OLIVER WYMAN

UNPAID LOSS & ALAE: RANGES AND PERCENTILES

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Casualty Loss Reserve Seminar
Austin, Texas

MARSH & McLENNAN COMPANIES

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Ranges and Percentiles

"Essentially, all models are wrong, but some are useful."
— George E.P. Box

The actuary should identify the intended measure of the unpaid claim estimate; examples of various types of measures for the unpaid claim estimate include, but are not limited to, **high estimate**, **low estimate**, median, mean, mode, **actuarial central estimate**, mean plus risk margin, actuarial central estimate plus risk margin, or **specified percentile**.

— ASOP #43 Section 3.3.a.1.

Ranges and Percentiles

- Sample statements in a report
  - Ranges
    - We believe that any estimate within our range would represent a reasonable actuarial central estimate
    - The range was selected to be reasonable when reviewed in total. Any individual policy year would have a wider range of reasonable estimates if reviewed in isolation.
  - Percentiles
    - Process risk, parameter risk, model risk
    - XX% chance that actual results will emerge at or less than the stated value.

Ranges and Percentiles

- Are they the same thing?
  - Can you present ranges by setting the “low” equal to some percentile and the “high” equal to another (for example 40th and 75th)
  - I think they are fundamentally different
    - Ranges admit that others might develop a different actuarial central estimate.
    - Percentiles seem to claim that not only do we know the actuarial central estimate, but we can estimate the volatility
- How do you reflect correlation/independence?

Unpaid Loss & ALAE

Example

Background of Example

- Corporate Entity with Large Deductible Workers' Compensation Program
  - 4/1 policy anniversary, 10 periods
  - $500,000 deductible for all periods
  - Client development triangles
  - Data valued 5/31/19
  - Interested in unpaid loss & ALAE as of 5/31/19

Develop Actuarial Central Estimate

- Perform five standard actuarial projection methods
  - Incurred loss development
  - Paid loss development
  - Case reserve development
  - Incurred Bornhuetter-Ferguson (BF)
  - Paid BF
- Actuarial judgment to select ultimate loss by policy period
- Subtract paid losses as of 5/31/19 to estimate unpaid loss & ALAE as of 5/31/19

Develop Actuarial Central Estimate

Accident Period	Reported Loss & ALAE as of 05/31/19 (1)	Reported Loss & ALAE Development Method (2)	Paid Loss & ALAE Development Method (3)	Reported Bornhuetter-Ferguson Method (4)	Paid Bornhuetter-Ferguson Method (5)	Case Development Method (6)	Selected Ultimate Loss & ALAE (7)
4/1/10-3/31/11	3,478,655	3,693,476	3,922,460	3,591,980	3,633,121	3,564,913	3,629,195
4/1/11-3/31/12	1,314,507	1,408,395	1,470,501	1,449,121	1,558,605	1,371,368	1,408,395
4/1/12-3/31/13	2,487,259	2,695,176	2,643,214	2,641,796	2,530,359	2,728,460	2,695,176
4/1/13-3/31/14	1,106,743	1,221,186	1,378,872	1,294,176	1,501,462	1,106,743	1,106,743
4/1/14-3/31/15	1,636,386	1,844,260	2,117,511	1,867,772	2,102,821	1,636,386	1,636,386
4/1/15-3/31/16	2,102,916	2,432,133	2,704,600	2,390,228	2,548,223	2,229,796	2,383,513
4/1/16-3/31/17	1,952,698	2,360,949	2,754,974	2,344,492	2,590,105	2,085,684	2,352,721
4/1/17-3/31/18	1,766,074	2,317,752	2,633,504	2,348,008	2,546,967	2,133,449	2,348,008
4/1/18-3/31/19	1,265,370	2,055,441	2,000,432	2,211,398	2,285,612	2,089,788	2,229,951
4/1/19-3/31/20	305,725	4,812,491	2,765,752	2,633,597	2,488,218	5,115,826	2,560,907
Total	17,416,333	24,841,260	24,391,819	22,772,567	23,785,493	24,062,414	22,350,995

Develop Actuarial Central Estimate

Accident Period	Paid Loss & ALAE as of 5/31/19 (1)	Case Reserves as of 5/31/19 (2)	Reported Loss & ALAE as of 5/31/19 (3)	IBNR as of 5/31/19 (4)	Total Unpaid Loss & ALAE as of 5/31/19 (5)	Selected Ultimate Loss & ALAE (6)
4/1/10-3/31/11	3,347,538	131,117	3,478,655	150,540	281,657	3,629,195
4/1/11-3/31/12	1,234,441	80,066	1,314,507	93,887	173,953	1,408,395
4/1/12-3/31/13	2,177,108	310,151	2,487,259	207,917	518,068	2,695,176
4/1/13-3/31/14	1,106,743	0	1,106,743	0	0	1,106,743
4/1/14-3/31/15	1,636,386	0	1,636,386	0	0	1,636,386
4/1/15-3/31/16	1,977,962	124,954	2,102,916	280,597	405,551	2,383,513
4/1/16-3/31/17	1,826,493	126,205	1,952,698	400,023	526,228	2,352,721
4/1/17-3/31/18	1,425,409	340,665	1,766,074	581,934	922,599	2,348,008
4/1/18-3/31/19	762,253	503,116	1,265,370	964,581	1,467,698	2,229,951
4/1/19-5/31/19	24,007	281,718	305,725	183,693	465,411	489,418
Total	15,518,341	1,897,992	17,416,333	2,863,172	4,761,164	20,279,505

Range of Reasonable Estimates

Three Methods

Method 1: Reserve Method

- Assume low is X% lower than selected and that high is Y% higher.
- Advantages:
  - Calculation is simple
  - Method is easily explained
- Challenges:
  - How do you support the selection of X% and Y%?
  - Would a survey be acceptable support?
  - Is this acceptable to regulators and auditors?

Method 1: Reserve Method

	Low	Selected	High
Indicated Reserves			
Reserve Method	4,523,106	4,761,164	5,237,281
Percent Variance			
Reserve Method	-5.0%	0.0%	10.0%
Dollar Variance			
Reserve Method	(238,058)	0	476,116

Method 2: Ultimate Method

- Make alternate selections for ultimate loss and ALAE by policy period.
  - Could choose a different method
  - Could use weighted average between methods, vary weights
- Advantages
  - Calculation is only a little bit more complex
  - Method is relatively easy to explain
- Challenges:
  - Do the five methods have enough dispersion? Can you reasonably select method for a given year given the assumptions of the method?

Method 2: Ultimate Method

Accident Period	Reported Loss & ALAE as of 05/31/19 (1)	Reported Loss & ALAE Development Method (2)	Paid Loss & ALAE Development Method (3)	Reported Bornhuetter-Ferguson Method (4)	Paid Bornhuetter-Ferguson Method (5)	Case Development Method (6)	Low Ultimate Loss & ALAE (7a)	Selected Ultimate Loss & ALAE (7b)	High Ultimate Loss & ALAE (7c)
4/1/10-3/31/11	3,478,655	3,693,476	3,922,460	3,591,980	3,633,121	3,564,913	3,597,054	3,629,195	3,661,336
4/1/11-3/31/12	1,314,507	1,408,395	1,470,501	1,449,121	1,558,605	1,371,368	1,389,882	1,408,395	1,423,921
4/1/12-3/31/13	2,487,259	2,695,176	2,643,214	2,641,796	2,530,359	2,728,460	2,669,195	2,695,176	2,728,460
4/1/13-3/31/14	1,106,743	1,221,186	1,378,872	1,294,176	1,501,462	1,106,743	1,106,743	1,106,743	1,135,354
4/1/14-3/31/15	1,636,386	1,844,260	2,117,511	1,867,772	2,102,821	1,636,386	1,636,386	1,636,386	1,688,354
4/1/15-3/31/16	2,102,916	2,432,133	2,704,600	2,390,228	2,548,223	2,229,796	2,351,198	2,383,513	2,432,133
4/1/16-3/31/17	1,952,698	2,360,949	2,754,974	2,344,492	2,590,105	2,085,684	2,318,611	2,352,721	2,405,895
4/1/17-3/31/18	1,766,074	2,317,752	2,633,504	2,348,008	2,546,967	2,133,449	2,299,322	2,348,008	2,397,747
4/1/18-3/31/19	1,265,370	2,055,441	2,000,432	2,211,398	2,285,612	2,089,788	2,133,419	2,229,951	2,267,058
4/1/19-3/31/20	305,725	4,812,491	2,765,752	2,633,597	2,488,218	5,115,826	2,524,563	2,560,907	2,633,597
Total	17,416,333	24,841,260	24,391,819	22,772,567	23,785,493	24,062,414	22,026,373	22,350,995	22,773,856

	Low	Selected	High
4/1/10-3/31/11	25% (2), 75% (6)	50% (2), 50% (6)	75% (2), 25% (6)
4/1/11-3/31/12	50% (2), 50% (6)	100% (2)	75% (2), 25% (3)
4/1/12-3/31/13	50% (2), 50% (3)	100% (2)	100% (6)
4/1/13-3/31/14	100% (1)	100% (1)	75% (1), 25% (2)
4/1/14-3/31/15	100% (1)	100% (1)	75% (1), 25% (2)
4/1/15-3/31/16	60% (2), 40% (6)	Max IBNR	100% (2)
4/1/16-3/31/17	90% (4), 10% (6)	50% (2), 50% (4)	75% (4), 25% (5)
4/1/17-3/31/18	90% (2), 10% (6)	100% (4)	75% (4), 25% (5)
4/1/18-3/31/19	50% (2), 50% (4)	75% (4), 25% (5)	25% (4), 75% (5)
4/1/19-3/31/20	75% (4), 25% (5)	50% (4), 50% (5)	100% (4)

Method 2: Ultimate Method

Accident Period	Paid Loss at 5/31/19 (1)	Low Unpaid Loss at 5/31/19 (2a)	Selected Unpaid Loss at 5/31/19 (2b)	High Unpaid Loss at 5/31/19 (2c)	Low Ultimate Loss (3a)	Selected Ultimate Loss (3b)	High Ultimate Loss (3c)
4/1/10-3/31/11	3,347,538	249,516	281,657	313,797	3,597,054	3,629,195	3,661,336
4/1/11-3/31/12	1,234,441	155,440	173,953	189,480	1,389,882	1,408,395	1,423,921
4/1/12-3/31/13	2,177,108	492,087	518,068	551,353	2,669,195	2,695,176	2,728,460
4/1/13-3/31/14	1,106,743	0	0	28,611	1,106,743	1,106,743	1,135,354
4/1/14-3/31/15	1,636,386	0	0	51,969	1,636,386	1,636,386	1,688,354
4/1/15-3/31/16	1,977,962	373,236	405,551	454,170	2,351,198	2,383,513	2,432,133
4/1/16-3/31/17	1,826,493	492,119	526,228	579,403	2,318,611	2,352,721	2,405,895
4/1/17-3/31/18	1,425,409	873,913	922,599	972,339	2,299,322	2,348,008	2,397,747
4/1/18-3/31/19	762,253	1,371,166	1,467,698	1,504,805	2,133,419	2,229,951	2,267,058
4/1/19-5/31/19	24,007	429,066	465,411	538,100	453,073	489,418	562,107
Total	15,518,341	4,436,543	4,761,164	5,184,026	19,954,883	20,279,505	20,702,367

Method 2: Ultimate Method

Accident Period	Low Variance	High Variance	Low Ratio	High Ratio
4/1/10-3/31/11	(32,141)	32,141	-11.4%	11.4%
4/1/11-3/31/12	(18,513)	15,527	-10.6%	8.9%
4/1/12-3/31/13	(25,981)	33,284	-5.0%	6.4%
4/1/13-3/31/14	0	28,611	N/A	N/A
4/1/14-3/31/15	0	51,969	N/A	N/A
4/1/15-3/31/16	(32,315)	48,619	-8.0%	12.0%
4/1/16-3/31/17	(34,109)	53,175	-6.5%	10.1%
4/1/17-3/31/18	(48,686)	49,740	-5.3%	5.4%
4/1/18-3/31/19	(96,532)	37,107	-6.6%	2.5%
4/1/19-5/31/19	(36,345)	72,690	-7.8%	15.6%
Total	(324,622)	422,862	-6.8%	8.9%

Comparison of Ranges

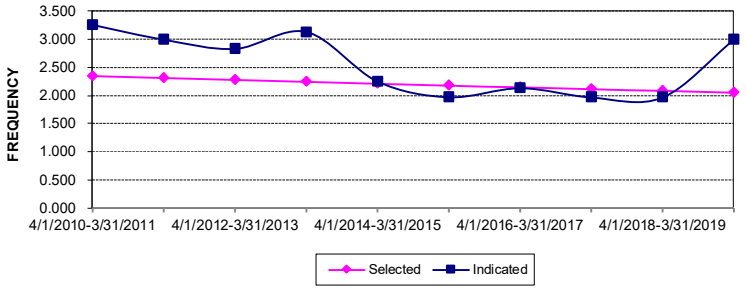
	Low	Selected	High
Indicated Reserves			
Reserve Method	4,523,106	4,761,164	5,237,281
Ultimate Method	4,436,543	4,761,164	5,184,026
Percent Variance			
Reserve Method	-5.0%	0.0%	10.0%
Ultimate Method	-6.8%	0.0%	8.9%
Dollar Variance			
Reserve Method	(238,058)	0	476,116
Ultimate Method	(324,622)	0	422,862

Method 3: Detail Method

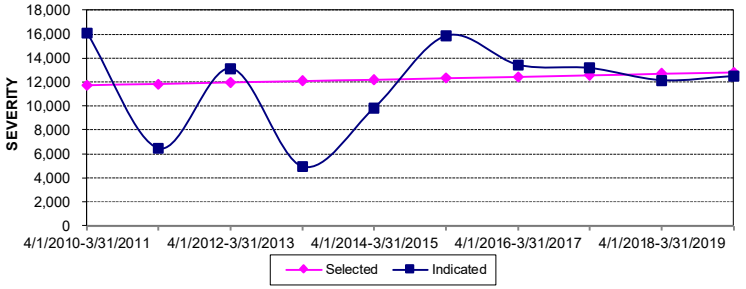
- Create separate versions of the analysis.
  - Vary LDFs, trends, ILFs
  - Vary selections of frequency, severity, loss cost and ultimate loss by policy period.
  - Review implied range, consider reasonableness.
- Advantages
  - Robust, defensible
  - Explanation: Vary parameters to reflect what another actuary might reasonably select.
- Challenges
  - More effort/time
  - How do you combine policy periods? How do you combine analysis segments?

Method 3: Detail Method (Low)

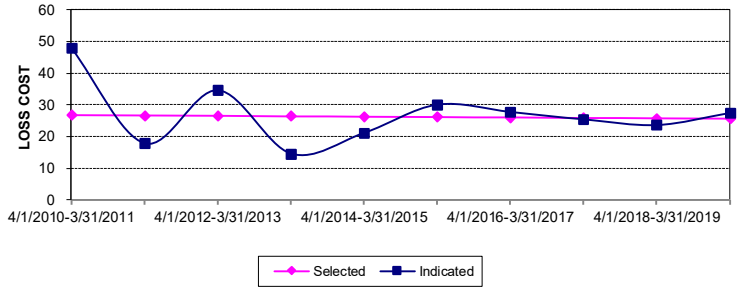
FREQUENCY TREND



SEVERITY TREND



LOSS & ALAE COST TREND



Notes:

The selected frequency trend is -1.50%.

The selected severity trend is 1.00%.

The selected loss & ALAE cost trend is -0.50%.

Method 3: Detail Method (Low)

REPORTED LOSS & ALAE -- LIMITED TO $500,000 PER OCCURRENCE

Accident Period	2	14	26	38	50	62	74	86	98	110
4/1/10-3/31/11	186,697	1,513,415	2,134,509	2,667,921	3,342,419	3,350,517	3,350,517	3,370,167	3,470,304	3,478,655
4/1/11-3/31/12	71,364	1,305,914	1,113,024	1,163,991	1,211,760	1,255,282	1,310,108	1,310,002	1,314,507	
4/1/12-3/31/13	146,732	1,707,993	2,158,254	2,065,187	2,300,634	2,319,078	2,319,857	2,487,259		
4/1/13-3/31/14	148,267	1,183,222	1,363,910	1,199,145	1,106,743	1,106,743	1,106,743			
4/1/14-3/31/15	224,693	1,619,030	1,424,195	1,467,441	1,635,712	1,636,386				
4/1/15-3/31/16	110,974	1,637,616	1,839,233	2,098,967	2,102,916					
4/1/16-3/31/17	333,712	1,274,149	1,589,193	1,952,698						
4/1/17-3/31/18	66,496	1,127,995	1,766,074							
4/1/18-3/31/19	14,874	1,265,370								
4/1/19-3/31/20	305,725									

Accident Period	2-14	14-26	26-38	38-50	50-62	62-74	74-86	86-98	98-110	110-ULT
4/1/10-3/31/11	8.106	1.410	1.250	1.253	1.002	1.000	1.006	1.030	1.002	
4/1/11-3/31/12	18.299	0.852	1.046	1.041	1.036	1.044	1.000	1.003		
4/1/12-3/31/13	11.640	1.264	0.957	1.114	1.008	1.000	1.072			
4/1/13-3/31/14	7.980	1.153	0.879	0.923	1.000	1.000				
4/1/14-3/31/15	7.206	0.880	1.030	1.115	1.000					
4/1/15-3/31/16	14.757	1.123	1.141	1.002						
4/1/16-3/31/17	3.818	1.247	1.229							
4/1/17-3/31/18	16.963	1.566								
4/1/18-3/31/19	85.073									
4/1/19-3/31/20										
All Years Weighted	9.691	1.178	1.085	1.097	1.007	1.007	1.027	1.022	1.002	
5 Years Weighted	9.223	1.167	1.049	1.045	1.007					
3 Years Weighted	8.836	1.286	1.137	1.017	1.004	1.012	1.027			
5 Years Average	25.563	1.194	1.047	1.039	1.009					
3 Years Average	35.285	1.312	1.133	1.013	1.003	1.015	1.026			
Industry - $500,000 Limits	9.569	1.238	1.091	1.051	1.029	1.021	1.015	1.011	1.009	1.069

Low	2-14	14-26	26-38	38-50	50-62	62-74	74-86	86-98	98-110	110-ULT
Age to Age	9.223	1.232	1.076	1.045	1.023	1.020	1.017	1.010	1.008	1.055
Age to Ultimate	14.577	1.580	1.283	1.192	1.140	1.114	1.093	1.074	1.064	1.055

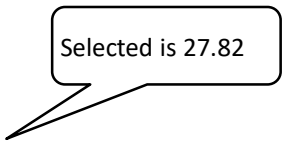
Selected	2-14	14-26	26-38	38-50	50-62	62-74	74-86	86-98	98-110	110-ULT
Age to Age	9.691	1.238	1.085	1.045	1.026	1.021	1.018	1.011	1.009	1.062
Age to Ultimate	15.741	1.624	1.312	1.209	1.157	1.127	1.103	1.084	1.071	1.062

Method 3: Detail Method (Low)

Accident Period	Initial Ultimate Loss & ALAE @ $500k	Adjustment to 2019/20 Benefit Level	Adjustment to Reflect Claims Mgmt Changes	Payroll (000's)	Indicated Loss & ALAE Cost	Trended to 2019/20 Loss & ALAE Cost	Smoothed Loss & ALAE Cost	Adjustment to 2019/20 Retention Level	Estimated Ultimate Loss & ALAE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
4/1/10-3/31/11	3,669,607	1.045	1.000	80,027	47.91	45.80	25.63	1.000	2,051,209
4/1/11-3/31/12	1,398,035	1.037	1.000	81,527	17.79	17.09	25.69	1.000	2,094,289
4/1/12-3/31/13	2,671,759	1.030	1.000	79,478	34.61	33.42	25.75	1.000	2,046,734
4/1/13-3/31/14	1,106,743	1.032	1.000	78,772	14.50	14.07	25.56	1.000	2,013,122
4/1/14-3/31/15	1,636,386	1.034	1.000	80,170	21.10	20.58	25.39	1.000	2,035,602
4/1/15-3/31/16	2,383,513	1.030	1.000	81,773	30.02	29.43	25.36	1.000	2,073,456
4/1/16-3/31/17	2,327,978	1.003	1.000	84,178	27.74	27.33	25.90	1.000	2,180,493
4/1/17-3/31/18	2,273,576	1.000	1.000	89,646	25.36	25.11	25.86	1.000	2,317,895
4/1/18-3/31/19	2,110,095	1.000	1.000	89,351	23.62	23.50	25.73	1.000	2,298,707
4/1/19-3/31/20	2,447,937	1.000	1.000	89,351	27.40	27.40	25.60	1.000	2,287,213
Total	22,025,629			834,273					21,398,720

AVERAGES AT THE 4/1/19-3/31/20 ACCIDENT PERIOD LEVEL

Average of accident periods 4/1/12-3/31/13 through 4/1/18-3/31/19:	24.78
Average of accident periods 4/1/14-3/31/15 through 4/1/18-3/31/19:	25.19
Average of accident periods 4/1/15-3/31/16 through 4/1/18-3/31/19:	26.34
Weighted average of accident periods 4/1/10-3/31/11 through 4/1/18-3/31/19:	26.22
Weighted average of accident periods 4/1/14-3/31/15 through 4/1/18-3/31/19:	25.19
Selected Accident Period 4/1/19-3/31/20 Loss & ALAE Cost at $500,000 Limitation:	25.60



Method 3: Detail Method (Low)

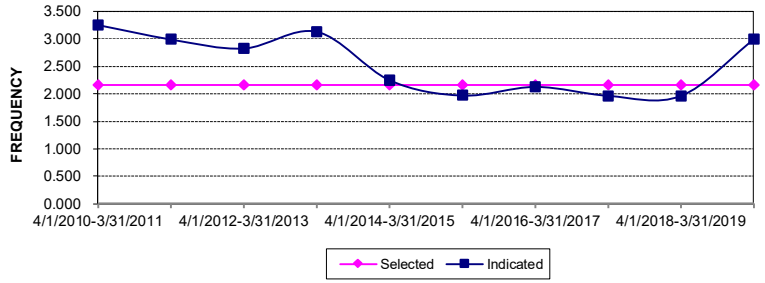
Accident Period	Reported Loss & ALAE as of 05/31/19 (1)	Reported Loss & ALAE Development Method (2)	Paid Loss & ALAE Development Method (3)	Reported Bornhuetter-Ferguson Method (4)	Paid Bornhuetter-Ferguson Method (5)	Case Development Method (6)	Selected Ultimate Loss & ALAE (7)
4/1/10-3/31/11	3,478,655	3,669,607	3,858,579	3,585,392	3,619,206	3,563,509	3,616,558
4/1/11-3/31/12	1,314,507	1,398,035	1,445,563	1,439,633	1,540,308	1,369,937	1,398,035
4/1/12-3/31/13	2,487,259	2,671,759	2,595,306	2,628,598	2,506,911	2,719,856	2,671,759
4/1/13-3/31/14	1,106,743	1,209,229	1,352,172	1,277,362	1,472,139	1,106,743	1,106,743
4/1/14-3/31/15	1,636,386	1,823,676	2,065,999	1,845,440	2,059,678	1,636,386	1,636,386
4/1/15-3/31/16	2,102,916	2,398,166	2,632,104	2,358,190	2,493,266	2,225,584	2,358,190
4/1/16-3/31/17	1,952,698	2,327,978	2,661,340	2,304,202	2,510,501	2,086,115	2,316,090
4/1/17-3/31/18	1,766,074	2,266,094	2,512,020	2,277,524	2,428,049	2,120,791	2,277,524
4/1/18-3/31/19	1,265,370	1,999,863	1,882,216	2,109,620	2,130,038	2,076,694	2,114,724
4/1/19-3/31/20	305,725	4,456,422	2,491,627	2,436,028	2,289,183	4,755,431	2,362,605
Total	17,416,333	24,220,829	23,496,927	22,261,989	23,049,279	23,661,045	21,858,615

Method 3: Detail Method (Low)

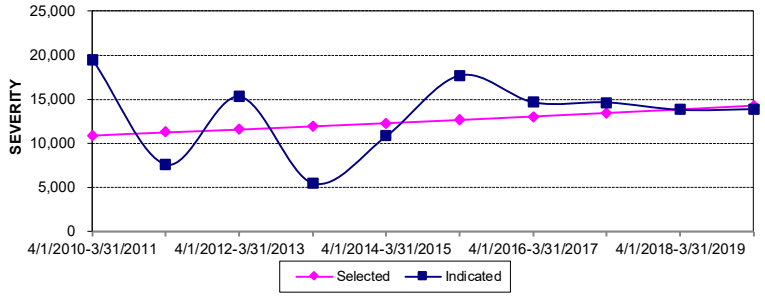
Accident Period	Paid Loss & ALAE as of 5/31/19 (1)	Case Reserves as of 5/31/19 (2)	Reported Loss & ALAE as of 5/31/19 (3)	IBNR as of 5/31/19 (4)	Total Unpaid Loss & ALAE as of 5/31/19 (5)	Selected Ultimate Loss & ALAE (6)
4/1/10-3/31/11	3,347,538	131,117	3,478,655	137,903	269,020	3,616,558
4/1/11-3/31/12	1,234,441	80,066	1,314,507	83,527	163,593	1,398,035
4/1/12-3/31/13	2,177,108	310,151	2,487,259	184,500	494,652	2,671,759
4/1/13-3/31/14	1,106,743	0	1,106,743	0	0	1,106,743
4/1/14-3/31/15	1,636,386	0	1,636,386	0	0	1,636,386
4/1/15-3/31/16	1,977,962	124,954	2,102,916	255,274	380,228	2,358,190
4/1/16-3/31/17	1,826,493	126,205	1,952,698	363,392	489,597	2,316,090
4/1/17-3/31/18	1,425,409	340,665	1,766,074	511,450	852,115	2,277,524
4/1/18-3/31/19	762,253	503,116	1,265,370	849,354	1,352,471	2,114,724
4/1/19-5/31/19	24,007	281,718	305,725	150,869	432,588	456,594
Total	15,518,341	1,897,992	17,416,333	2,536,271	4,434,263	19,952,603

Method 3: Detail Method (High)

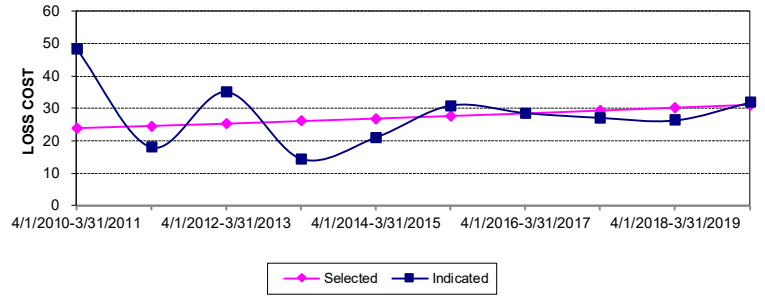
FREQUENCY TREND



SEVERITY TREND



LOSS & ALAE COST TREND



Notes:

The selected frequency trend is 0.00%.

The selected severity trend is 3.00%.

The selected loss & ALAE cost trend is 3.00%.

Method 3: Detail Method (High)

REPORTED LOSS & ALAE -- LIMITED TO $500,000 PER OCCURRENCE

Accident Period	2	14	26	38	50	62	74	86	98	110
4/1/10-3/31/11	186,697	1,513,415	2,134,509	2,667,921	3,342,419	3,350,517	3,350,517	3,370,167	3,470,304	3,478,655
4/1/11-3/31/12	71,364	1,305,914	1,113,024	1,163,991	1,211,760	1,255,282	1,310,108	1,310,002	1,314,507	
4/1/12-3/31/13	146,732	1,707,993	2,158,254	2,065,187	2,300,634	2,319,078	2,319,857	2,487,259		
4/1/13-3/31/14	148,267	1,183,222	1,363,910	1,199,145	1,106,743	1,106,743	1,106,743			
4/1/14-3/31/15	224,693	1,619,030	1,424,195	1,467,441	1,635,712	1,636,386				
4/1/15-3/31/16	110,974	1,637,616	1,839,233	2,098,967	2,102,916					
4/1/16-3/31/17	333,712	1,274,149	1,589,193	1,952,698						
4/1/17-3/31/18	66,496	1,127,995	1,766,074							
4/1/18-3/31/19	14,874	1,265,370								
4/1/19-3/31/20	305,725									

Accident Period	2-14	14-26	26-38	38-50	50-62	62-74	74-86	86-98	98-110	110-ULT
4/1/10-3/31/11	8.106	1.410	1.250	1.253	1.002	1.000	1.006	1.030	1.002	
4/1/11-3/31/12	18.299	0.852	1.046	1.041	1.036	1.044	1.000	1.003		
4/1/12-3/31/13	11.640	1.264	0.957	1.114	1.008	1.000	1.072			
4/1/13-3/31/14	7.980	1.153	0.879	0.923	1.000	1.000				
4/1/14-3/31/15	7.206	0.880	1.030	1.115	1.000					
4/1/15-3/31/16	14.757	1.123	1.141	1.002						
4/1/16-3/31/17	3.818	1.247	1.229							
4/1/17-3/31/18	16.963	1.566								
4/1/18-3/31/19	85.073									
4/1/19-3/31/20										
All Years Weighted	9.691	1.178	1.085	1.097	1.007	1.007	1.027	1.022	1.002	
5 Years Weighted	9.223	1.167	1.049	1.045	1.007					
3 Years Weighted	8.836	1.286	1.137	1.017	1.004	1.012	1.027			
5 Years Average	25.563	1.194	1.047	1.039	1.009					
3 Years Average	35.285	1.312	1.133	1.013	1.003	1.015	1.026			
Industry - $500,000 Limits	9.569	1.238	1.091	1.051	1.029	1.021	1.015	1.011	1.009	1.069

High	2-14	14-26	26-38	38-50	50-62	62-74	74-86	86-98	98-110	110-ULT
Age to Age	10.167	1.250	1.095	1.051	1.029	1.021	1.019	1.012	1.009	1.069
Age to Ultimate	17.110	1.683	1.346	1.230	1.170	1.137	1.113	1.092	1.078	1.069

Selected	2-14	14-26	26-38	38-50	50-62	62-74	74-86	86-98	98-110	110-ULT
Age to Age	9.691	1.238	1.085	1.045	1.026	1.021	1.018	1.011	1.009	1.062
Age to Ultimate	15.741	1.624	1.312	1.209	1.157	1.127	1.103	1.084	1.071	1.062

Method 3: Detail Method (High)

Accident Period	Initial Ultimate Loss & ALAE @ $500k	Adjustment to 2019/20 Benefit Level	Adjustment to Reflect Claims Mgmt Changes	Payroll (000's)	Indicated Loss & ALAE Cost	Trended to 2019/20 Loss & ALAE Cost	Smoothed Loss & ALAE Cost	Adjustment to 2019/20 Retention Level	Estimated Ultimate Loss & ALAE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
4/1/10-3/31/11	3,717,345	1.045	1.000	80,027	48.53	63.32	22.89	1.000	1,832,148
4/1/11-3/31/12	1,417,496	1.037	1.000	81,527	18.03	22.85	23.75	1.000	1,936,428
4/1/12-3/31/13	2,715,544	1.030	1.000	79,478	35.18	43.26	24.65	1.000	1,959,026
4/1/13-3/31/14	1,106,743	1.032	1.000	78,772	14.50	17.32	25.32	1.000	1,994,634
4/1/14-3/31/15	1,636,386	1.034	1.000	80,170	21.10	24.46	26.04	1.000	2,087,853
4/1/15-3/31/16	2,460,197	1.030	1.000	81,773	30.99	34.88	26.92	1.000	2,201,487
4/1/16-3/31/17	2,400,855	1.003	1.000	84,178	28.61	31.27	28.47	1.000	2,396,569
4/1/17-3/31/18	2,434,869	1.000	1.000	89,646	27.16	28.82	29.42	1.000	2,637,201
4/1/18-3/31/19	2,360,984	1.000	1.000	89,351	26.42	27.22	30.30	1.000	2,707,368
4/1/19-3/31/20	2,847,919	1.000	1.000	89,351	31.87	31.87	31.21	1.000	2,788,589
Total	23,098,337			834,273					22,541,303

AVERAGES AT THE 4/1/19-3/31/20 ACCIDENT PERIOD LEVEL

Average of accident periods 4/1/12-3/31/13 through 4/1/18-3/31/19:	29.60
Average of accident periods 4/1/14-3/31/15 through 4/1/18-3/31/19:	29.33
Average of accident periods 4/1/15-3/31/16 through 4/1/18-3/31/19:	30.54
Weighted average of accident periods 4/1/10-3/31/11 through 4/1/18-3/31/19:	32.48
Weighted average of accident periods 4/1/14-3/31/15 through 4/1/18-3/31/19:	29.31
High Accident Period 4/1/19-3/31/20 Loss & ALAE Cost at $500,000 Limitation:	31.21

Selected is 27.82

Method 3: Detail Method (High)

Accident Period	Reported Loss & ALAE as of 05/31/19 (1)	Reported Loss & ALAE Development Method (2)	Paid Loss & ALAE Development Method (3)	Reported Bornhuetter-Ferguson Method (4)	Paid Bornhuetter-Ferguson Method (5)	Case Development Method (6)	Selected Ultimate Loss & ALAE (7)
4/1/10-3/31/11	3,478,655	3,717,345	3,986,340	3,596,297	3,641,136	3,566,318	3,641,832
4/1/11-3/31/12	1,314,507	1,417,496	1,495,473	1,455,200	1,572,441	1,371,599	1,417,496
4/1/12-3/31/13	2,487,259	2,715,544	2,696,066	2,651,947	2,554,195	2,727,740	2,715,544
4/1/13-3/31/14	1,106,743	1,231,784	1,408,218	1,309,223	1,533,759	1,106,743	1,106,743
4/1/14-3/31/15	1,636,386	1,860,265	2,162,577	1,887,655	2,144,395	1,636,386	1,636,386
4/1/15-3/31/16	2,102,916	2,460,197	2,777,462	2,422,626	2,611,666	2,230,144	2,422,626
4/1/16-3/31/17	1,952,698	2,400,855	2,839,630	2,400,055	2,681,553	2,091,178	2,400,455
4/1/17-3/31/18	1,766,074	2,377,682	2,740,648	2,444,438	2,691,004	2,159,607	2,444,438
4/1/18-3/31/19	1,265,370	2,129,474	2,106,708	2,363,974	2,490,036	2,143,857	2,395,489
4/1/19-3/31/20	305,725	5,230,825	2,985,734	2,931,330	2,790,174	5,568,017	2,860,752
Total	17,416,333	25,541,468	25,198,856	23,462,742	24,710,359	24,601,589	23,041,761

Method 3: Detail Method (High)

Accident Period	Paid Loss & ALAE as of 5/31/19 (1)	Case Reserves as of 5/31/19 (2)	Reported Loss & ALAE as of 5/31/19 (3)	IBNR as of 5/31/19 (4)	Total Unpaid Loss & ALAE as of 5/31/19 (5)	Selected Ultimate Loss & ALAE (6)
4/1/10-3/31/11	3,347,538	131,117	3,478,655	163,177	294,294	3,641,832
4/1/11-3/31/12	1,234,441	80,066	1,314,507	102,989	183,055	1,417,496
4/1/12-3/31/13	2,177,108	310,151	2,487,259	228,285	538,436	2,715,544
4/1/13-3/31/14	1,106,743	0	1,106,743	0	0	1,106,743
4/1/14-3/31/15	1,636,386	0	1,636,386	0	0	1,636,386
4/1/15-3/31/16	1,977,962	124,954	2,102,916	319,710	444,664	2,422,626
4/1/16-3/31/17	1,826,493	126,205	1,952,698	447,757	573,962	2,400,455
4/1/17-3/31/18	1,425,409	340,665	1,766,074	678,364	1,019,029	2,444,438
4/1/18-3/31/19	762,253	503,116	1,265,370	1,130,119	1,633,236	2,395,489
4/1/19-5/31/19	24,007	281,718	305,725	231,203	512,921	536,928
Total	15,518,341	1,897,992	17,416,333	3,301,604	5,199,596	20,717,937

Method 3: Detail Method

	Low	Selected	High		
Frequency Trend	-1.5%	-1.0%	0.0%	-0.5%	1.0%
Severity Trend	1.0%	2.0%	3.0%	-1.0%	1.0%
Loss Cost Trend	-0.5%	1.0%	3.0%	-1.5%	2.0%
Incurred LDF					
110	1.055	1.062	1.069	89%	111%
98	1.064	1.071	1.078	89%	110%
86	1.074	1.084	1.092	89%	110%
74	1.093	1.103	1.113	90%	109%
62	1.114	1.127	1.137	90%	108%
50	1.140	1.157	1.170	90%	109%
38	1.192	1.209	1.230	92%	110%
26	1.283	1.312	1.346	91%	111%
14	1.580	1.624	1.683	93%	109%
2	14.577	15.741	17.110	92%	109%

Method 3: Detail Method

	Low	Selected	High				
Frequency	2.05	2.08	2.16	(0.04)	0.08	-2%	4%
Severity	12,825	13,484	14,277	(659.77)	792.87	-5%	6%
Loss Cost	25.60	27.82	31.21	(2.22)	3.39	-8%	12%
Unpaid							
4/1/10-3/31/11	269,020	281,657	294,294	(12,637)	12,637	-4.5%	4.5%
4/1/11-3/31/12	163,593	173,953	183,055	(10,360)	9,102	-6.0%	5.2%
4/1/12-3/31/13	494,652	518,068	538,436	(23,417)	20,368	-4.5%	3.9%
4/1/13-3/31/14	0	0	0	0	0	N/A	N/A
4/1/14-3/31/15	0	0	0	0	0	N/A	N/A
4/1/15-3/31/16	380,228	405,551	444,664	(25,323)	39,113	-6.2%	9.6%
4/1/16-3/31/17	489,597	526,228	573,962	(36,631)	47,734	-7.0%	9.1%
4/1/17-3/31/18	852,115	922,599	1,019,029	(70,483)	96,430	-7.6%	10.5%
4/1/18-3/31/19	1,352,471	1,467,698	1,633,236	(115,227)	165,538	-7.9%	11.3%
4/1/19-5/31/19	432,588	465,411	512,921	(32,823)	47,510	-7.1%	10.2%
Total	4,434,263	4,761,164	5,199,596	(326,902)	438,432	-6.9%	9.2%

Comparison of Ranges

	Low	Selected	High
Indicated Reserves			
Reserve Method	4,523,106	4,761,164	5,237,281
Ultimate Method	4,436,543	4,761,164	5,184,026
Detail Method	4,434,263	4,761,164	5,199,596
Percent Variance			
Reserve Method	-5.0%	0.0%	10.0%
Ultimate Method	-6.8%	0.0%	8.9%
Detail Method	-6.9%	0.0%	9.2%
Dollar Variance			
Reserve Method	(238,058)	0	476,116
Ultimate Method	(324,622)	0	422,862
Detail Method	(326,902)	0	438,432

Percentile Estimates

Three Methods

Method 1: Aggregate Model

- Assume aggregate unpaid loss and ALAE follow a lognormal distribution.
  - Skewed to the right, relatively simple calculation
  - Need two parameters
    - Set mean equal to actuarial central estimate
    - Base aggregate CV on the number of pending claims and a modeled severity distribution CV (individual CV)
  - Excel has functions to provide percentiles of the lognormal distribution LOGINV(X%, Mu, Sigma)
    - Assume mean = 1 for convenience of calculation, then;
      - Sigma = SQRT(LN(1+CV^2))
      - Mu = -0.5 x Sigma^2

Method 1: Aggregate Model

- Model individual claim severity distribution CV

Trend Date	5/31/2019
Loss Trend	2.00%
Deductible	500,000

Max	500,000
Min	3
# of claims	5,401

Claim #	**Acc Date**	**Incurred**	**Trended**
36765	8/22/2000	587,087	500,000
37458	7/16/2002	231,910	323,917
43178	3/14/2018	220,266	225,620
38087	4/5/2004	12,554	16,947
37739	4/23/2003	12,498	17,192
38811	3/30/2006	12,470	16,185
41904	9/17/2014	12,467	13,683

Mean	8,152
Stdev	37,674
CV	4.62
Selected CV	**4.62**

These are examples, table includes all claims

Method 1: Aggregate Model

- Calculate aggregate model CV
  - CV(Agg) = [(1+CV(Ind)^2) / #Pending + Risk^2] ^ .5
    - This formula is a convenient approximation
    - Note 0.25 Risk yields 54.1% aggregate CV

Coverage	Total Outstanding Unpaid	CV
Workers' Compensation	4,761,164	49.0%

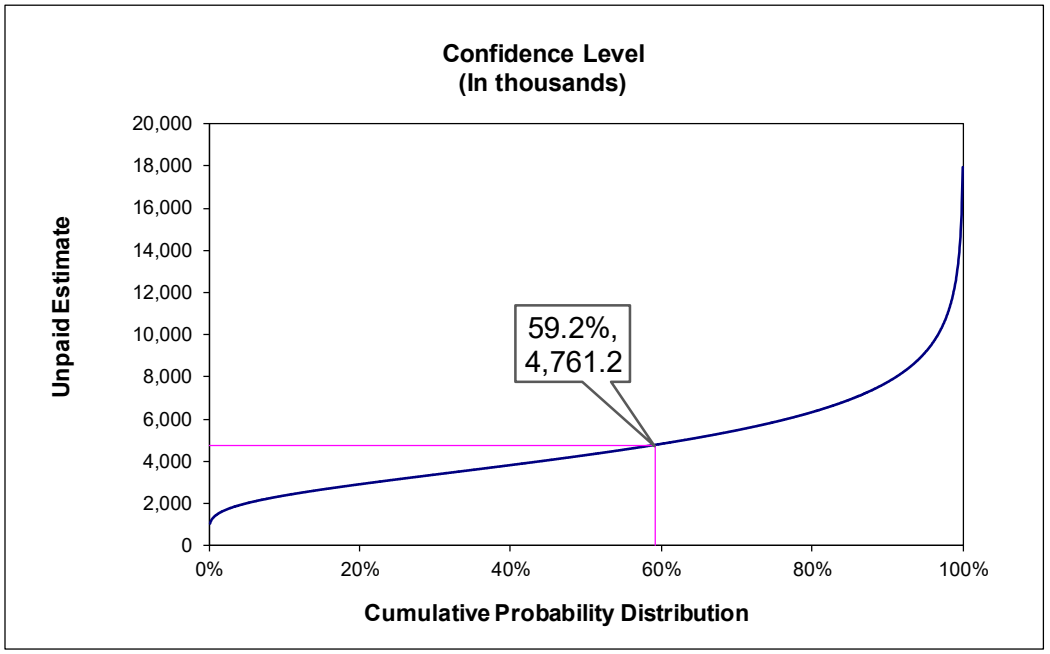
Parameter Risk	0.100
# of IBNR and Open	97
CV for severity	4.62

Method 1: Aggregate Model

- Calculate percentiles of the lognormal

Parameters of a Lognormal Curve Fit	
Coefficient of Variation	0.490
σ	0.464
σ2	0.215
μ	(0.107)

Confidence Level	Factors	Unpaid
99.0%	2.641	12,573,197
98.0%	2.327	11,080,471
95.0%	1.925	9,167,008
90.0%	1.627	7,745,994
80.0%	1.327	6,316,808
70.0%	1.145	5,452,876
60.0%	1.010	4,808,940
50.0%	0.898	4,276,005
40.0%	0.799	3,802,131



Method 2: Triangle Method

- Assume aggregate unpaid loss and ALAE follow a lognormal distribution.
  - Skewed to the right, relatively simple calculation
  - Need two parameters
    - Set mean equal to actuarial central estimate
    - Estimate CV directly from the paid loss triangle
  - Excel has functions to provide percentiles of the lognormal distribution LOGINV(X%, Mu, Sigma)
    - Assume mean=1 for convenience of calculation, then;
      - Sigma = SQRT(LN(1+CV^2))
      - Mu = -0.5 x Sigma^2

Method 2: Triangle Model

- Estimate CV by age from paid loss triangle
  - Each entry is ultimate loss / paid loss

Policy Year	2	14	26	38	50	62	74	86	98	110
4/1/10-3/31/11	122.242	3.912	2.241	1.575	1.363	1.182	1.143	1.108	1.095	1.084
4/1/11-3/31/12	70.354	1.705	1.324	1.299	1.201	1.162	1.151	1.148	1.141	
4/1/12-3/31/13	109.221	2.339	1.754	1.468	1.284	1.257	1.247	1.238		
4/1/13-3/31/14	64.683	1.498	1.089	1.000	1.000	1.000	1.000			
4/1/14-3/31/15	196.259	1.690	1.292	1.115	1.000	1.000				
4/1/15-3/31/16	158.889	3.222	1.780	1.281	1.205					
4/1/16-3/31/17	180.620	1.903	1.532	1.288						
4/1/17-3/31/18	41.682	2.313	1.647							
4/1/18-3/31/19	149.924	2.925								
4/1/19-3/31/20	106.674									
Mean LDF-1	119.055	1.390	0.582	0.290	0.176	0.120	0.136	0.165	0.118	0.084
Var LDF	2,650.570	0.662	0.129	0.038	0.022	0.013	0.010	0.004	0.001	
CV	0.432	0.586	0.617	0.672	0.845	0.959	0.752	0.404	0.273	
Select CV	0.432	0.586	0.617	0.672	0.845	0.882	0.701	0.650	0.650	0.650

Method 2: Triangle Model

- Estimate aggregate CV
  - Combine policy periods, test correlation
  - Add parameter risk by varying tail factor

Policy Year	Unpaid	CV	Std Dev	Variance
4/1/10-3/31/11	281,657	0.650	183,167	3.36E+10
4/1/11-3/31/12	173,953	0.650	113,125	1.28E+10
4/1/12-3/31/13	518,068	0.650	336,910	1.14E+11
4/1/13-3/31/14	0	0.701	0	0.00E+00
4/1/14-3/31/15	0	0.882	0	0.00E+00
4/1/15-3/31/16	405,551	0.845	342,604	1.17E+11
4/1/16-3/31/17	526,228	0.672	353,820	1.25E+11
4/1/17-3/31/18	922,599	0.617	569,284	3.24E+11
4/1/18-3/31/19	1,467,698	0.586	859,439	7.39E+11
4/1/19-5/31/19	465,411	0.432	201,261	4.05E+10
Total Independent	4,761,164	0.258	1,227,048	1.51E+12
40% Correlated	4,761,164	0.441	2,099,311	4.41E+12
100% Correlated	4,761,164	0.622	2,959,611	8.76E+12

Parameter Risk CV	0.134
Total CV	0.461
Selected CV	0.461

Estimate the parameter risk CV

Paid To Date	tail 1.050		
3,347,538	281,657	114,280	449,034
1,234,441	173,953	112,231	235,675
2,177,108	518,068	409,213	626,924
1,106,743	-	-	-
1,636,386	-	-	-
1,977,962	405,551	306,653	504,449
1,826,493	526,228	434,903	617,553
1,425,409	922,599	851,328	993,869
762,253	1,467,698	1,429,585	1,505,810
24,007	465,411	464,211	466,611
Unpaid	4,761,164	4,122,404	5,399,925
CV	0.134		

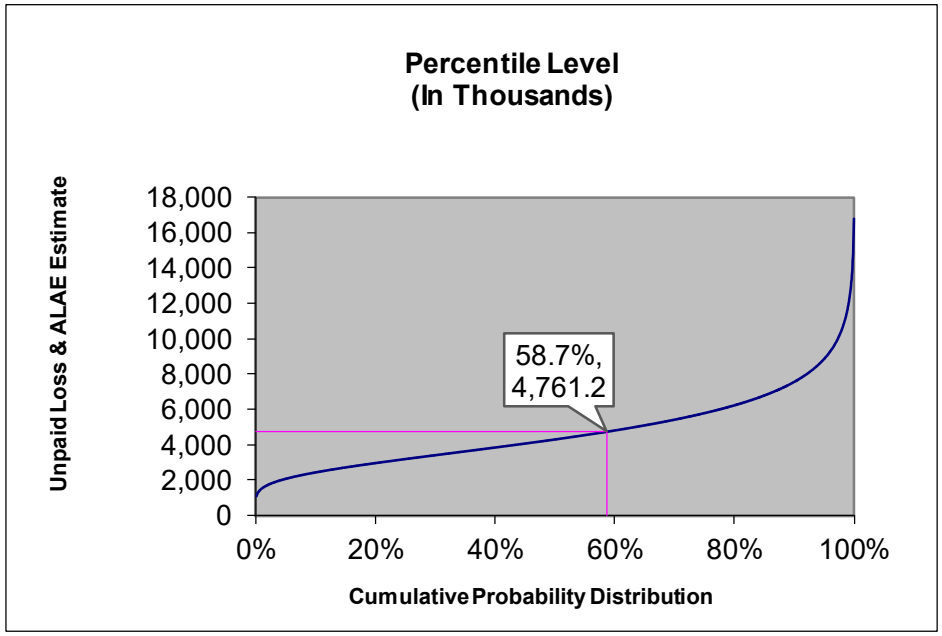
Method 2: Triangle Model

- Calculate percentiles of the lognormal

Parameters of a Lognormal Curve Fit

Coefficient of Variation	0.461
σ	0.439
σ^2	0.193
μ	(0.096)

Percentile Level Factors		**Unpaid**
99.0%	2.521	12,003,104
98.0%	2.237	10,649,660
95.0%	1.869	8,900,198
90.0%	1.594	7,588,461
80.0%	1.314	6,256,080
70.0%	1.143	5,443,014
60.0%	1.015	4,832,549
50.0%	0.908	4,324,022
40.0%	0.813	3,869,007



Method 3: Simulation

- Create simulation model
  - This is in development
  - Frequency is based on traditional analysis
    - Open counts, IBNR counts, Re-open counts
    - If you use Poisson distribution, consider adding parameter risk
  - Severity is based on claims data
    - Trend and develop claims
    - Which claims to include?
      - Reserves include claims that remain open, tend to be more complex
      - Balance homogeneity and credibility
    - Consider adding parameter risk

Method 3: Simulation

- Create simulation model (continued)
  - Challenges
    - For workers' compensation, should you model the ultimate value of the claim? The unpaid amount? The IBNR amount?
    - Should claims be independent or correlated? How about in extreme cases?
    - How do you reconcile results of the simulation model to the actuarial central estimate determined by traditional methods?
    - Would predictive modeling improve estimates?
    - This method requires more time.

Method 3: Simulation

- Base simulation on unpaid amounts
  - Frequency
    - 87 open claims are fixed
    - IBNR and re-open claims combined.
      - Expected value is 13
      - Add parameter uncertainty to Poisson distribution

Probability	Mean
0.25	11.05
0.48	13.00
0.18	14.30
0.09	15.81

Method 3: Simulation

- Base simulation on unpaid amounts (continued)
  - Severity
    - Need a series of loss runs
      - For claims that were open at 14 months, want paid value at 14 months and ultimate value.
        - Test incurred development and case development to estimate ultimate by claim.
        - How to reflect limit?
      - Could also test claims open at 26, 38, etc. but need to balance credibility and homogeneity.
      - Trend to common date
        - Current average open is about 2017/18

Method 3: Simulation

- Base simulation on unpaid amounts (continued)
  - Severity (continued)
    - Assume lognormal curve (could use others)
    - Test maximum likelihood estimates and method of moments estimates.
    - These are based on limited losses, so multiply mean by 1.3 (excess loss factor) and keep CV = 5

	M.O.M	M.L.E.	Selected
Mean	23,840	45,954	45,954
SD	75,512	2,370,083	229,772
CV	3.17	51.57	5.00

Method 3: Simulation

- Base simulation on unpaid amounts (continued)
  - Model just caps unpaid at $500k, could set it up to simulate the actual open claims. Would lower the estimates.
  - Correlation has a large influence

	Independent	10% Correlation	40% Correlation	MLE 10% Correlation
Mean	4,670,687	4,679,208	4,671,155	2,301,286
99%	7,169,885	12,251,119	22,750,055	7,964,112
98%	6,836,893	10,943,175	19,346,883	6,826,630
95%	6,357,153	9,183,314	14,430,630	5,454,809
90%	5,931,350	7,842,062	10,903,580	4,396,968
80%	5,456,659	6,398,880	7,275,084	3,391,256
70%	5,120,383	5,490,622	5,300,262	2,779,477
60%	4,853,648	4,826,647	3,993,848	2,298,727
50%	4,610,621	4,246,655	3,015,227	1,918,174
40%	4,365,187	3,743,673	2,277,305	1,595,039

Comparison of Percentiles

	Aggregate Model	Triangle Model	Individual Claim Model
Mean	4,761,164	4,761,164	4,679,208
99%	12,573,197	12,003,104	12,251,119
98%	11,080,471	10,649,660	10,943,175
95%	9,167,008	8,900,198	9,183,314
90%	7,745,994	7,588,461	7,842,062
80%	6,316,808	6,256,080	6,398,880
70%	5,452,876	5,443,014	5,490,622
60%	4,808,940	4,832,549	4,826,647
50%	4,276,005	4,324,022	4,246,655
40%	3,802,131	3,869,007	3,743,673

Ranges & Percentiles

Questions?

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