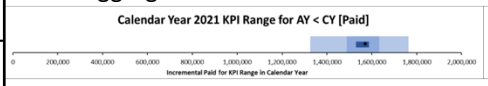
- Company has an integrated risk management framework, including reserving risk Key Performance Indicators (KPIs), based on the realization of incremental paid (and incurred) loss relative to outcomes of their models and pre-defined thresholds

- Management would like to receive the actuary's best estimate as of 31 December 2021 by 24 January 2022 (3 weeks)

Monitor/Control Reserving Risk

Compare actual to expected (ΣAY<CY)

- Aggregate Paid Loss



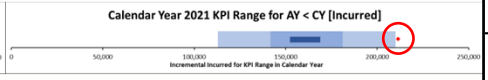
- Aggregate Incurred Loss

- PPA Paid

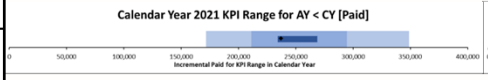
- PPA Incurred

- CA Paid

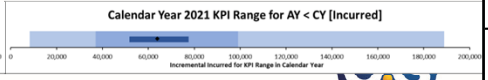
- CA Incurred



- HO Paid



- HO Incurred



Monitor/Control Reserving Risk

Compare actual to expected (ΣAY<CY)

- Aggregate

NOTE: Comparison of aggregate accruals requires correlation assumptions

Sample Insurance Company
Aggregation of All Segments
Stochastic Actual vs. Expected as of December 31, 2021

AY	Age	Actual Paid	Expected Paid	Percentile	Actual Incurred	Expected Incurred	Percentile
2012	120	3,069	4,077	31.8%	1,863	2,115	43.8%
2013	108	5,905	6,163	47.9%	3,145	1,819	80.6%
2014	96	8,986	10,176	33.6%	3,553	6,026	20.9%
2015	84	18,992	20,033	39.0%	9,872	10,399	46.3%
2016	72	51,003	48,298	71.6%	25,942	25,562	55.3%
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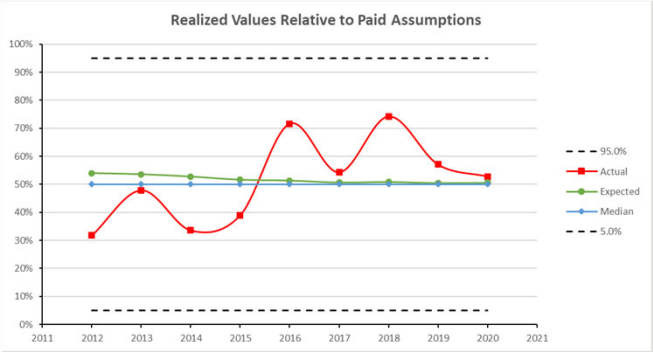
2020	24	841,484	839,689	52.8%	454,217	469,822	29.3%
2021	12	1,798,138			2,528,235		
Totals		3,370,010			3,375,371		
AY<CY		1,571,872	1,560,637	61.2%	847,136	858,093	37.6%

- Several of the 20 observable outcomes are near the thresholds
  - 20 observable outcomes = (9 AYs + 1 ΣAY<CY) for paid and incurred
- AY 2015 could be addressed if pricing risk was included

Integrated ERM Framework

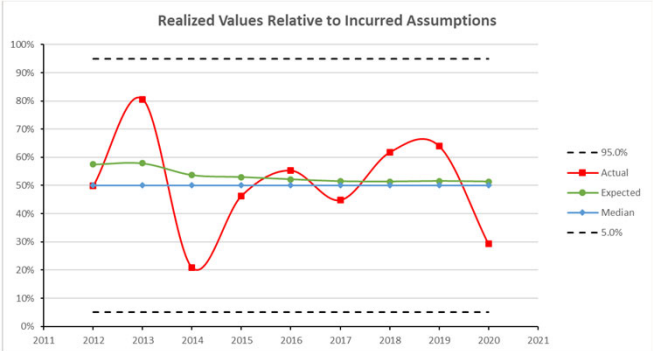
Non-Life Reserve Risk KPI: Observation (Aggregate)



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

Integrated ERM Framework

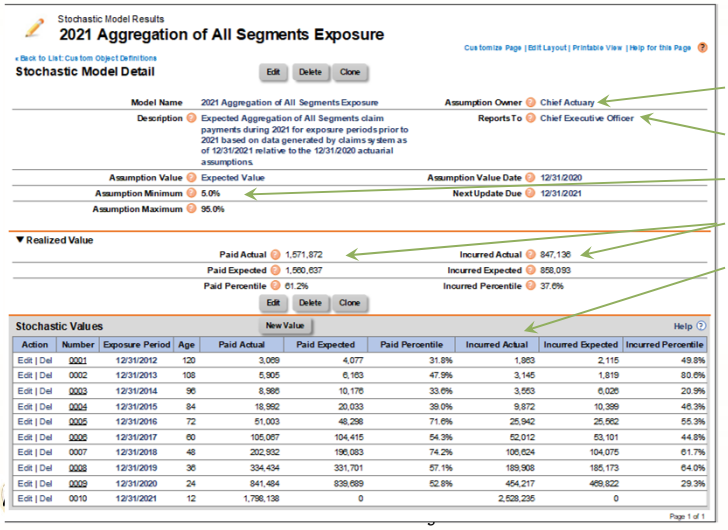
Non-Life Reserve Risk KPI: Observation (Aggregate)



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

Integrated ERM Framework

Non-Life Reserve Risk KPI: Aggregate Paid



Stochastic Model Results

2021 Aggregation of All Segments Exposure

Customize Page | Edit Layout | Printable View | Help for this Page

« Back to List: Custom Object Definitions

Stochastic Model Detail

Edit | Delete | Clone

Model Name	2021 Aggregation of All Segments Exposure	Assumption Owner	Chief Actuary
Description	Expected Aggregation of All Segments claim payments during 2021 for exposure periods prior to 2021 based on data generated by claims system as of 12/31/2021 relative to the 12/31/2020 actuarial assumptions	Reports To	Chief Executive Officer
Assumption Value	Expected Value	Assumption Value Date	12/31/2020
Assumption Minimum	5.0%	Next Update Due	12/31/2021
Assumption Maximum	95.0%		

▼ Realized Value

Paid Actual	1,571,872	Incurred Actual	847,136
Paid Expected	1,560,637	Incurred Expected	858,093
Paid Percentile	61.2%	Incurred Percentile	37.6%

Edit | Delete | Clone

Stochastic Values — New Value — Help

Action	Number	Exposure Period	Age	Paid Actual	Paid Expected	Paid Percentile	Incurred Actual	Incurred Expected	Incurred Percentile
Edit | Del	0001	12/31/2012	120	3,069	4,077	31.8%	1,963	2,115	49.8%
Edit | Del	0002	12/31/2013	108	5,905	6,183	47.9%	3,145	1,819	80.6%
Edit | Del	0003	12/31/2014	96	8,986	10,176	33.6%	3,553	6,026	20.9%
Edit | Del	0004	12/31/2015	84	18,992	20,033	39.0%	9,872	10,399	46.3%
Edit | Del	0005	12/31/2016	72	51,003	48,298	71.6%	25,942	25,562	55.3%
Edit | Del	0006	12/31/2017	60	105,067	104,415	54.3%	52,012	53,101	44.8%
Edit | Del	0007	12/31/2018	48	202,932	196,083	74.2%	106,624	104,075	61.7%
Edit | Del	0008	12/31/2019	36	334,434	331,701	57.1%	189,908	185,173	64.0%
Edit | Del	0009	12/31/2020	24	841,484	839,689	52.8%	454,217	469,822	29.3%
Edit | Del	0010	12/31/2021	12	1,798,138	0		2,528,235	0	

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Risk Owner

Risk Reviewer

Thresholds

Realized Values

AY / UY Details

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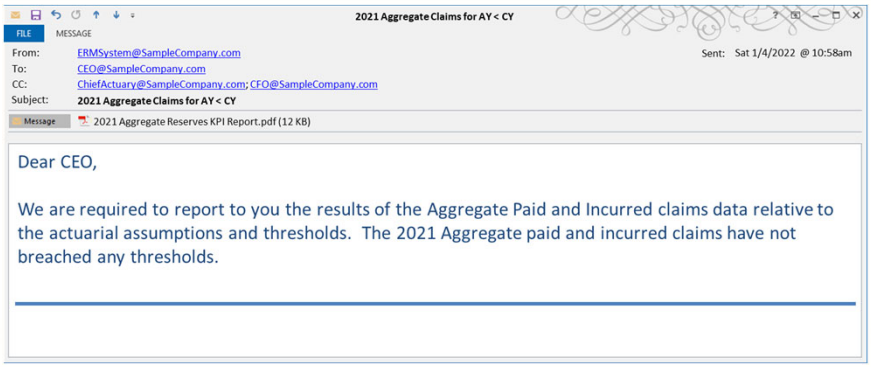
Integrated ERM Framework

Automated E-Mail to the CEO



2021 Aggregate Claims for AY < CY

FILE MESSAGE

From: ERMSystem@SampleCompany.com

To: CEO@SampleCompany.com

CC: ChiefActuary@SampleCompany.com; CFO@SampleCompany.com

Subject: 2021 Aggregate Claims for AY < CY

Sent: Sat 1/4/2022 @ 10:58am

Message 2021 Aggregate Reserves KPI Report.pdf (12 KB)

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 2021 Aggregate paid and incurred claims have not breached any thresholds.

ACTSoft

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Monitor/Control Reserving Risk

Do outcomes tell us something? (ΣAY<CY)

Sample Insurance Company
Summary of Theshold Activity by Segment as of December 31, 2021

	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%**
HO	10	12	18	20	2	0	50.0%	60.0%	90.0%	100.0%	10.0%	0.0%
AGG	10	18	18	20	2	0	50.0%	90.0%	90.0%	100.0%	10.0%	0.0%
Total	40	49	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 (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

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Monitor/Control Reserving Risk

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

- Given the actual losses paid in CY 2021, we can obtain a preliminary estimate of the amount by which reserves for AY 2020 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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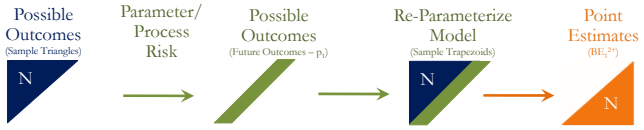
Monitor/Control Reserving Risk

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

- Calculate, separately for each LOB:
  - "Conditional Reserve @ 31 December 2021" = 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 2021
  - "Expected Reserve @ 31 December 2021" = Expected Reserve @ 31 December 2020 less CY 2021 Paid
    - This is the reserve @ 31 December 2021 if we did not change Ultimates at all
  - Difference between Conditional Reserve and Expected Reserve represents the estimated reserve change

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Monitor/Control Reserving Risk

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

Sample Insurance Company
Aggregation of All Segments
Summary of Conditional Reserves as of December 31, 2021

	Private Passenger Auto			Commercial Auto			Homeowners			Total
AY	Conditional Reserve	Expected Reserve	Change	Conditional Reserve	Expected Reserve	Change	Conditional Reserve	Expected Reserve	Change	Change
2012	2,680	2,991	(311)	643	603	40	-	747	(747)	(1,018)
2013	7,248	5,498	1,750	3,257	4,242	(985)	164	721	(557)	208
2014	8,654	10,061	(1,406)	1,675	2,582	(907)	1,367	1,640	(272)	(2,586)
2015	15,635	19,472	(3,836)	5,593	4,121	1,472	(1,153)	1,793	(2,946)	(5,311)
2016	31,595	38,066	(6,470)	13,946	6,632	7,313	3,722	340	3,381	4,224
2017	73,359	71,302	2,057	20,073	19,441	632	3,979	6,894	(2,915)	(227)
2018	151,670	156,061	(4,390)	57,978	45,442	12,536	12,839	9,468	3,370	11,516
2019	292,882	322,812	(29,930)	110,701	81,627	29,075	21,590	26,615	(5,024)	(5,880)
2020	581,448	574,019	7,430	170,589	147,146	23,442	59,458	80,333	(20,875)	9,997
Totals	1,165,174	1,200,281	(35,107)	384,456	311,837	72,619	101,967	128,553	(26,586)	10,329
AY<CY	1,159,897	1,200,281	(40,385)	390,213	311,837	78,376	96,676	128,553	(31,876)	6,115

- AYs 2018-20 should also drive reserves up
  - Most of this increase is driven by CA

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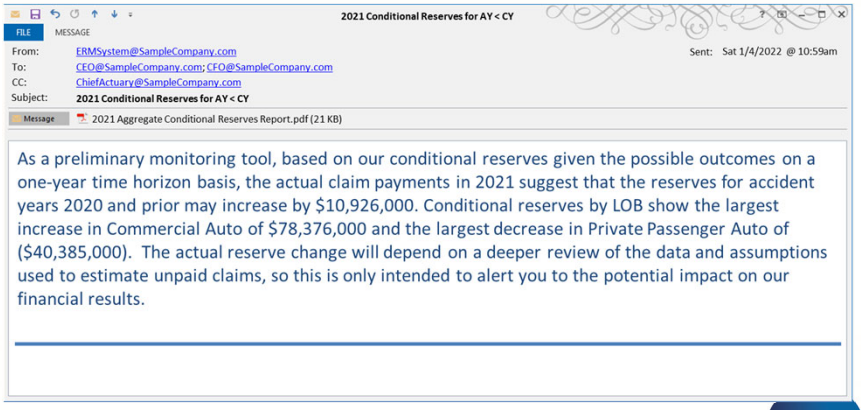
Integrated ERM Framework

Automated E-Mail to the CEO/CFO



2021 Conditional Reserves for AY < CY

FILE MESSAGE

From: ERMSystem@SampleCompany.com
Sent: Sat 1/4/2022 @ 10:59am
To: CEO@SampleCompany.com; CFO@SampleCompany.com
CC: ChiefActuary@SampleCompany.com
Subject: 2021 Conditional Reserves for AY < CY

Message 2021 Aggregate Conditional Reserves Report.pdf (21 KB)

As a preliminary monitoring tool, based on our conditional reserves given the possible outcomes on a one-year time horizon basis, the actual claim payments in 2021 suggest that the reserves for accident years 2020 and prior may increase by $10,926,000. Conditional reserves by LOB show the largest increase in Commercial Auto of $78,376,000 and the largest decrease in Private Passenger Auto of ($40,385,000). The actual reserve change will depend on a deeper review of the data and assumptions used to estimate unpaid claims, so this is only intended to alert you to the potential impact on our financial results.

Monitor/Control Reserving Risk

- Focus on Commercial Auto (CA)

Monitor/Control Reserving Risk

Compare CA actual to expected (ΣAY<CY)

- CA

Sample Insurance Company
Commercial Auto
Stochastic Actual vs. Expected as of December 31, 2021

AY	Age	Actual Paid	Expected Paid	Percentile	Actual Incurred	Expected Incurred	Percentile
2012	120	543	571	57.9%	(47)	154	0.0%
2013	108	2,387	3,131	21.8%	1,040	448	82.8%
2014	96	1,177	1,665	33.5%	851	1,167	44.5%
2015	84	5,403	5,044	63.1%	2,954	1,669	86.1%
2016	72	14,120	11,061	91.1%	9,035	5,606	94.2%
2017	60	23,636	23,276	56.1%	16,524	11,960	93.9%
2018	48	51,020	45,272	86.7%	36,454	29,103	92.7%
2019	36	75,813	62,481	96.5%	61,541	44,392	99.3%
2020	24	88,832	79,698	86.1%	83,154	66,555	97.0%
2021	12	99,123			178,539		
Totals		362,054			390,045		
AY<CY		262,931	232,199	98.9%	211,506	161,054	100.0%

- AYs 2015-20 are driving high #s
  - Need to check assumptions (i.e., IELRs, LDFs, weights, etc.)

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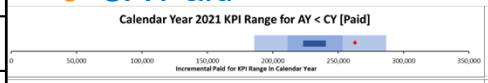
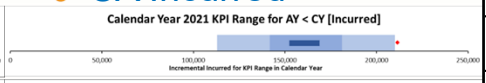
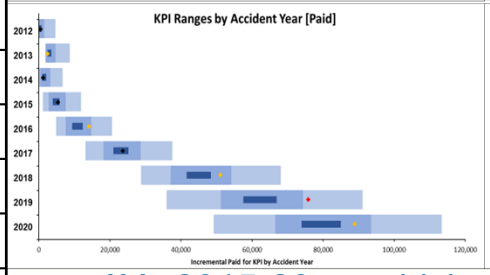
Monitor/Control Reserving Risk

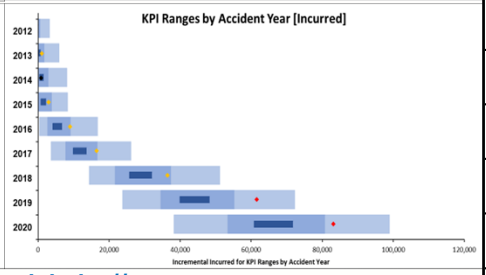
Compare CA actual to expected (ΣAY<CY)

- CA Paid
- CA Incurred









- AYs 2015-20 are driving high #s
  - Need to check all assumptions

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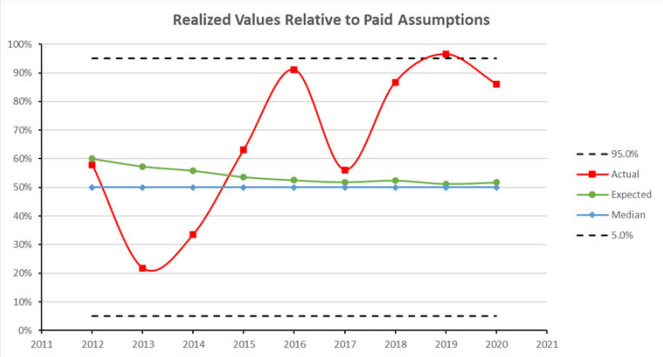
Integrated ERM Framework

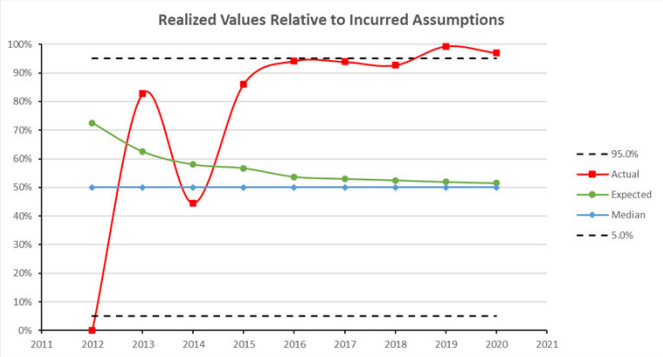
Non-Life Reserve Risk KPI: Observation (LOB: CA)



- Threshold breached
- Are expectations from the 2020 model biased low?

Integrated ERM Framework

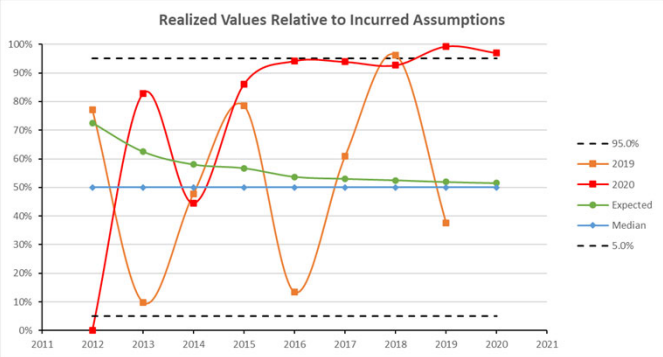
Non-Life Reserve Risk KPI: Observation (LOB: CA)



- Threshold breached
- Are expectations from the 2020 model biased low?

Integrated ERM Framework

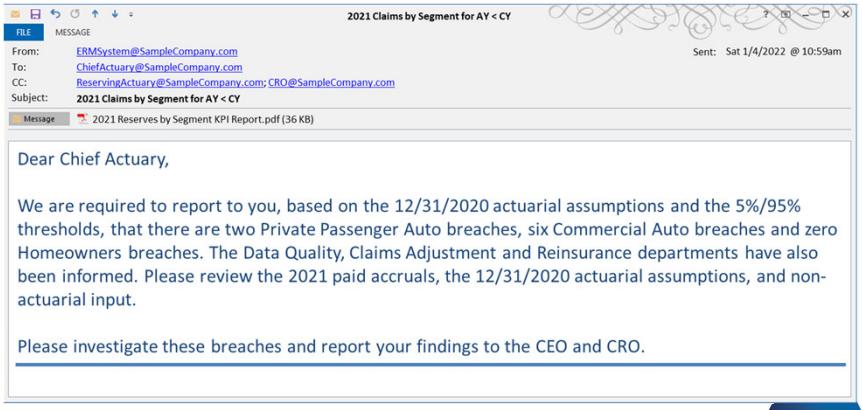
Non-Life Reserve Risk KPI: Observation (LOB: CA)



- Threshold breached
- Are expectations from the 2020 model biased low?
  Check 2019
- Are we aware of all internal process changes?
- Are we underestimating uncertainty?

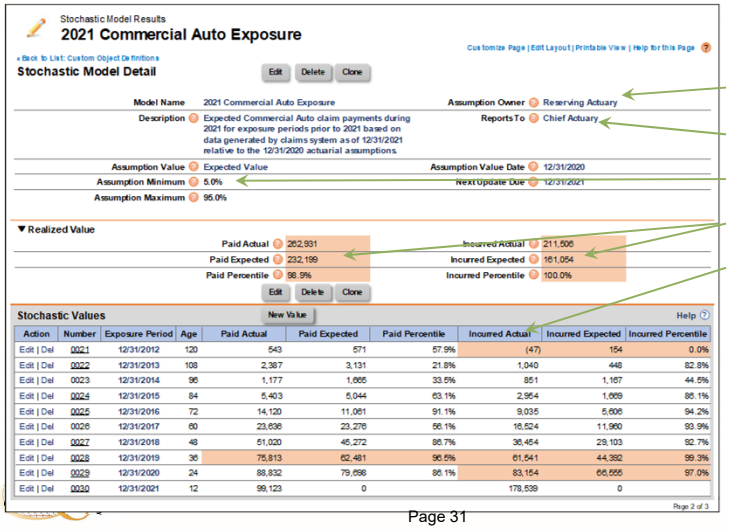
Integrated ERM Framework

Automated E-Mail to the Chief Actuary



Integrated ERM Framework

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



Stochastic Model Results

2021 Commercial Auto Exposure

Stochastic Model Detail

Edit | Delete | Clone

Model Name	2021 Commercial Auto Exposure	Assumption Owner	Reserving Actuary
Description	Expected Commercial Auto claim payments during 2021 for exposure periods prior to 2021 based on data generated by claims system as of 12/31/2021 relative to the 12/31/2020 actuarial assumptions.	Reports To	Chief Actuary
Assumption Value	Expected Value	Assumption Value Date	12/31/2020
Assumption Minimum	5.0%	Next Update Due	12/31/2021
Assumption Maximum	95.0%		

▼ Realized Value

Paid Actual	262,931	Incurred Actual	211,506
Paid Expected	232,199	Incurred Expected	161,054
Paid Percentile	98.9%	Incurred Percentile	100.0%

Edit | Delete | Clone

Stochastic Values — New Value — Help

Action	Number	Exposure Period	Age	Paid Actual	Paid Expected	Paid Percentile	Incurred Actual	Incurred Expected	Incurred Percentile
Edit | Del	0021	12/31/2012	120	543	571	57.9%	(47)	154	0.0%
Edit | Del	0022	12/31/2013	108	2,387	3,131	21.8%	1,040	448	82.8%
Edit | Del	0023	12/31/2014	96	1,177	1,665	33.5%	851	1,157	44.5%
Edit | Del	0024	12/31/2015	84	5,403	5,044	63.1%	2,954	1,669	86.1%
Edit | Del	0025	12/31/2016	72	14,120	11,061	91.1%	9,035	5,606	94.2%
Edit | Del	0026	12/31/2017	60	23,636	23,276	56.1%	16,524	11,960	93.9%
Edit | Del	0027	12/31/2018	48	51,020	45,272	86.7%	36,454	29,103	92.7%
Edit | Del	0028	12/31/2019	36	75,813	62,481	96.5%	61,541	44,392	99.3%
Edit | Del	0029	12/31/2020	24	88,832	79,696	86.1%	83,154	66,555	97.0%
Edit | Del	0030	12/31/2021	12	99,123	0		178,539	0	

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Risk Owner

Risk Reviewer

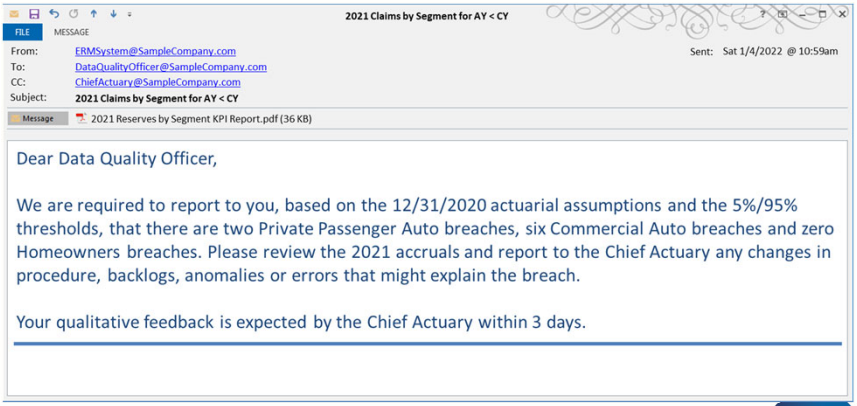
Thresholds

Realized Values

AY / UY Details

Integrated ERM Framework

Automated E-Mail to Data Quality Department



2021 Claims by Segment for AY < CY

FILE MESSAGE

From: ERMSystem@SampleCompany.com

To: DataQualityOfficer@SampleCompany.com

CC: ChiefActuary@SampleCompany.com

Sent: Sat 1/4/2022 @ 10:59am

Subject: **2021 Claims by Segment for AY < CY**

Message 2021 Reserves by Segment KPI Report.pdf (36 KB)

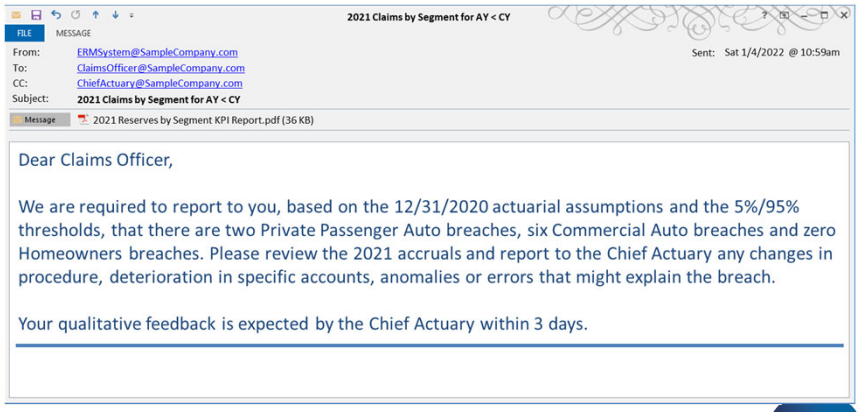
Dear Data Quality Officer,

We are required to report to you, based on the 12/31/2020 actuarial assumptions and the 5%/95% thresholds, that there are two Private Passenger Auto breaches, six Commercial Auto breaches and zero Homeowners breaches. Please review the 2021 accruals and report to the Chief Actuary any changes in procedure, backlogs, anomalies or errors that might explain the breach.

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

Integrated ERM Framework

Automated E-Mail to Claims Department



2021 Claims by Segment for AY < CY

FILE MESSAGE

From: ERMSystem@SampleCompany.com
Sent: Sat 1/4/2022 @ 10:59am
To: ClaimsOfficer@SampleCompany.com
CC: ChiefActuary@SampleCompany.com
Subject: 2021 Claims by Segment for AY < CY

Message 2021 Reserves by Segment KPI Report.pdf (36 KB)

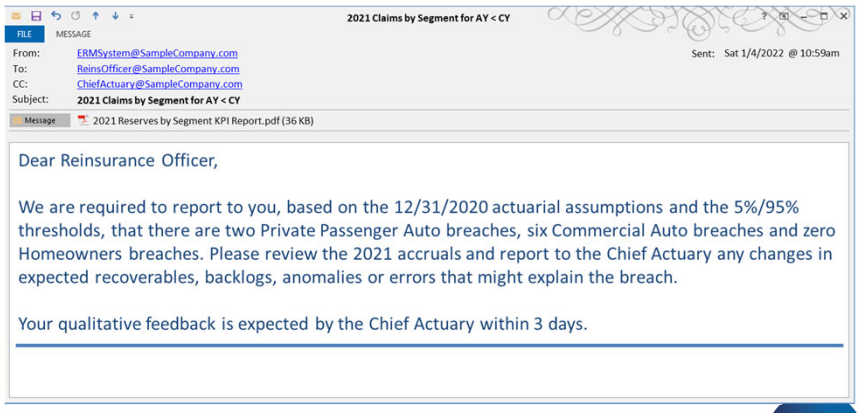
Dear Claims Officer,

We are required to report to you, based on the 12/31/2020 actuarial assumptions and the 5%/95% thresholds, that there are two Private Passenger Auto breaches, six Commercial Auto breaches and zero Homeowners breaches. Please review the 2021 accruals and report to the Chief Actuary any changes in procedure, deterioration in specific accounts, anomalies or errors that might explain the breach.

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

Integrated ERM Framework

Automated E-Mail to the Reinsurance Department



2021 Claims by Segment for AY < CY

FILE MESSAGE

From: ERMSystem@SampleCompany.com
Sent: Sat 1/4/2022 @ 10:59am
To: ReinsOfficer@SampleCompany.com
CC: ChiefActuary@SampleCompany.com
Subject: 2021 Claims by Segment for AY < CY

Message 2021 Reserves by Segment KPI Report.pdf (36 KB)

Dear Reinsurance Officer,

We are required to report to you, based on the 12/31/2020 actuarial assumptions and the 5%/95% thresholds, that there are two Private Passenger Auto breaches, six Commercial Auto breaches and zero Homeowners breaches. Please review the 2021 accruals and report to the Chief Actuary any changes in expected recoverables, backlogs, anomalies or errors that might explain the breach.

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

Validation as of 31 Dec 2020

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

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Validation as of 31 Dec 2020

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)

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Validation as of 31 Dec 2020

Assumptions: Each requiring validation

- Exposure 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
- IELRs & CoVs used in BF Models
- Weighting of models
- Shifting mean of distribution
- Missed CY trend?

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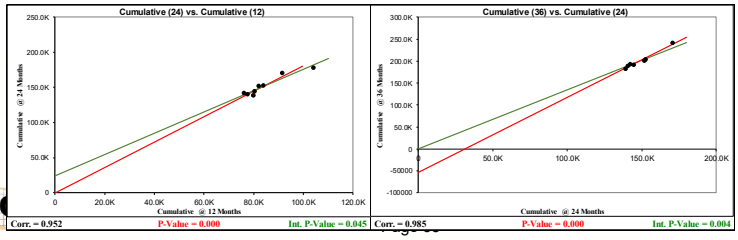
Validation as of 31 Dec 2020

Assumptions: LDF Validation (Paid)

Sample Insurance Company
Commercial Auto -- Paid Data
Chain Ladder Development as of December 31, 2020

AY	12	24	36	48	60	72	84	96	108
2012	77,401	140,425	189,316	223,326	243,182	250,182	254,305	256,672	257,689
2013	76,085	142,122	193,196	224,406	246,220	257,226	263,698	264,871	
2014	79,850	139,041	181,905	209,366	228,012	237,792	240,300		
2015	80,323	144,482	192,134	227,723	249,165	259,339			
2016	83,919	152,487	203,761	245,150	270,525				
2017	82,001	151,768	201,189	245,541					
2018	91,514	170,696	240,652						
2019	103,957	177,709							
2020	105,547								
	12-24	24-36	36-48	48-60	60-72	72-84	84-96	96-108	108-120
ATA	1.805	1.347	1.184	1.095	1.039	1.018	1.007	1.004	1.002
CDF	3.385	1.875	1.392	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),…,c(w,d)] = c(w,d) x F(d)



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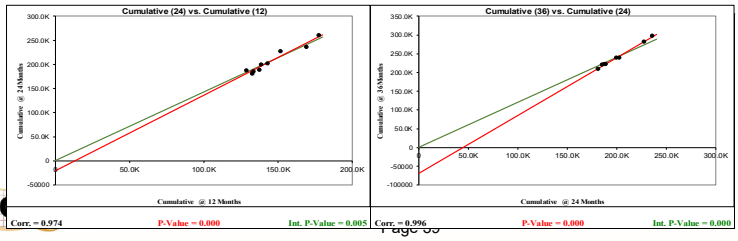
Validation as of 31 Dec 2020

Assumptions: LDF Validation (Incurred)

Sample Insurance Company
Commercial Auto – Incurred Data
Chain Ladder Development as of December 31, 2020

AY	12	24	36	48	60	72	84	96	108
2012	133,521	185,161	221,635	241,420	251,646	255,508	256,596	258,041	258,524
2013	128,727	187,403	222,093	247,345	258,712	265,636	269,558	270,758	
2014	132,567	181,263	209,262	226,237	236,863	241,107	242,171		
2015	137,295	188,962	222,624	247,335	258,856	265,496			
2016	142,862	202,363	239,239	269,940	281,376				
2017	138,650	199,791	239,719	266,101					
2018	151,778	227,353	282,394						
2019	169,171	235,983							
2020	177,611								
	12-24	24-36	36-48	48-60	60-72	72-84	84-96	96-108	108-120
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
Unrptd	0.507	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),…,c(w,d)] = c(w,d) x F(d)



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Validation as of 31 Dec 2020

Assumptions: AY Independence

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

Sample Insurance Company
Commercial Auto - Paid
Test of the Independence Between Accident Years

Acc Year	12	24	36	48	60	72	84	96	Cal Year Small	Cal Year Large
2012	1.81	1.35	1.18	1.09	1.03	1.02	1.01	1.00	1	0
2013	1.87	1.36	1.16	1.10	1.04	1.03	1.00		0	2
2014	1.74	1.31	1.15	1.09	1.04	1.01			2	1
2015	1.80	1.33	1.19	1.09	1.04				4	0
2016	1.82	1.34	1.20	1.10					3	2
2017	1.85	1.33	1.22						1	3
2018	1.87	1.41							1	5
2019	1.71								4	3
Median	1.82	1.34	1.18	1.09	1.04	1.02	1.01	1.00		

Sample Insurance Company
Commercial Auto - Incurred
Test of the Independence Between Accident Years

Acc Year	12	24	36	48	60	72	84	96	Cal Year Small	Cal Year Large
2012	1.39	1.20	1.09	1.04	1.02	1.00	1.01	1.00	1	0
2013	1.46	1.19	1.11	1.05	1.03	1.01	1.00		0	2
2014	1.37	1.15	1.08	1.05	1.02	1.00			2	0
2015	1.38	1.18	1.11	1.05	1.03				3	1
2016	1.42	1.18	1.13	1.04					3	1
2017	1.44	1.20	1.11						2	4
2018	1.50	1.24							1	6
2019	1.39								4	2
Median	1.41	1.19	1.11	1.05	1.02	1.00	1.01	1.00		

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Validation as of 31 Dec 2020

Assumptions: AY Independence

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

Sample Insurance Company
Commercial Auto - Paid
Test of the Independence Between Accident Years

Cal Year	Small	Large	Z*	n	E[Z]	Var[Z]	Low^	High^	Result
2012	1	0	0	1	0.00	0.00	0.00	0.00	
2013	0	2	0	2	0.50	0.25	0.00	1.32	Pass
2014	2	1	1	3	0.75	0.19	0.04	1.46	Pass
2015	4	0	0	4	1.25	0.44	0.16	2.34	Fail
2016	3	2	2	5	1.56	0.37	0.56	2.56	Pass
2017	1	3	1	4	1.25	0.44	0.16	2.34	Pass
2018	1	5	1	6	2.06	0.62	0.77	3.36	Pass
2019	4	3	3	7	2.41	0.55	1.18	3.63	Pass
Total			8		9.78	2.86	7.00	12.56	Pass

Sample Insurance Company
Commercial Auto - Incurred
Test of the Independence Between Accident Years

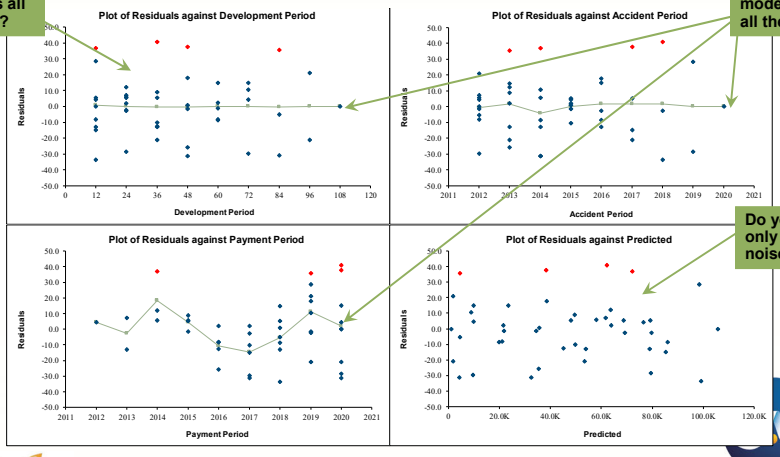
Cal Year	Small	Large	Z*	n	E[Z]	Var[Z]	Low^	High^	Result
2012	1	0	0	1	0.00	0.00	0.00	0.00	
2013	0	2	0	2	0.50	0.25	0.00	1.32	Pass
2014	2	0	0	2	0.50	0.25	0.00	1.32	Pass
2015	3	1	1	4	1.25	0.44	0.16	2.34	Pass
2016	3	1	1	4	1.25	0.44	0.16	2.34	Pass
2017	2	4	2	6	2.06	0.62	0.77	3.36	Pass
2018	1	6	1	7	2.41	0.55	1.18	3.63	Fail
2019	4	2	2	6	2.06	0.62	0.77	3.36	Pass
Total			7		10.03	3.17	7.10	12.96	Fail

* Z = Min(Small, Large)
^ Alpha = 5.0%

Validation as of 31 Dec 2020

Assumptions: CA Paid Diagnostics

Are the variances all the same?

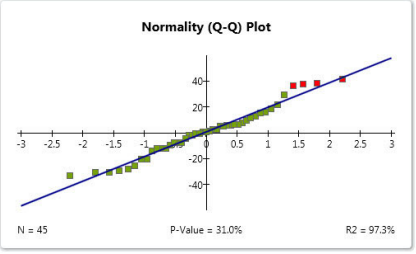


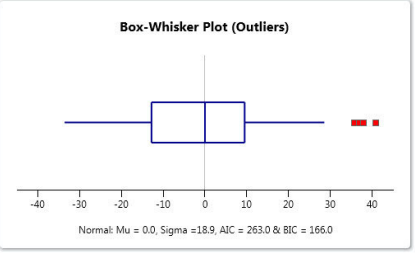
Does the model explain all the trends?

Do you have only random noise left?

Validation as of 31 Dec 2020

Assumptions: CA Paid Diagnostics





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

Validation as of 31 Dec 2020

Assumptions: BF Initial Expected Loss Ratio

- Choice of 2020 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
2012	73.2%	73.2%	73.3%	73.2%
2013	76.0%	77.3%	77.4%	76.7%
2014	64.5%	64.5%	64.6%	64.5%
2015	62.8%	63.2%	63.2%	63.0%
2016	60.4%	60.7%	60.8%	60.6%
2017	53.2%	53.2%	53.4%	53.2%
2018	57.9%	58.5%	58.5%	58.2%
2019	54.5%	55.3%	54.7%	54.9%
2020	57.3%	57.7%	52.9%	54.7%

Validation as of 31 Dec 2020

Assumptions: BF IELR and Weights

Sample Insurance Company
Commercial Auto
Calculation of Weighted Ultimate as of December 31, 2020

		Ultimate Values by Method				Weights by Method				Weighted
AY	Age	Paid CL	Inc CL	Paid BF	Inc BF	Paid CL	Inc CL	Paid BF	Inc BF	Ultimate
2012	108	258,835	258,835	258,837	258,836	50.0%	50.0%	0.0%	0.0%	258,835
2013	96	267,103	271,591	267,143	271,592	50.0%	50.0%	0.0%	0.0%	269,347
2014	84	243,981	244,137	243,991	244,141	50.0%	50.0%	0.0%	0.0%	244,059
2015	72	267,942	269,784	267,999	269,783	50.0%	50.0%	0.0%	0.0%	268,863
2016	60	290,475	292,079	290,608	292,092	50.0%	50.0%	0.0%	0.0%	291,277
2017	48	288,645	288,592	288,785	288,669	50.0%	50.0%	0.0%	0.0%	288,618
2018	36	335,023	338,775	335,956	338,702	25.0%	25.0%	25.0%	25.0%	337,114
2019	24	333,220	337,698	333,662	336,635	0.0%	0.0%	50.0%	50.0%	335,149
2020	12	357,305	360,286	338,097	344,953	0.0%	0.0%	50.0%	50.0%	341,525
Totals		2,642,529	2,661,779	2,625,078	2,645,402					2,634,788

- Optimism Regarding AY 2020 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

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Validation as of 31 Dec 2020

Assumptions: BF Initial Expected Loss Ratio

- 2020 IELR
  - No longer 52.9%
  - Used 57.5%
- Explains AY 2020 deviation only
- Still breach LoB threshold

Sample Insurance Company
Commercial Auto
Stochastic Actual vs. Expected as of December 31, 2021

AY	Age	Actual Paid	Initial Expected	Initial Percentile	Alternative Expected	Alternative Percentile
2012	120	543	577	57.5%	566	57.8%
2013	108	2,387	1,043	91.8%	1,064	91.4%
2014	96	1,177	1,636	35.6%	1,639	35.2%
2015	84	5,403	4,540	74.1%	4,569	73.3%
2016	72	14,120	10,630	93.5%	10,650	93.1%
2017	60	23,636	23,300	56.2%	23,359	54.8%
2018	48	51,020	44,746	88.8%	44,662	89.3%
2019	36	75,813	62,082	96.9%	62,032	97.2%
2020	24	88,832	79,335	87.0%	85,452	66.2%
2021	12	99,123				
Totals		362,054				
AY<CY		262,931	227,889	99.6%	233,993	98.5%

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Validation as of 31 Dec 2020

Assumptions: BF Coefficient of Variation

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

Sample Insurance Company
Commercial Auto
Impact of Coefficent of Variation

	Chain Ladder (Unshifted)		IELR	BF (Unshifted)	
AY	Paid	Incurred	CoV	Paid	Incurred
2012	55.9%	56.5%	8.0%	79.8%	78.6%
2013	49.4%	48.9%	8.0%	57.0%	56.5%
2014	38.0%	37.3%	8.0%	41.9%	42.1%
2015	24.4%	24.3%	8.0%	26.9%	26.8%
2016	16.1%	15.3%	8.0%	17.9%	17.6%
2017	11.3%	10.1%	8.0%	13.2%	12.9%
2018	8.1%	6.9%	8.0%	10.6%	10.0%
2019	7.2%	6.2%	8.0%	9.6%	8.5%
2020	7.6%	6.6%	8.0%	9.1%	7.9%
Totals	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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Validation as of 31 Dec 2020

Assumptions: BF Coefficient of Variation (*Alternative*)

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

Sample Insurance Company
Commercial Auto
Impact of Coefficent of Variation

	Chain Ladder (Unshifted)		IELR	BF (Unshifted)	
AY	Paid	Incurred	CoV	Paid	Incurred
2012	55.9%	56.5%	0.0%	78.1%	78.5%
2013	49.4%	48.9%	0.0%	56.0%	56.5%
2014	38.0%	37.3%	0.0%	40.5%	40.9%
2015	24.4%	24.3%	0.0%	25.7%	25.0%
2016	16.1%	15.3%	0.0%	16.1%	15.9%
2017	11.3%	10.1%	0.0%	10.4%	10.4%
2018	8.1%	6.9%	0.0%	6.9%	7.0%
2019	7.2%	6.2%	0.0%	5.1%	5.5%
2020	7.6%	6.6%	0.0%	4.0%	4.7%
Totals	4.9%	4.0%		3.1%	3.2%

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

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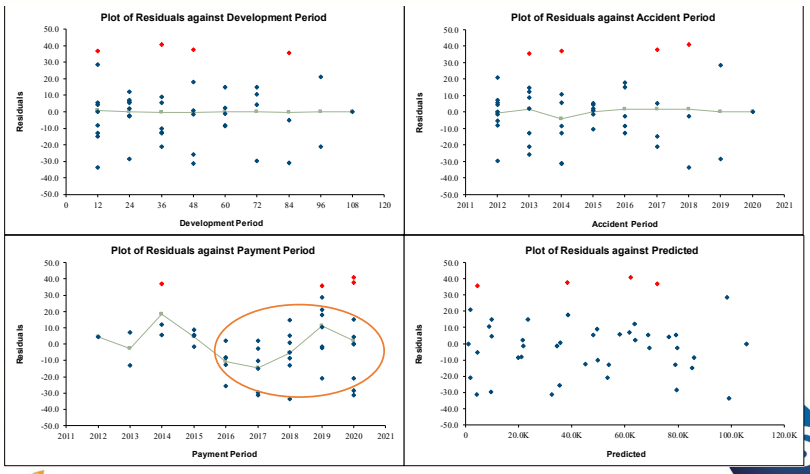
Validation as of 31 Dec 2020

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



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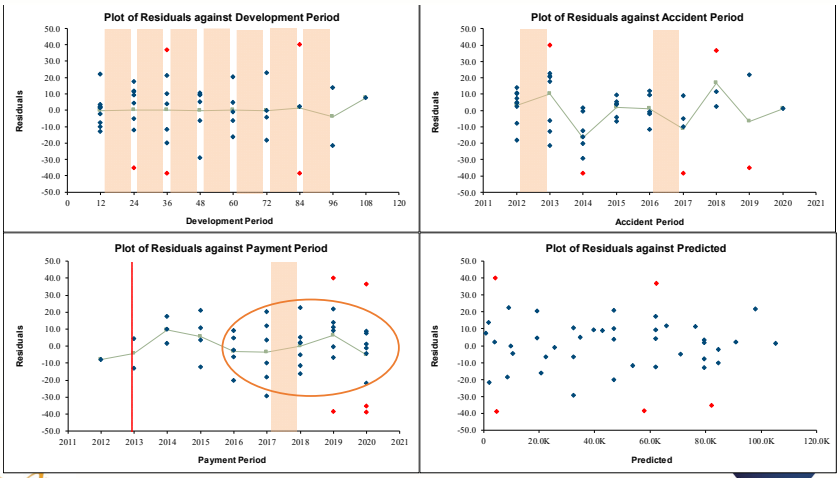
New GLM model with CY Trend:

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



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Monitor/Control Reserving Risk

Impact of change in prior assumption (ΣAY<CY)

Sample Insurance Company
Commercial Auto
Stochastic Actual vs. Expected as of December 31, 2021

AY	Age	Actual Paid	Expected Paid	Percentile	Actual Incurred	Expected Incurred	Percentile
2012	120	543	432	69.4%	(47)	228	2.0%
2013	108	2,387	942	96.6%	1,040	516	86.8%
2014	96	1,177	2,117	14.0%	851	1,181	37.9%
2015	84	5,403	5,001	64.1%	2,954	2,665	64.7%
2016	72	14,120	12,100	82.3%	9,035	6,659	89.8%
2017	60	23,636	27,514	11.8%	16,524	13,869	84.2%
2018	48	51,020	46,010	87.6%	36,454	31,896	87.7%
2019	36	75,813	66,910	94.6%	61,541	50,020	98.5%
2020	24	88,832	88,362	54.1%	83,154	78,184	77.8%
2021	12	99,123			178,539		
Totals		362,054			390,045		
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

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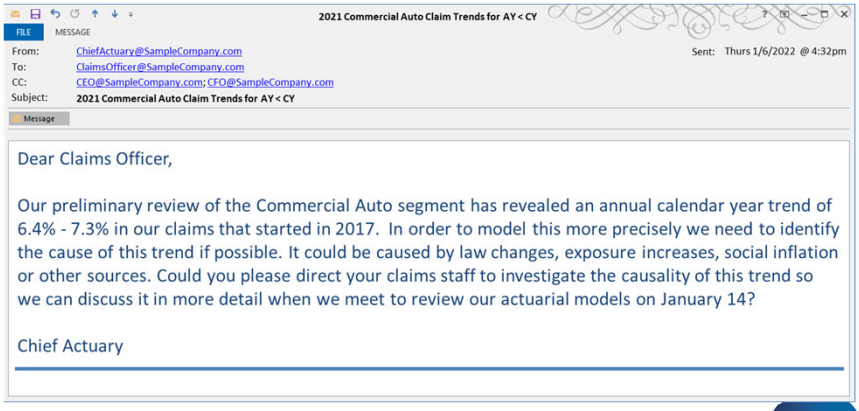
Integrated ERM Framework

Manual E-Mail to the Claims Officer



2021 Commercial Auto Claim Trends for AY < CY

FILE MESSAGE

From: ChiefActuary@SampleCompany.com
To: ClaimsOfficer@SampleCompany.com
CC: CEO@SampleCompany.com; CFO@SampleCompany.com
Subject: 2021 Commercial Auto Claim Trends for AY < CY
Sent: Thurs 1/6/2022 @ 4:32pm

Message

Dear Claims Officer,

Our preliminary review of the Commercial Auto segment has revealed an annual calendar year trend of 6.4% - 7.3% in our claims that started in 2017. In order to model this more precisely we need to identify the cause of this trend if possible. It could be caused by law changes, exposure increases, social inflation or other sources. Could you please direct your claims staff to investigate the causality of this trend so we can discuss it in more detail when we meet to review our actuarial models on January 14?

Chief Actuary

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Validation as of 31 Dec 2020

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

Sample Insurance Company
Rank Correlation of Residuals prior to Hetero Adj. - Paid

	PPA	CA	HO
PPA	1.000	0.276	(0.142)
CA	0.276	1.000	0.027
HO	(0.142)	0.027	1.000

Sample Insurance Company
P-Values of Rank Correlation of Residuals prior to Hetero Adj. - Paid

	PPA	CA	HO
PPA	0.000	0.066	0.352
CA	0.066	0.000	0.860
HO	0.352	0.860	0.000

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

Sample Insurance Company
Assumed Correlation Matrix

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

Questions?