Unpaid Claim Variability for a Multi-Line Non-Life Insurance Company

Presented by:
Mark R. Shapland, FCAS, ASA, MAAA
Consulting Actuary

October 1, 2009

Asociación Mexicana de Actuarios Conference
Hotel Melia Azul – Ixtapa Zihuatanejo, Mexico

Milliman

Background on Case Study

- Building an Economic Capital (EC) model is complex
- Risk transfer is at the core of insurance and thus an EC model
- Largest risk transfer element and Balance Sheet item for most Non-Life insurers is Unpaid Claims
- Balance Sheets require a single-point or deterministic estimate
- Need to estimate Distribution of Possible Outcomes (Claim Variability) for EC

Economic Capital – Fundamental Concepts

- Confidence level, risk metrics, time horizons, etc. issues also apply to Non-Life (Section I)
- Wide variety of models available to estimate claim variability (Section II.E)
- Many models address Parameter and Process Risk.
- Using multiple models helps to address Model Risk.
- Models of distributions of possible outcomes can also provide cash flow and pricing risk analysis tools in addition to unpaid claim risk.
- Unpaid claim variability is a key building block for an Economic Capital model.

Economic Capital – Fundamental Concepts

- Diagnostics are used to understand and interpret quality of models and output.

  "All models are wrong, some models are useful."

- Model correlation can take place at 3 levels:
  - Between model parameters in different segments (e.g., inflation)
  - Between random increments in different segments – claim payments
  - Between ultimate loss ratios in the future – pricing risk

Milliman

Unpaid Claims Case Study

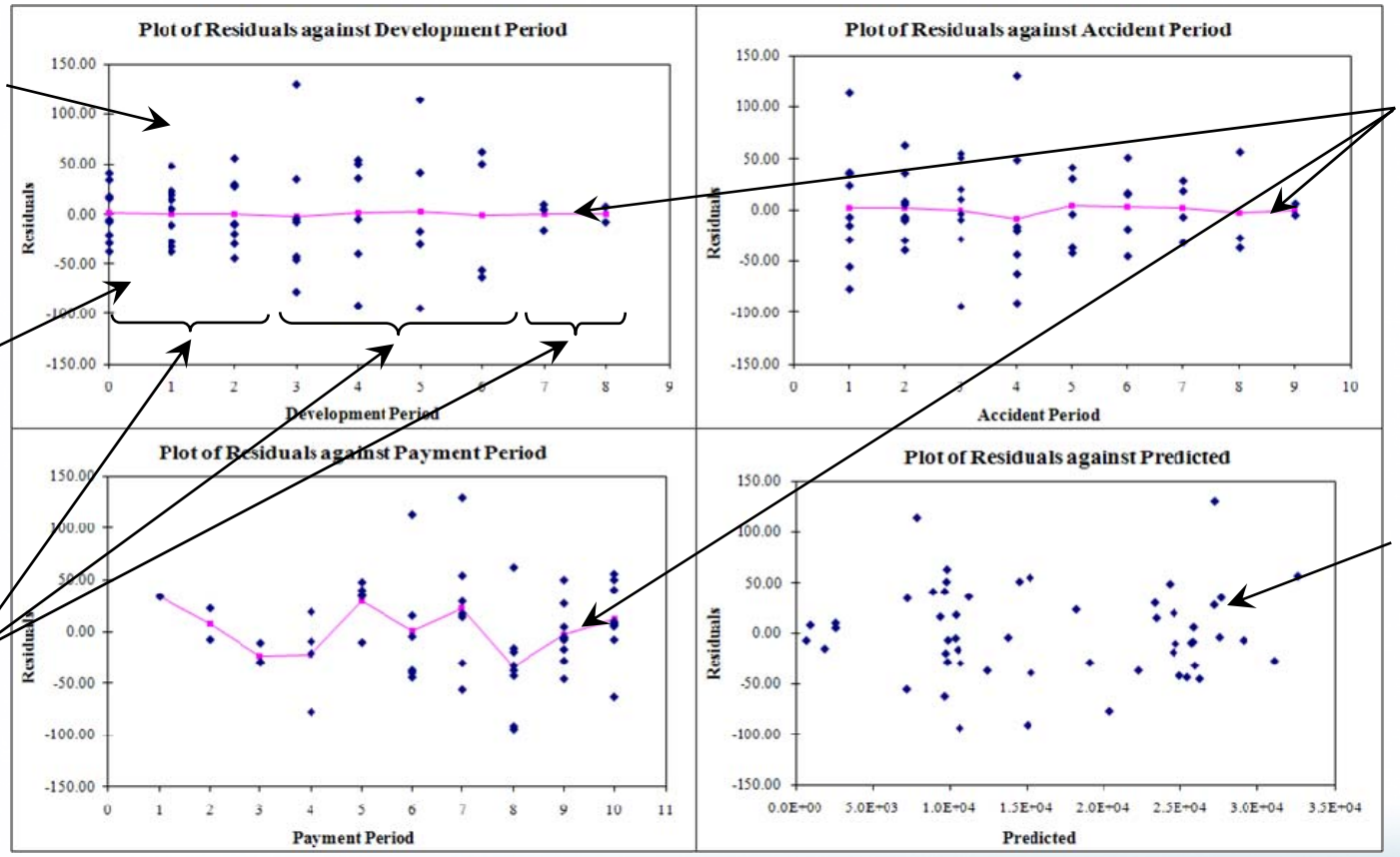
- Selected Bootstrap model to illustrate key input to Economic Capital:
  - Aggregate data (i.e., triangles) are readily available
  - Some parts of methodology are very well known (e.g., volume weighted average age-to-age factors)
  - Methodology reasonably commonly used and understood
  - While easy to use, also has sophisticated elements
  - Model framework allows for multiple models (e.g., chain ladder, Bornhuetter-Ferguson, Cape Cod)
  - Can “weight” multiple models to address model risk.
  - Appendix includes description of bootstrap model and correlation.

Unpaid Claims Case Study

- Sample Insurance Company (SIC) is a multi-line Non-Life company
- SIC writes coverage in 3 primary areas: property, casualty one and casualty two.
- Stable underwriting and claims handling environment for last 10 years with only modest exposure growth
- Property is exposed to weather related claims, but it is geographically diverse and not subject to major catastrophes
- Focused on casualty one

Unpaid Claims Case Study

Residual Graphs Prior to Heteroscedasticity Adjustment – Paid Loss



Are the variances all the same?

No

Adjusting the model to fit the data, here's what happens.

It looks like we have 3 different variances.

Does the model explain all the trends?

✓ **Yes**

Do you have only random noise left?

✓ **Yes**

Checking residual plots is a good way to test assumptions.

Milliman

Unpaid Claims Case Study

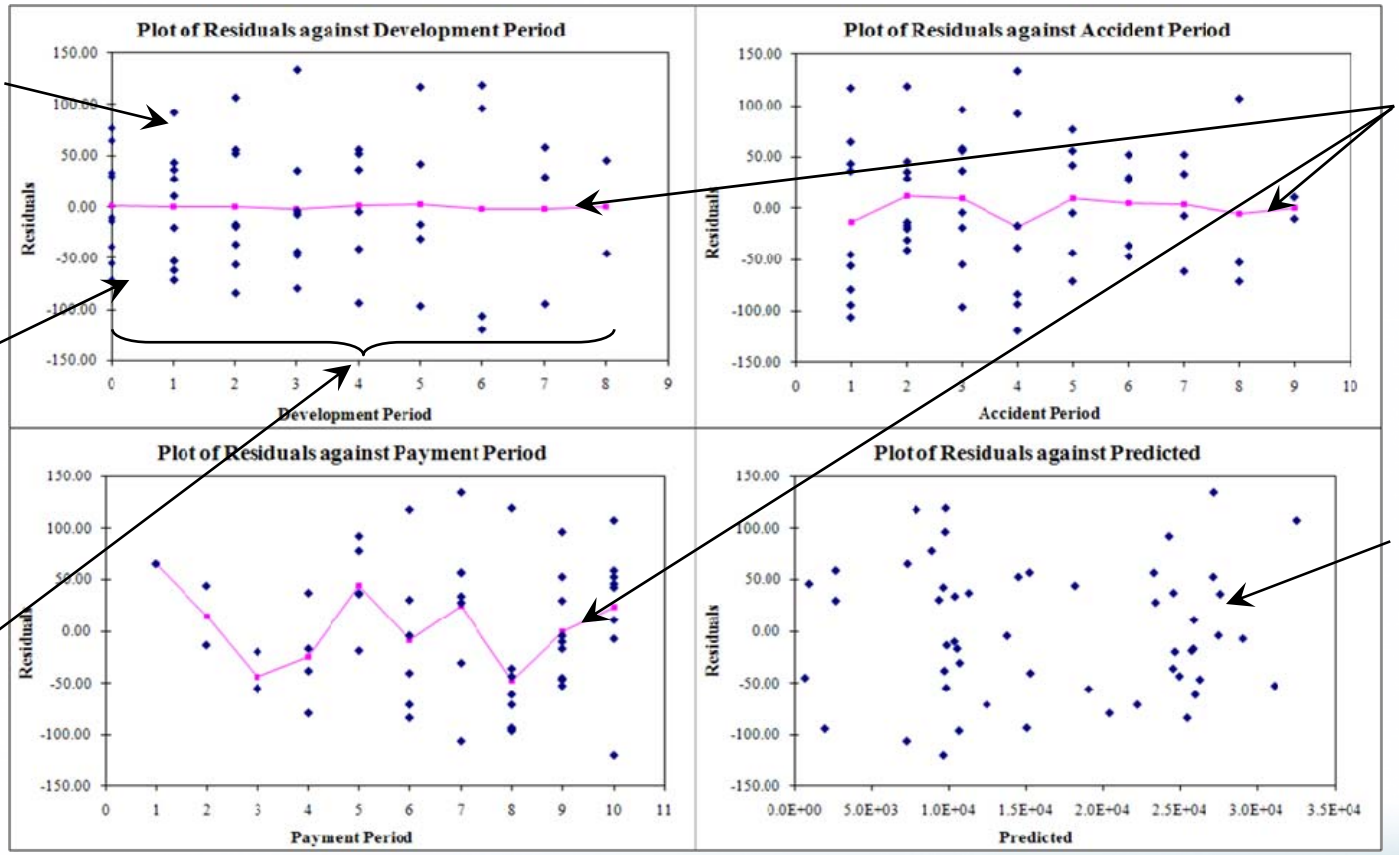
Residual Graphs After Heteroscedasticity Adjustment – Paid Loss

Are the variances now the same?

✓ **Yes**

Adjusting the model to fit the data, here's what happens.

Now we have the same variance.



Are the trends still explained by the model?

✓ **Yes**

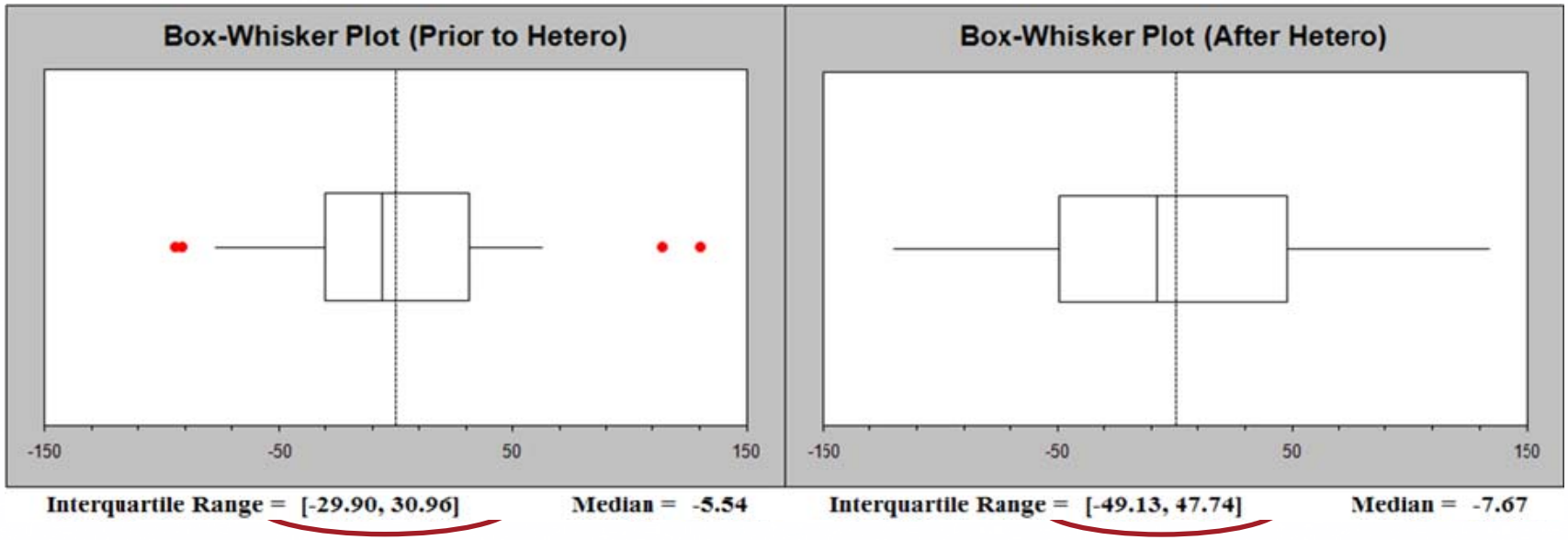
Do you still have random noise left?

✓ **Yes**

If the model describes the data, it becomes a better predictor.

Milliman

Unpaid Claims Case Study



Normality before adjustments

Outliers before adjustments

Normality after adjustments

No outliers after adjustments

Both residuals are not Normal, Normality test helps to determine the fit.

Milliman

Unpaid Claims Case Study

Casualty One
Accident Year Unpaid
Paid Chain Ladder Model

Accident Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.0% Percentile
1999	-	-	0.0%	-	-	-	-	-	-
2000	-	-	0.0%	-	-	-	-	-	-
2001	976	454	46.5%	61	3,281	916	1,246	1,819	2,225
2002	3,596	993	27.6%	1,029	8,937	3,505	4,197	5,400	6,235
2003	12,187	4,270	35.0%	2,913	39,429	11,645	14,707	19,850	23,782
2004	22,792	8,796	38.6%	5,230	62,407	21,546	27,858	39,518	48,890
2005	41,378	14,172	34.3%	6,231	101,480	39,797	50,516	66,463	80,247
2006	84,576	22,276	26.3%	33,391	173,224	82,471	98,243	124,937	143,191
2007	97,687	26,188	26.8%	23,024	192,785	95,807	114,852	144,415	164,088
2008	112,068	45,828	40.9%	17,001	294,564	108,003	143,382	190,353	233,141
Totals	375,258	65,906	17.6%	178,745	642,724	370,784	419,399	486,903	545,865
Normal Dist.	375,258	65,906	17.6%			375,258	419,711	483,664	528,579
logNormal Dist.	375,318	66,906	17.8%			369,493	416,310	494,260	557,576
Gamma Dist.	375,258	65,906	17.6%			371,407	417,364	489,835	545,348
TVaR						427,997	461,990	523,880	575,418
Normal TVaR						427,843	459,032	511,203	550,912
logNormal TVaR						428,009	464,459	533,362	592,941
Gamma TVaR						427,618	462,007	523,994	574,816

The [illegible] year.

Milliman

Unpaid Claims Case Study

Casualty One
Calendar Year Unpaid
Paid Chain Ladder Model

Calendar Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.0% Percentile
2009	123,393	22,538	18.3%	58,136	214,264	121,375	138,524	161,982	182,711
2010	96,444	22,279	23.1%	35,774	202,000	94,991	110,223	135,394	155,003
2011	70,278	20,395	29.0%	21,655	168,722	67,897	82,934	106,885	126,542
2012	42,389	14,170	33.4%	9,869	98,242	40,420	51,107	68,369	83,108
2013	24,833	9,366	37.7%	5,629	74,666	23,330	29,853	42,065	52,794
2014	13,409	5,411	40.4%	3,066	39,488	12,590	16,571	23,587	28,784
2015	3,577	1,312	36.7%	853	9,144	3,428	4,429	5,896	7,094
2016	934	558	59.8%	23	3,563	828	1,263	2,003	2,507
2017	-	-	0.0%	-	-	-	-	-	-
2018	-	-	0.0%	-	-	-	-	-	-
Totals	375,258	65,906	17.6%	178,745	642,724	370,784	419,399	486,903	545,865

Standard Error can be used to assess the variability in the cash flows.

Coefficient of Variation is a relative measure of risk.

Milliman

Unpaid Claims Case Study

Casualty One
Accident Year Ultimate Loss Ratios
Paid Chain Ladder Model

Accident Year	Mean Loss Ratio	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.0% Percentile
1999	59.5%	9.4%	15.7%	29.0%	89.8%	59.5%	66.0%	75.1%	80.6%
2000	74.3%	10.3%	13.8%	44.7%	110.0%	74.1%	81.3%	91.6%	98.3%
2001	68.2%	9.4%	13.8%	34.3%	96.8%	68.1%	74.6%	83.6%	89.3%
2002	65.7%	9.5%	14.4%	37.2%	96.1%	65.4%	72.3%	81.8%	87.5%
2003	60.2%	9.8%	16.2%	30.8%	96.4%	60.2%	66.6%	76.6%	83.6%
2004	61.1%	10.6%	17.3%	27.3%	103.7%	60.7%	68.1%	78.8%	87.0%
2005	61.8%	11.2%	18.1%	27.4%	109.9%	61.3%	69.2%	81.2%	89.4%
2006	65.6%	11.6%	17.6%	36.1%	109.2%	64.8%	72.9%	86.2%	94.3%
2007	48.1%	11.2%	23.2%	16.0%	86.4%	47.4%	55.6%	67.5%	75.5%
2008	40.8%	16.4%	40.1%	6.7%	104.1%	39.5%	52.0%	68.8%	83.4%
Totals	59.0%	4.3%	7.3%	47.0%	75.6%	58.9%	61.9%	66.3%	69.7%

Loss ratios can be cyclical, but Standard Error and Coefficient of Variation should be relatively constant.

Ultimate loss ratios can be used for future pricing analysis!

Milliman

Unpaid Claims Case Study

Casualty One
Accident Year Incremental Values by Development Period
Paid Chain Ladder Model

Accident Year	Mean Values										
	12	24	36	48	60	72	84	96	108	120	120+
1999	7,278	18,357	19,080	20,562	11,629	8,027	7,161	1,974	723	-	-
2000	9,874	24,855	25,677	27,491	15,255	10,476	9,942	2,663	969	-	-
2001	9,797	24,417	25,614	27,153	15,164	10,729	9,660	2,636	976	-	-
2002	9,758	24,331	25,305	27,215	14,969	10,401	9,592	2,634	962	-	-
2003	9,064	22,469	23,150	25,018	14,096	9,786	8,857	2,430	900	-	-
2004	9,261	23,423	24,616	26,384	14,417	9,862	9,430	2,561	938	-	-
2005	10,366	26,004	27,007	28,932	16,231	11,116	10,157	2,829	1,045	-	-
2006	12,429	31,083	32,689	34,468	19,198	13,671	12,589	3,399	1,252	-	-
2007	10,401	25,788	27,053	28,643	16,451	11,395	10,294	2,812	1,038	-	-
2008	9,300	23,314	24,665	26,537	14,639	10,095	9,345	2,538	934	-	-

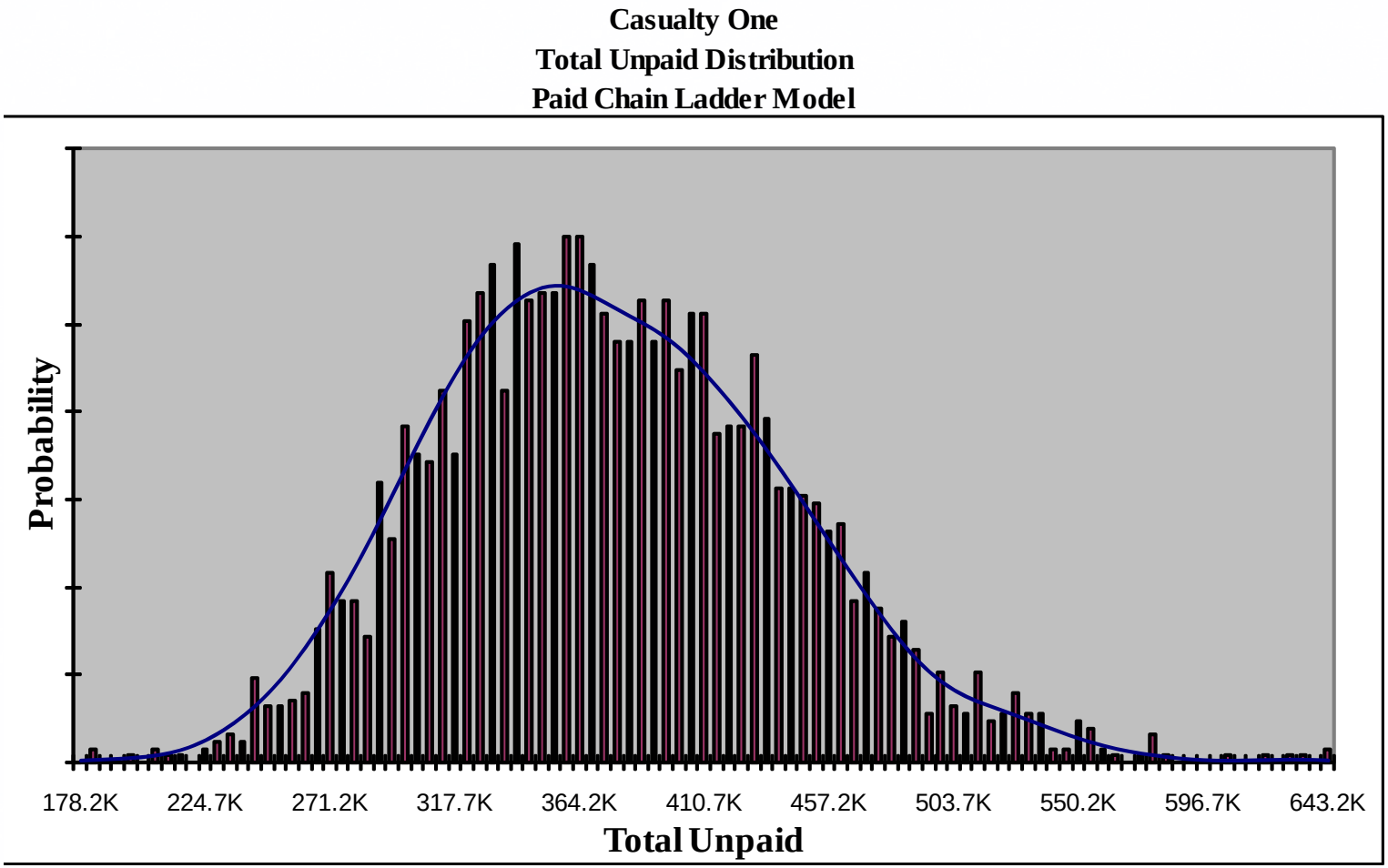
Casualty One
Accident Year Incremental Values by Development Period
Paid Chain Ladder Model

Accident Year	Standard Error Values										
	12	24	36	48	60	72	84	96	108	120	120+
1999	2,952	4,774	4,766	9,238	6,836	5,660	2,890	470	291	-	-
2000	3,486	5,303	5,481	10,669	7,766	6,606	3,413	556	342	-	-
2001	3,444	5,432	5,457	10,497	8,008	6,567	3,366	564	454	-	-
2002	3,324	5,410	5,437	10,464	7,872	6,616	3,353	795	465	-	-
2003	3,283	5,236	5,272	10,136	7,594	6,309	3,916	779	436	-	-
2004	3,406	5,228	5,384	10,407	7,742	6,949	4,245	807	459	-	-
2005	3,528	5,485	5,662	10,982	9,146	7,652	4,248	868	500	-	-
2006	3,893	6,003	6,211	13,622	10,376	8,763	4,934	916	559	-	-
2007	3,508	5,617	8,239	12,940	9,529	8,209	4,501	899	510	-	-
2008	3,330	10,232	10,796	15,279	10,237	8,070	5,249	1,175	558	-	-

Check rows and columns for consistency.

Milliman

Unpaid Claims Case Study



Is the shape of the distribution reasonable?

Milliman

Unpaid Claims Case Study

Accident Year	Model Weights by Accident Year						
	Chain Ladder		Bornhuetter-Ferguson		Cape Cod		
	Paid	Incurred	Paid	Incurred	Paid	Incurred	TOTAL
1999	50.0%	50.0%					100.0%
2000	50.0%	50.0%					100.0%
2001	50.0%	50.0%					100.0%
2002	50.0%	50.0%					100.0%
2003	50.0%	50.0%					100.0%
2004	50.0%	50.0%					100.0%
2005	50.0%	50.0%					100.0%
2006			25.0%	25.0%	25.0%	25.0%	100.0%
2007			25.0%	25.0%	25.0%	25.0%	100.0%
2008			25.0%	25.0%	25.0%	25.0%	100.0%

With multiple distributions, need to weight to get "best estimate".

Milliman

Unpaid Claims Case Study

Casualty One
Summary of Results by Model

Accident Year	Mean Estimated Unpaid						
	Chain Ladder		Bornhuetter Ferguson		Cape Cod		Best Est.
	Paid	Incurred	Paid	Incurred	Paid	Incurred	(Weighted)
1999	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-
2001	976	1,207	1,032	1,240	907	1,145	1,090
2002	3,596	4,656	3,871	4,817	3,518	4,646	4,105
2003	12,187	16,438	13,330	20,228	13,127	17,868	14,231
2004	22,792	30,589	24,157	37,519	24,588	32,670	26,673
2005	41,378	55,528	41,710	59,644	45,017	58,288	48,336
2006	84,576	110,101	100,078	109,110	88,926	110,051	101,536
2007	97,687	121,158	137,189	146,400	143,199	157,838	145,932
2008	112,068	142,762	185,269	172,251	201,321	202,841	189,555
Totals	375,258	482,439	506,636	551,208	520,603	585,346	531,458

Range of Mean Estimates

Best Estimate of the Mean

Milliman

Unpaid Claims Case Study

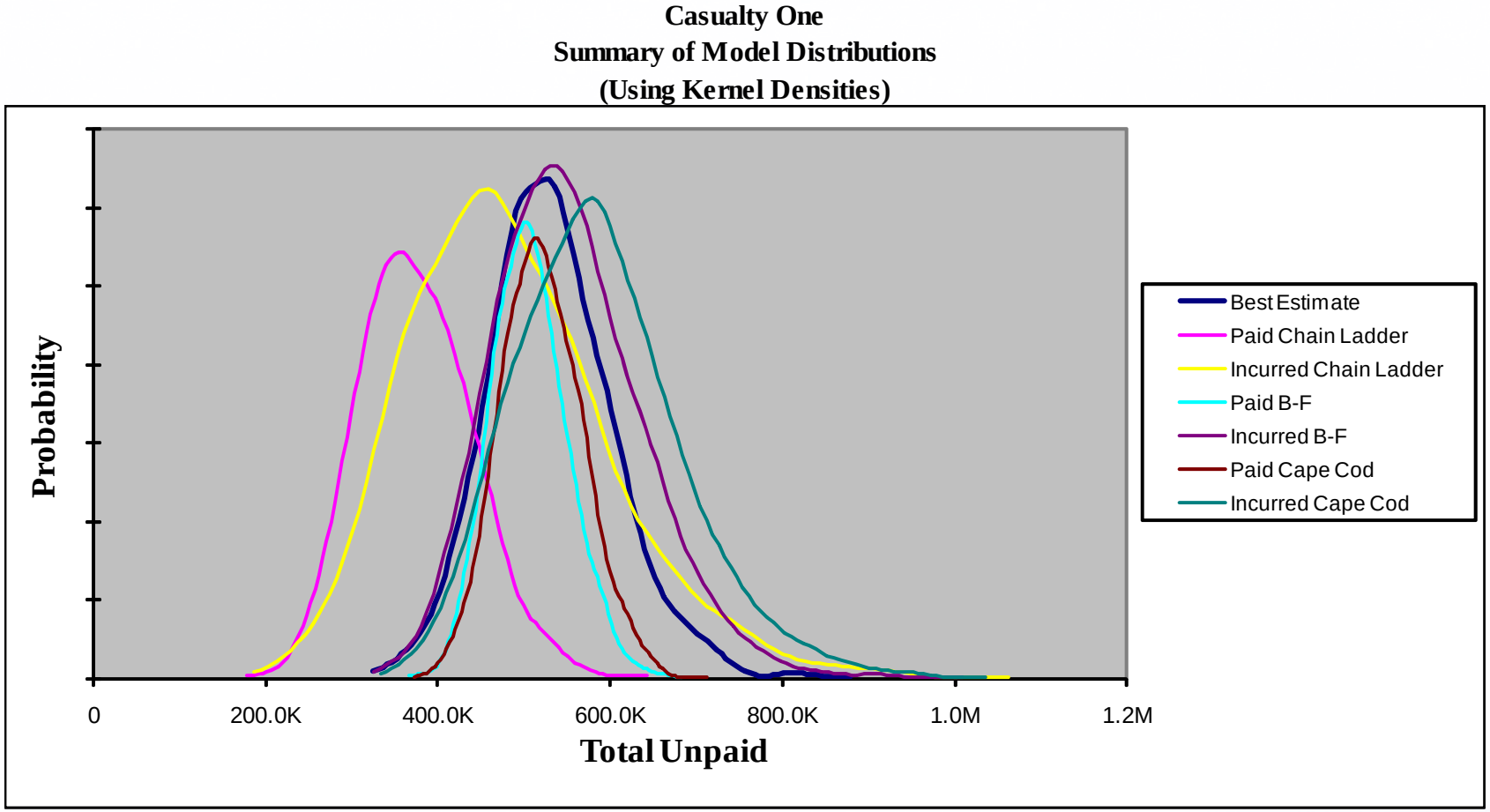
Casualty One
Accident Year Unpaid
Best Estimate (Weighted)

Accident Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.0% Percentile
1999	-	-	0.0%	-	-	-	-	-	-
2000	-	-	0.0%	-	-	-	-	-	-
2001	1,090	561	51.5%	92	4,011	986	1,400	2,138	2,907
2002	4,105	1,446	35.2%	1,027	12,262	3,850	4,873	6,840	8,694
2003	14,231	5,952	41.8%	3,270	43,752	13,248	17,399	25,426	33,551
2004	26,673	12,366	46.4%	5,512	117,480	24,462	32,539	49,433	68,566
2005	48,336	20,344	42.1%	6,231	159,440	45,136	58,707	88,891	111,742
2006	101,536	29,029	28.6%	34,484	267,750	97,546	117,790	156,226	189,465
2007	145,932	36,889	25.3%	47,377	415,623	141,425	163,623	215,319	263,222
2008	189,555	47,174	24.9%	68,217	470,041	187,980	212,051	273,525	327,577
Totals	531,458	72,925	13.7%	325,354	878,155	527,167	575,720	658,026	722,120
Normal Dist.	531,458	72,925	13.7%			531,458	580,645	651,409	701,106
logNormal Dist	531,470	73,048	13.7%			526,520	577,415	659,386	723,818
Gamma Dist.	531,458	72,925	13.7%			528,126	578,661	656,823	715,657
TVaR						588,000	626,587	703,503	772,366
Normal TVaR						589,644	624,153	681,881	725,818
logNormal TVaR						589,301	627,978	699,103	758,866
Gamma TVaR						589,491	626,789	692,999	746,498

Best estimate will have all the same outputs as each model.

Milliman

Unpaid Claims Case Study



The best estimate is a weighted average of individual models

Milliman

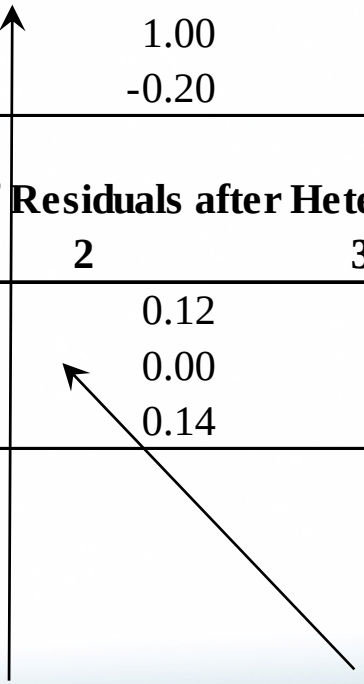
Unpaid Claims Case Study

Rank Correlation of Residuals after Hetero Adjustment - Paid

LOB	1	2	3
1	1.00	-0.22	0.22
2	-0.22	1.00	-0.20
3	0.22	-0.20	1.00

P-Values of Rank Correlation of Residuals after Hetero Adjustment - Paid

LOB	1	2	3
1	0.00	0.12	0.12
2	0.12	0.00	0.14
3	0.12	0.14	0.00

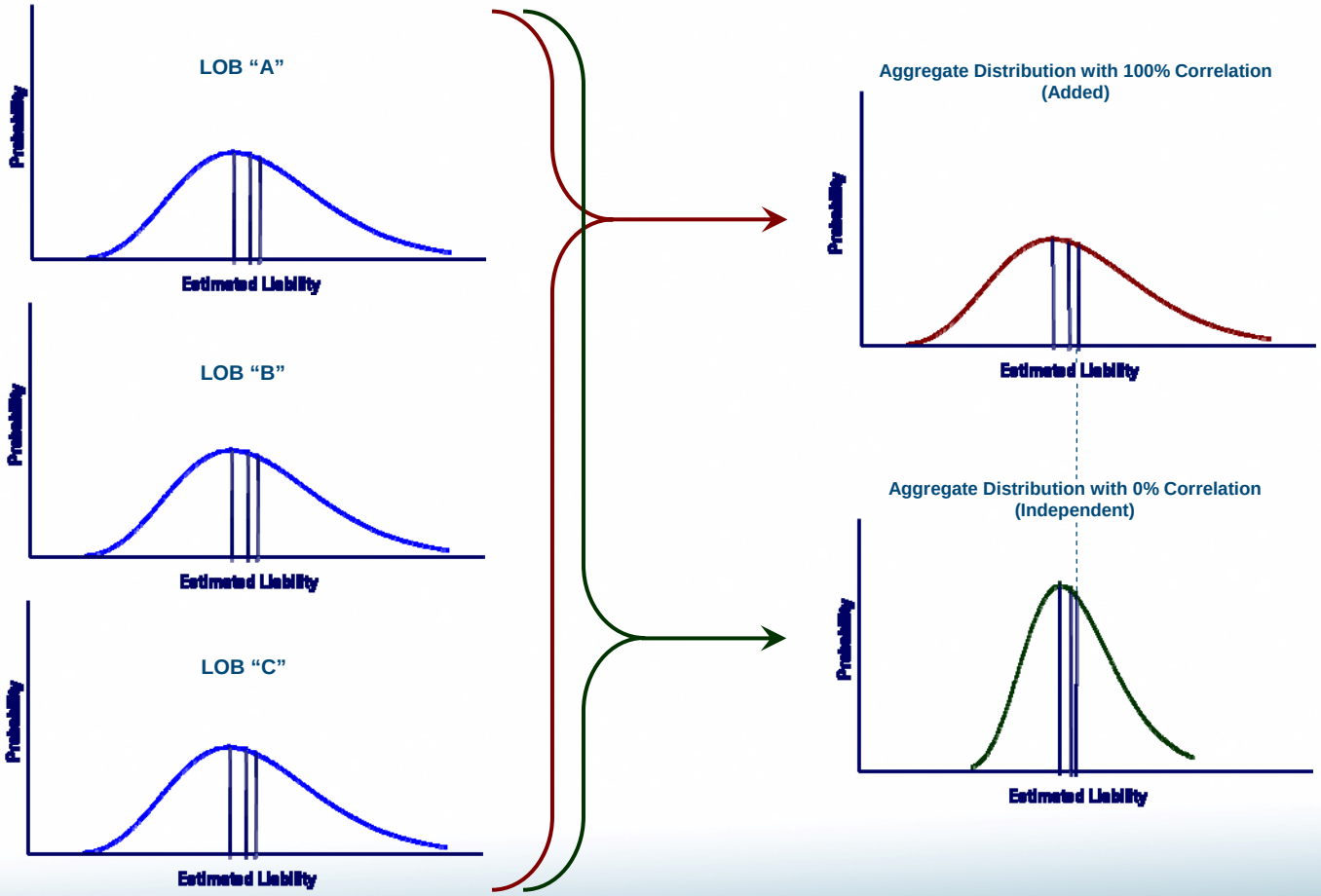


Analyst should both measure and evaluate correlation.

Milliman

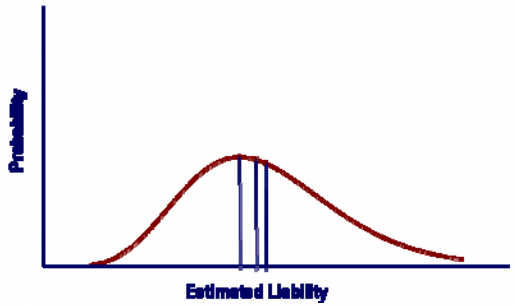
Unpaid Claims Case Study

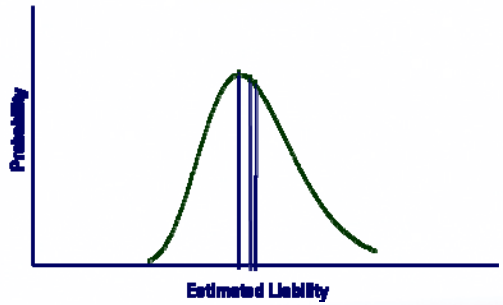
Adding the distributions to get the aggregate is not enough



Milliman

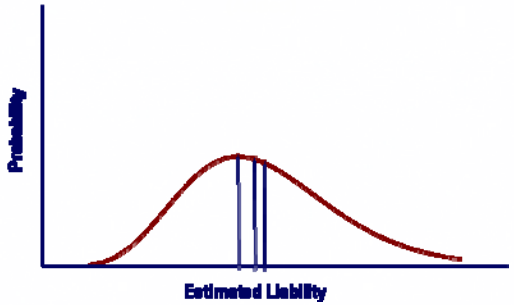
Unpaid Claims Case Study

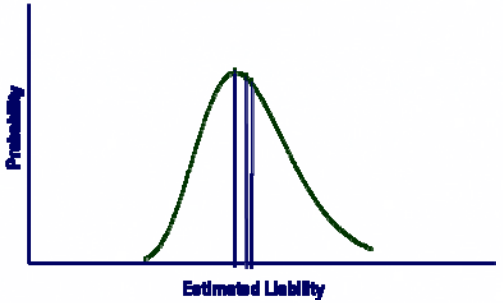




Milliman

Unpaid Claims Case Study

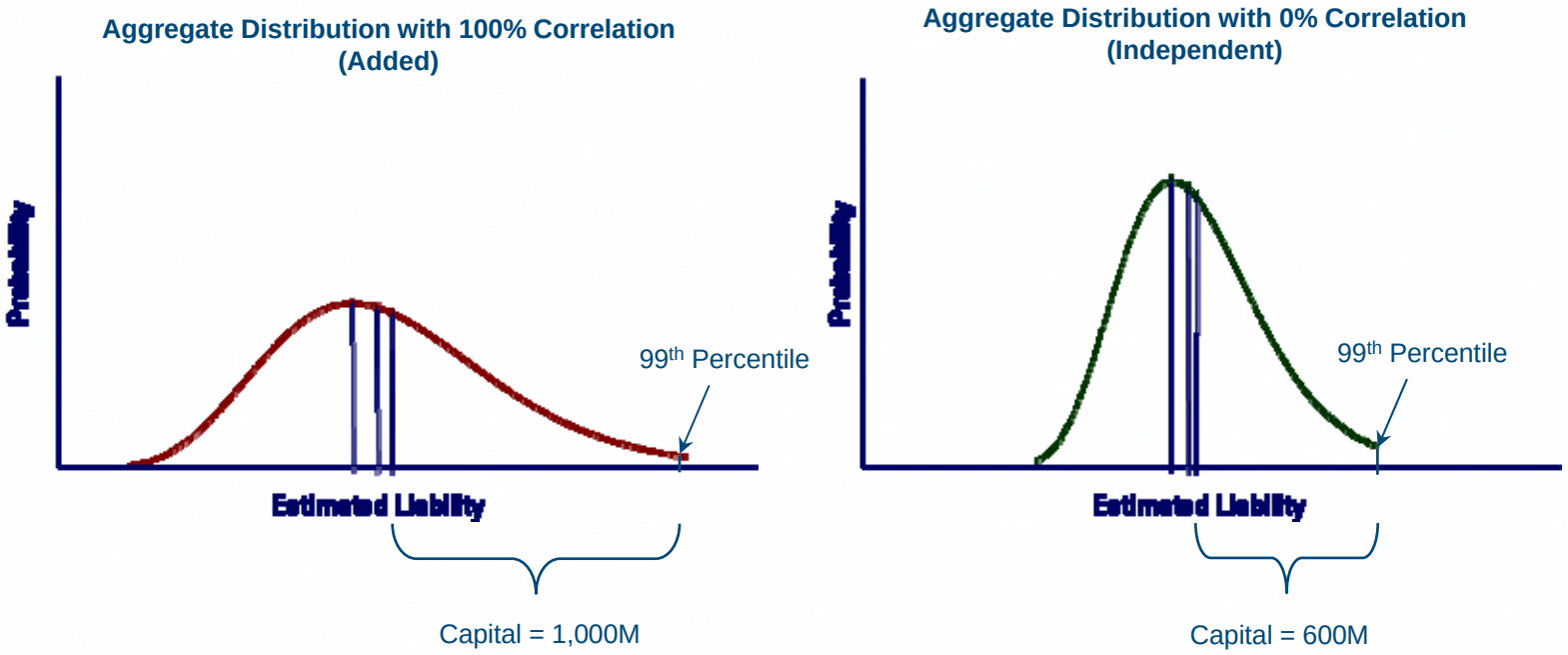




Milliman

Unpaid Claims Case Study

How much capital you need depends on correlation



Milliman

Unpaid Claims Case Study

Aggregate All Lines of Business
Accident Year Unpaid

Accident Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.0% Percentile
1999	16,435	9,051	55.1%	-	58,465	15,486	21,569	33,056	42,454
2000	16,831	9,141	54.3%	-	58,719	15,986	22,173	33,077	41,801
2001	19,358	9,461	48.9%	473	59,797	18,449	24,986	36,711	46,414
2002	30,685	12,420	40.5%	3,627	83,178	29,864	38,764	52,499	61,836
2003	40,009	12,788	32.0%	8,705	93,308	38,907	47,989	62,282	73,247
2004	62,956	18,184	28.9%	16,743	173,665	61,589	73,761	93,988	112,889
2005	123,202	30,348	24.6%	49,952	256,752	121,242	142,119	174,216	204,499
2006	210,465	39,193	18.6%	88,361	358,102	208,243	234,493	278,841	313,267
2007	303,949	45,030	14.8%	190,743	568,321	299,581	330,647	382,138	437,422
2008	560,718	61,724	11.0%	362,079	826,297	556,150	599,796	666,590	719,999
Totals	1,384,609	144,806	10.5%	988,951	1,942,710	1,381,216	1,478,766	1,632,970	1,725,027
Normal Dist.	1,384,609	144,806	10.5%			1,384,609	1,482,279	1,622,793	1,721,477
logNormal Dist.	1,384,636	145,544	10.5%			1,377,049	1,477,936	1,636,181	1,757,343
Gamma Dist.	1,384,609	144,806	10.5%			1,379,564	1,479,335	1,631,087	1,743,565
TVaR						1,501,022	1,573,271	1,696,921	1,790,845
Normal TVaR						1,500,147	1,568,672	1,683,301	1,770,547
logNormal TVaR						1,500,233	1,575,453	1,710,765	1,821,875
Gamma TVaR						1,499,971	1,572,743	1,700,205	1,801,856

Aggregate best estimate will also have all the same outputs.

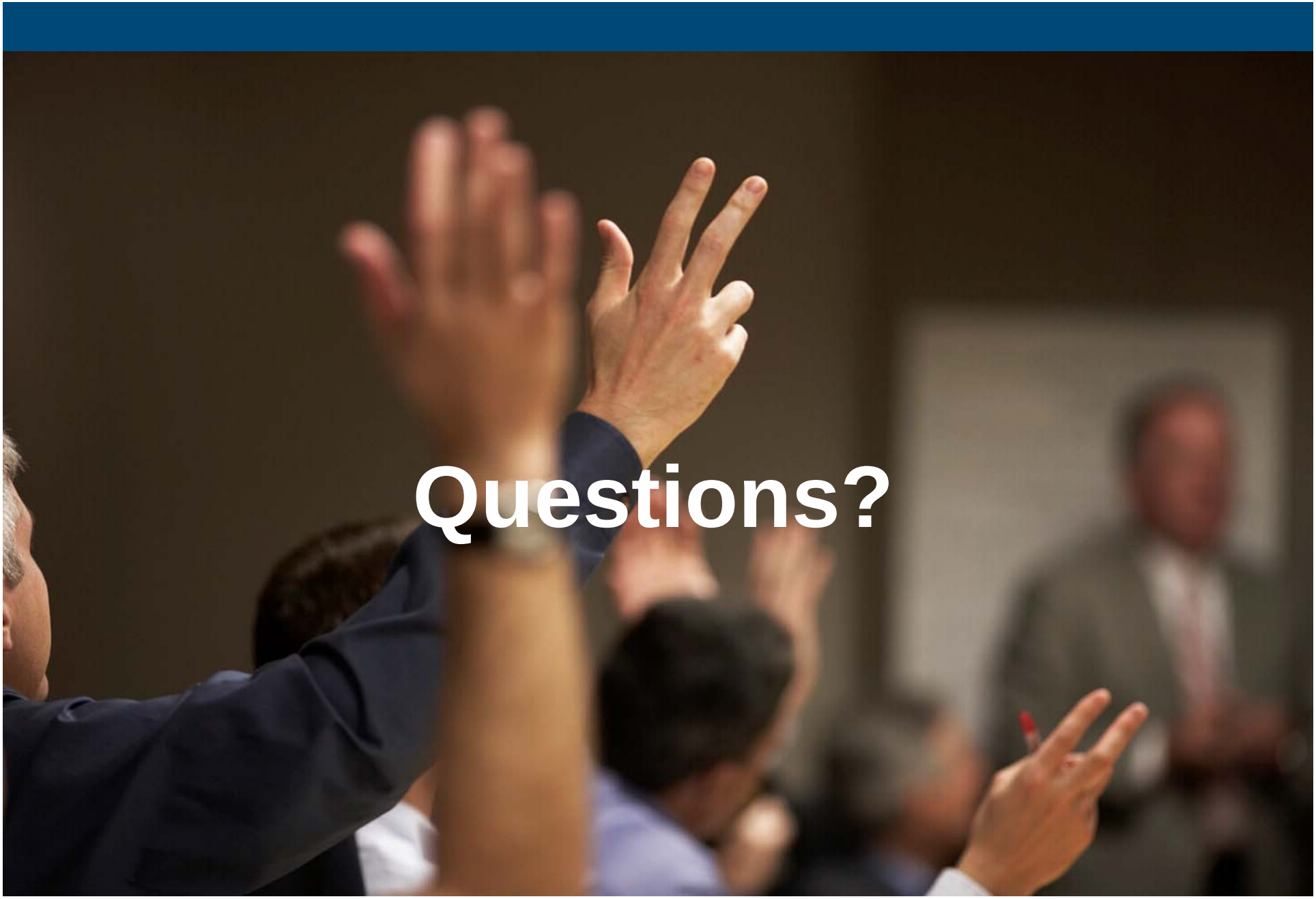
Milliman

Unpaid Claims Case Study

	Indicated Unpaid-claims-risk Portion of Required Capital as of December 31, 2008 (No Discounting, Modeled Correlation, in 000s)					
	(1) 2008 Premium	(2) Mean Unpaid	(3) 99.0% Unpaid	(4) (3) – (2) Indicated VaR Risk Capital	(5) Allocated Unpaid Claim Risk Capital	(6) (5) / (1) Ratio
Property	1,716	136	199	63	36	2.1%
Casualty One	298	531	722	191	111	37.1%
Casualty Two	374	717	1,050	334	193	51.7%
Sum	2,387	1,385	1,972	587		
SIC Aggregate	2,387	1,385	1,725	340	340	14.3%

Model output is used for RBC and EC models.

Milliman



Milliman