Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon

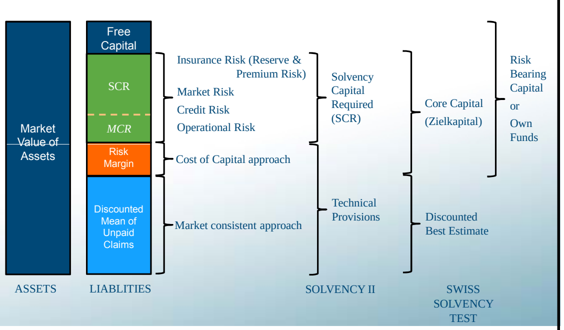
1 Casualty Loss Reserve Seminar
September 20 – 21, 2010

Agenda

- **Technical Provisions**
- Ultimate Time Horizon (t=0)
- One-Year Time Horizon (t=1)
  - Process Algorithm
  - Residual Algorithm
  - Possible Outcomes Algorithm
  - Focused VaR Algorithm
  - Focused Group VaR Algorithm
- Technical Provisions

2

Technical Provisions



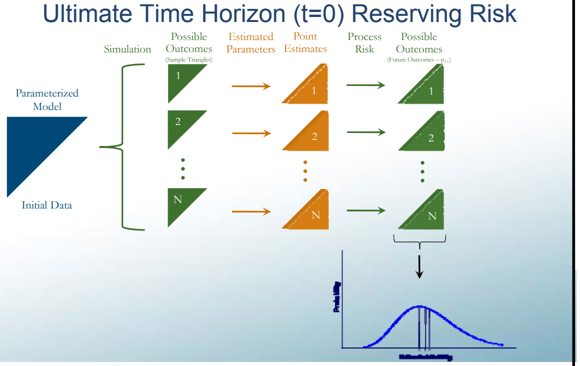
3

Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon

Agenda

- Technical Provisions
- **Ultimate Time Horizon (t=0)**
- One-Year Time Horizon (t=1)
  - Process Algorithm
  - Residual Algorithm
  - Possible Outcomes Algorithm
  - Focused VaR Algorithm
  - Focused Group VaR Algorithm
- Technical Provisions

Ultimate Time Horizon (t=0) Reserving Risk



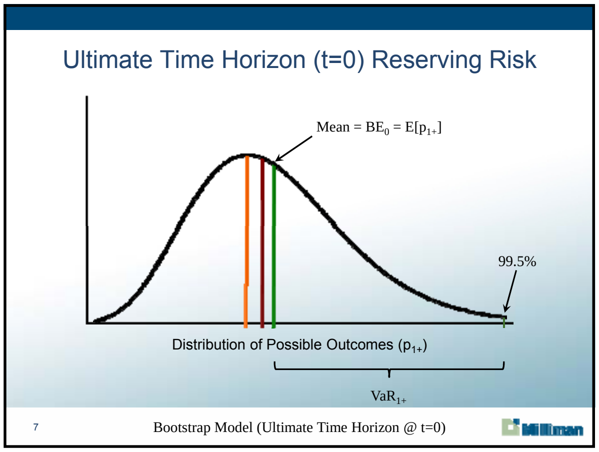
Ultimate Time Horizon (t=0) Reserving Risk

Many models are based on paid data only. Should also use incurred data to reflect information in case reserves.

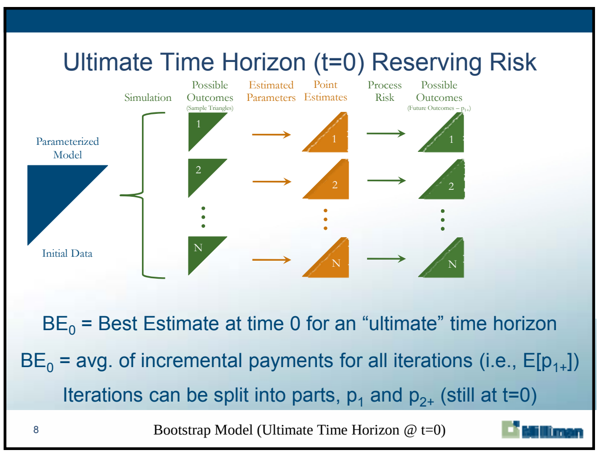
Many models only use chain ladder methodology. Could also use Bornhuetter-Ferguson and Cape Cod methodologies.

Could also “weight” models and “shift” to reconcile with your deterministic “best estimate” – i.e., output converted to distribution of paid cash flow (p_{1+}) reconciled to your ultimate “best estimate”.

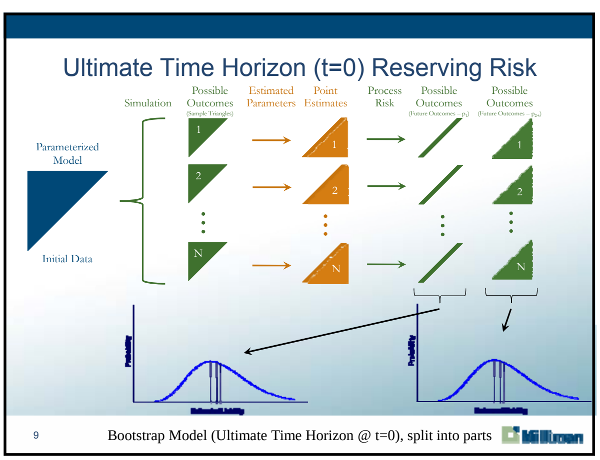
Finally, aggregation of LOB data into a consolidated corporate result needs to be addressed, even though this is for one LOB.



Ultimate Time Horizon (t=0) Reserving Risk
Mean = BE_0 = $E[p_{1+}]$
99.5%
Distribution of Possible Outcomes (p_{1+})
VaR_{1+}
7
Bootstrap Model (Ultimate Time Horizon @ t=0)

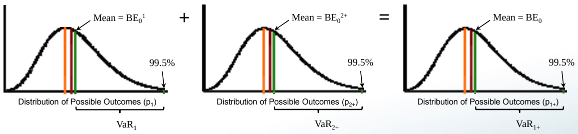


Ultimate Time Horizon (t=0) Reserving Risk
Simulation
Possible Outcomes
Estimated Parameters
Point Estimates
Process Risk
Possible Outcomes
Parameterized Model
Initial Data
BE_0 = Best Estimate at time 0 for an "ultimate" time horizon
BE_0 = avg. of incremental payments for all iterations (i.e., $E[p_{1+}]$)
Iterations can be split into parts, p_1 and p_{2+} (still at t=0)
8
Bootstrap Model (Ultimate Time Horizon @ t=0)



Ultimate Time Horizon (t=0) Reserving Risk
Simulation
Possible Outcomes
Estimated Parameters
Point Estimates
Process Risk
Possible Outcomes
Possible Outcomes
Parameterized Model
Initial Data
9
Bootstrap Model (Ultimate Time Horizon @ t=0), split into parts

Ultimate Time Horizon (t=0) Reserving Risk



- Some level of correlation (independence)
  - i.e., “+” is not technically correct for graphs (mean is OK)
- Note, $BE_0^1 + BE_0^{2+} = BE_0$ and usually, $VaR_1 + VaR_{2+} > VaR_{1+}$*
- But, $VaR_1 < VaR_{1+}$ (perhaps significantly less)
- $BE_0^1 = E[p_1]$ and $BE_0^{2+} = E[p_{2+}]$

* Sub-additivity of VaR can be a problem, but should normally not be an issue.

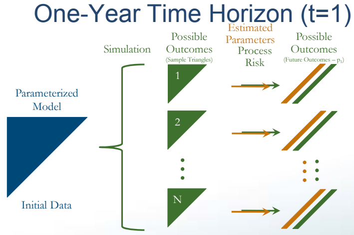
10 Bootstrap Model (Ultimate Time Horizon @ t=0), split into parts Milliman

Agenda

- Technical Provisions
- Ultimate Time Horizon (t=0)
- **One-Year Time Horizon (t=1)**
  - **Process Algorithm**
  - Residual Algorithm
  - Possible Outcomes Algorithm
  - Focused VaR Algorithm
  - Focused Group VaR Algorithm
- Technical Provisions

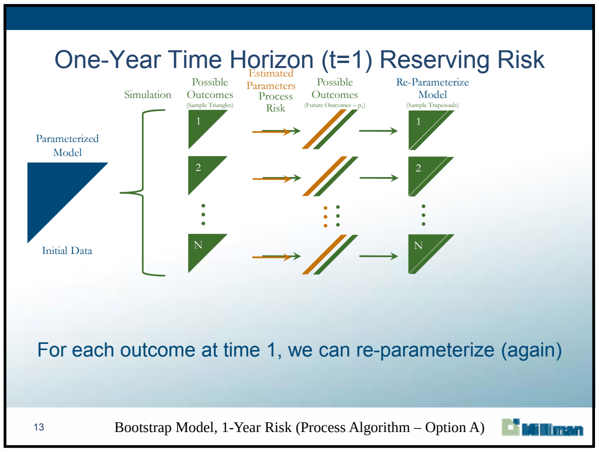
11 Milliman

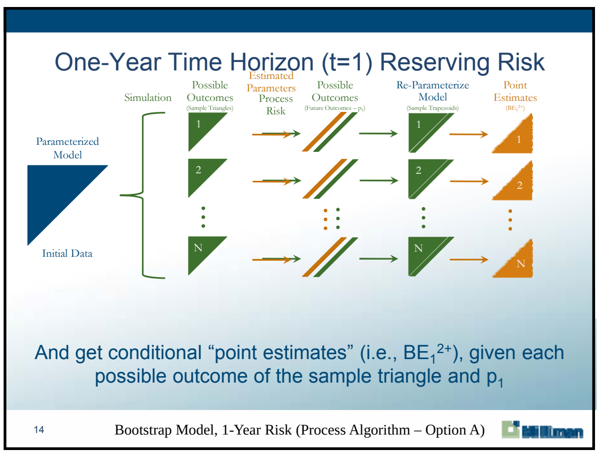
One-Year Time Horizon (t=1) Reserving Risk

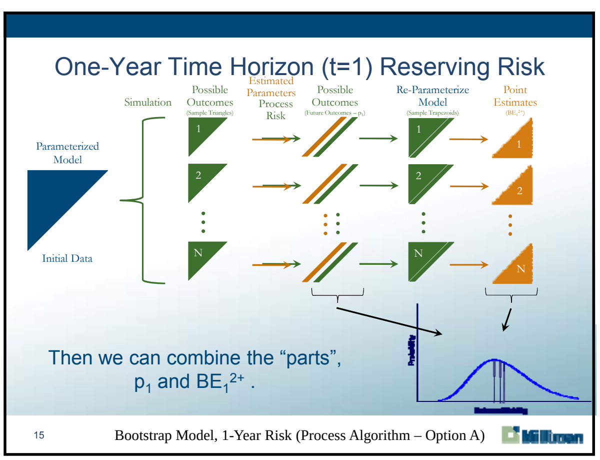


One Year Risk starts with the first diagonal

12 Bootstrap Model, 1-Year Risk (Process Algorithm – Option A) Milliman

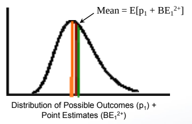

One-Year Time Horizon (t=1) Reserving Risk
Simulation
Possible Outcomes
Estimated Parameters
Process Risk
Possible Outcomes
Re-Parameterize Model
Parameterized Model
Initial Data
For each outcome at time 1, we can re-parameterize (again)
13
Bootstrap Model, 1-Year Risk (Process Algorithm – Option A)


One-Year Time Horizon (t=1) Reserving Risk
Simulation
Possible Outcomes
Estimated Parameters
Process Risk
Possible Outcomes
Re-Parameterize Model
Point Estimates
Parameterized Model
Initial Data
And get conditional "point estimates" (i.e., BE_1^{2+}), given each possible outcome of the sample triangle and p_1
14
Bootstrap Model, 1-Year Risk (Process Algorithm – Option A)


One-Year Time Horizon (t=1) Reserving Risk
Simulation
Possible Outcomes
Estimated Parameters
Process Risk
Possible Outcomes
Re-Parameterize Model
Point Estimates
Parameterized Model
Initial Data
Then we can combine the "parts", p_1 and BE_1^{2+} .
15
Bootstrap Model, 1-Year Risk (Process Algorithm – Option A)

Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon

One-Year Time Horizon (t=1) Reserving Risk

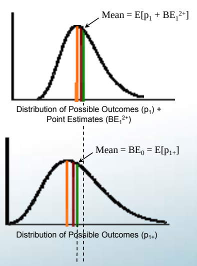


This results in a combined distribution of the outcomes of p_1 and each associated "point estimate" BE_1^{2+} (i.e., they are correlated).

We can then compare this to the original distribution.

16 Bootstrap Model, 1-Year Risk (Process Algorithm – Option A)

One-Year Time Horizon (t=1) Reserving Risk

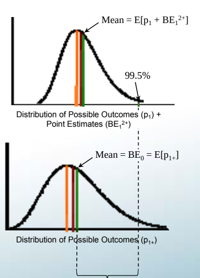


- In general, $E[p_1 + BE_1^{2+}] \neq BE_0$

  (In theory, they could be equal for symmetrical distributions)

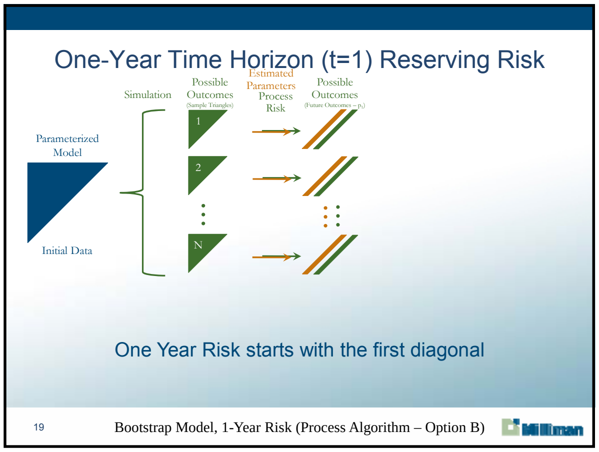
17 Bootstrap Model, 1-Year Risk (Process Algorithm – Option A)

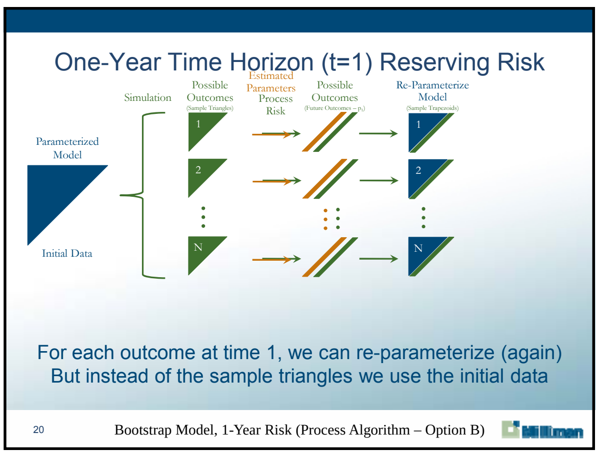
One-Year Time Horizon (t=1) Reserving Risk

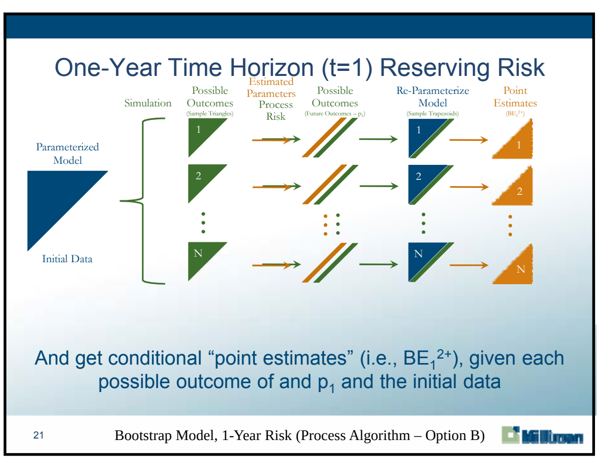


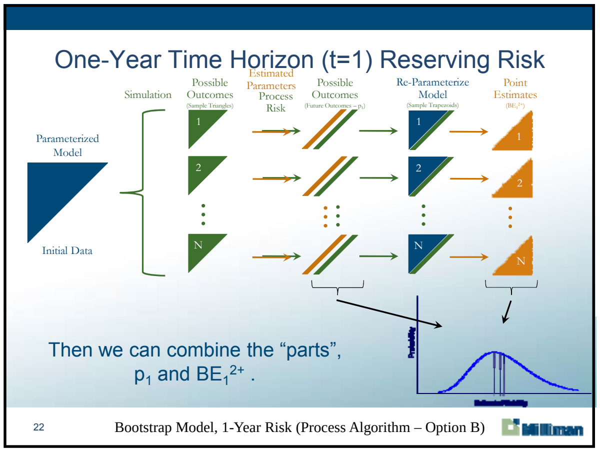
$VaR_{99.5}[(p_1 + BE_1^{2+}) - BE_0]$
$= VaR_{99.5}[p_1 + BE_1^{2+}] + (E[p_1 + BE_1^{2+}] - E[p_{1+}])$

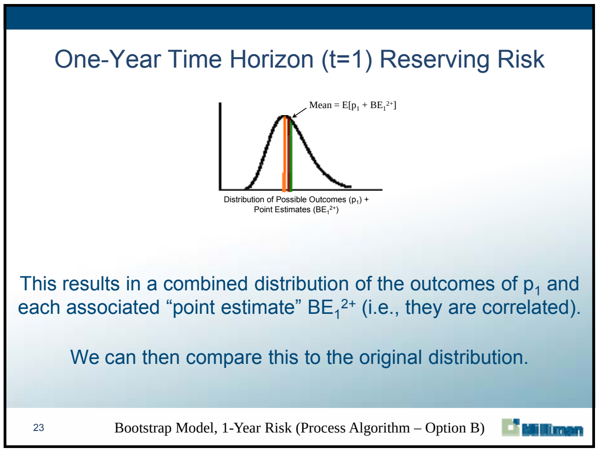
18 Bootstrap Model, 1-Year Risk (Process Algorithm – Option A)

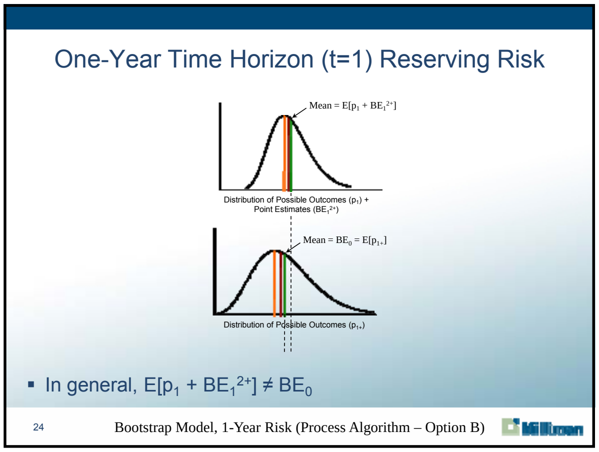

One-Year Time Horizon (t=1) Reserving Risk
Simulation
Possible Outcomes
Estimated Parameters Process Risk
Possible Outcomes
Parameterized Model
Initial Data
1
2
N
One Year Risk starts with the first diagonal
19
Bootstrap Model, 1-Year Risk (Process Algorithm – Option B)


One-Year Time Horizon (t=1) Reserving Risk
Simulation
Possible Outcomes
Estimated Parameters Process Risk
Possible Outcomes
Re-Parameterize Model
Parameterized Model
Initial Data
1
2
N
For each outcome at time 1, we can re-parameterize (again)
But instead of the sample triangles we use the initial data
20
Bootstrap Model, 1-Year Risk (Process Algorithm – Option B)


One-Year Time Horizon (t=1) Reserving Risk
Simulation
Possible Outcomes
Estimated Parameters Process Risk
Possible Outcomes
Re-Parameterize Model
Point Estimates
Parameterized Model
Initial Data
1
2
N
And get conditional “point estimates” (i.e., BE_1^{2+}), given each possible outcome of and p_1 and the initial data
21
Bootstrap Model, 1-Year Risk (Process Algorithm – Option B)

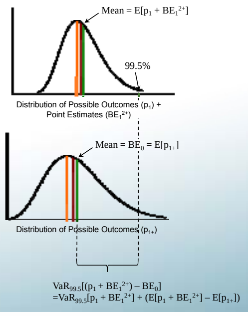

One-Year Time Horizon (t=1) Reserving Risk
Simulation
Possible Outcomes
(Sample Triangles)
Estimated Parameters
Process Risk
Possible Outcomes
(Future Outcomes – p1)
Re-Parameterize Model
(Sample Trapezoids)
Point Estimates
(BE1 2+)
Parameterized Model
Initial Data
1
2
N
Then we can combine the “parts”,
p1 and BE1 2+ .
22
Bootstrap Model, 1-Year Risk (Process Algorithm – Option B)


One-Year Time Horizon (t=1) Reserving Risk
Mean = E[p1 + BE1 2+]
Distribution of Possible Outcomes (p1) +
Point Estimates (BE1 2+)
This results in a combined distribution of the outcomes of p1 and each associated “point estimate” BE1 2+ (i.e., they are correlated).
We can then compare this to the original distribution.
23
Bootstrap Model, 1-Year Risk (Process Algorithm – Option B)


One-Year Time Horizon (t=1) Reserving Risk
Mean = E[p1 + BE1 2+]
Distribution of Possible Outcomes (p1) +
Point Estimates (BE1 2+)
Mean = BE0 = E[p1+]
Distribution of Possible Outcomes (p1+)
In general, E[p1 + BE1 2+] ≠ BE0
24
Bootstrap Model, 1-Year Risk (Process Algorithm – Option B)

Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon

One-Year Time Horizon (t=1) Reserving Risk



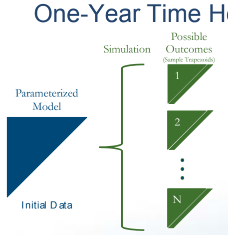
25 Bootstrap Model, 1-Year Risk (Process Algorithm – Option B)

Agenda

- Technical Provisions
- Ultimate Time Horizon (t=0)
- **One-Year Time Horizon (t=1)**
  - Process Algorithm
  - **Residual Algorithm**
  - Possible Outcomes Algorithm
  - Focused VaR Algorithm
  - Focused Group VaR Algorithm
- Technical Provisions

26

One-Year Time Horizon (t=1) Reserving Risk

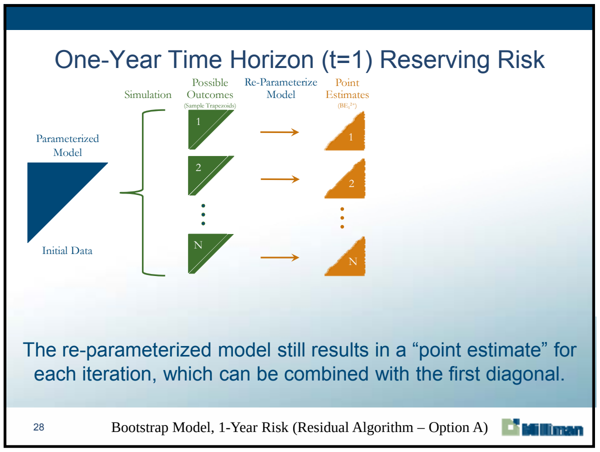


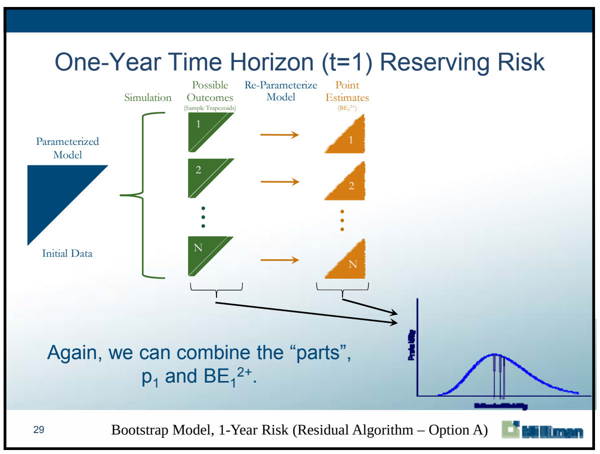
Alternatively, most models will allow the "direct" simulation of the first diagonal (e.g., with Bootstrap sample residuals)

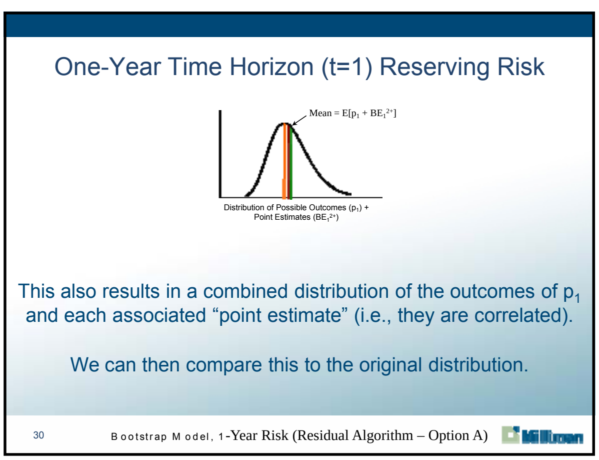
Assuming the possible outcomes are consistent, this will speed up the processing time

27 Bootstrap Model, 1-Year Risk (Residual Algorithm – Option A)

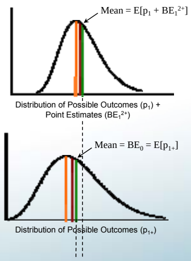
Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon







One-Year Time Horizon (t=1) Reserving Risk

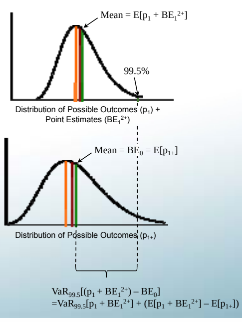


- In general, $E[p_1 + BE_1^{2+}] \neq BE_0$

(In theory, they could be equal for symmetrical distributions)

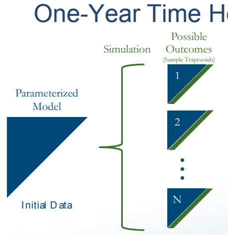
31 Bootstrap Model, 1-Year Risk (Residual Algorithm – Option A)

One-Year Time Horizon (t=1) Reserving Risk



32 Bootstrap Model, 1-Year Risk (Residual Algorithm – Option A)

One-Year Time Horizon (t=1) Reserving Risk

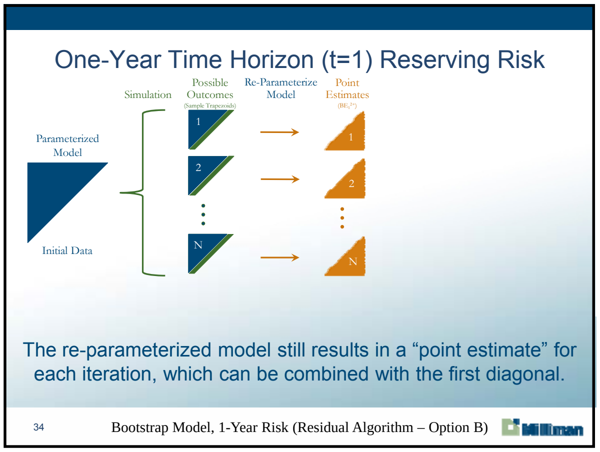


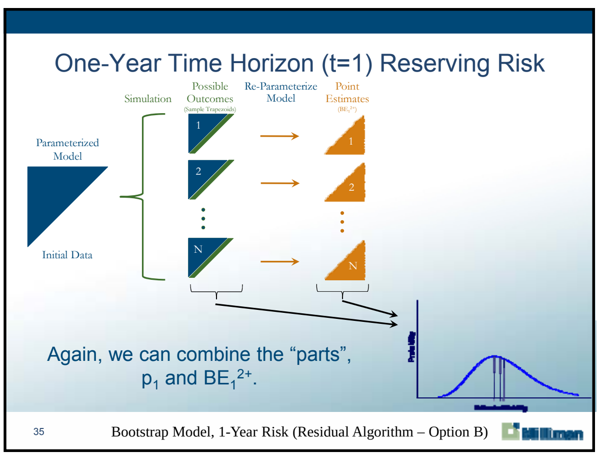
Alternatively, most models will allow the "direct" simulation of the first diagonal (e.g., with Bootstrap sample residuals)

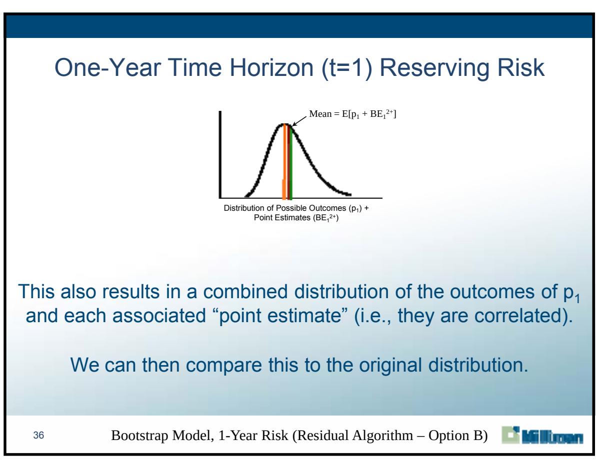
To be consistent with the Process Option, it would make sense to "reuse" the initial data and only sample the future diagonal

33 Bootstrap Model, 1-Year Risk (Residual Algorithm – Option B)

Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon

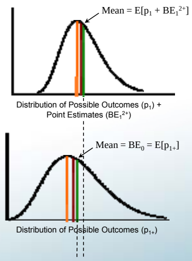






Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon

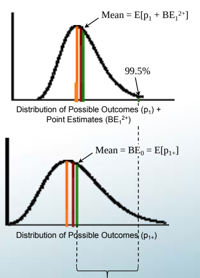
One-Year Time Horizon (t=1) Reserving Risk



- In general, $E[p_1 + BE_1^{2+}] \neq BE_0$

37 Bootstrap Model, 1-Year Risk (Residual Algorithm – Option B)

One-Year Time Horizon (t=1) Reserving Risk



$VaR_{99.5}[(p_1 + BE_1^{2+}) - BE_0]$
$= VaR_{99.5}[p_1 + BE_1^{2+}] + (E[p_1 + BE_1^{2+}] - E[p_{1+}])$

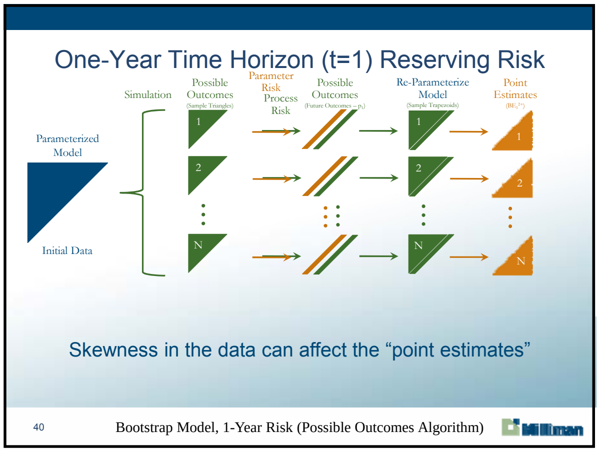
38 Bootstrap Model, 1-Year Risk (Residual Algorithm – Option B)

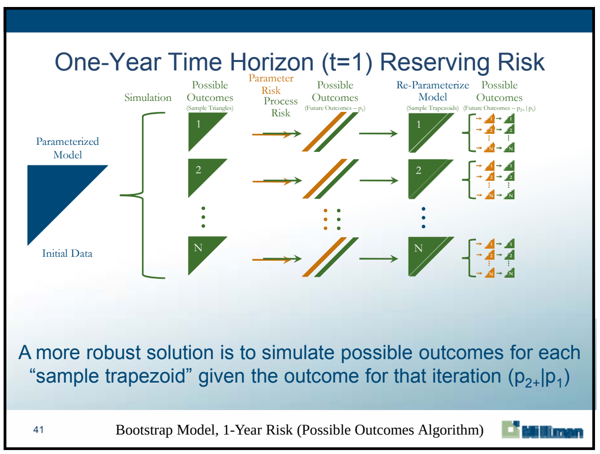
Agenda

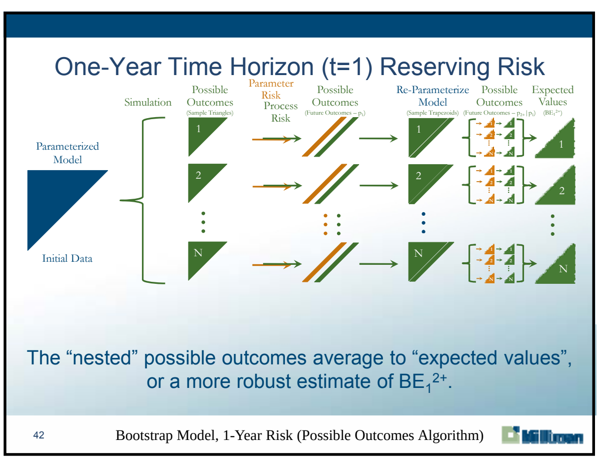
- Technical Provisions
- Ultimate Time Horizon (t=0)
- **One-Year Time Horizon (t=1)**
  - Process Algorithm
  - Residual Algorithm
  - **Possible Outcomes Algorithm**
  - Focused VaR Algorithm
  - Focused Group VaR Algorithm
- Technical Provisions

39

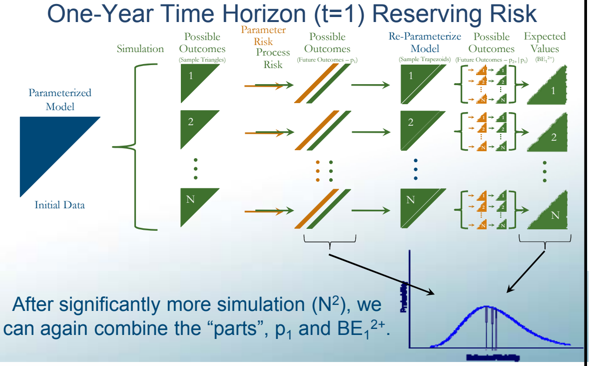
Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon







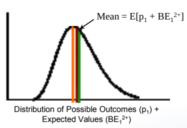
One-Year Time Horizon (t=1) Reserving Risk



After significantly more simulation (N^2), we can again combine the "parts", p_1 and BE_1^{2+}.

43 Bootstrap Model, 1-Year Risk (Possible Outcomes Algorithm) Milliman

One-Year Time Horizon (t=1) Reserving Risk

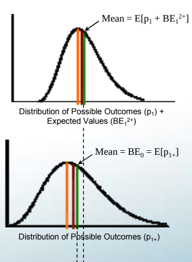


This results in a combined distribution of the outcomes of p_1 and each associated "expected value" (i.e., they are correlated).

Again, we can compare this to the original distribution.

44 Bootstrap Model, 1-Year Risk (Possible Outcomes Algorithm) Milliman

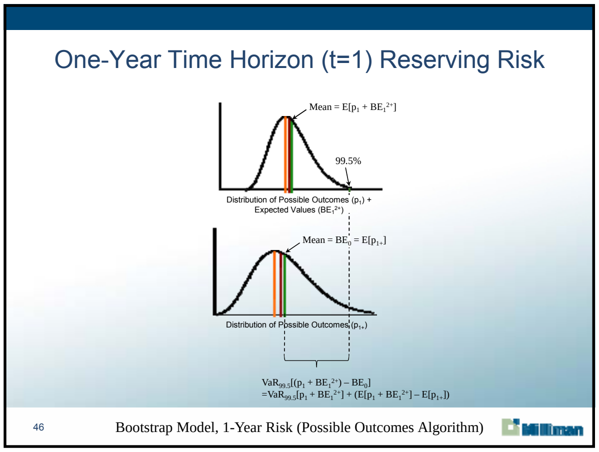
One-Year Time Horizon (t=1) Reserving Risk

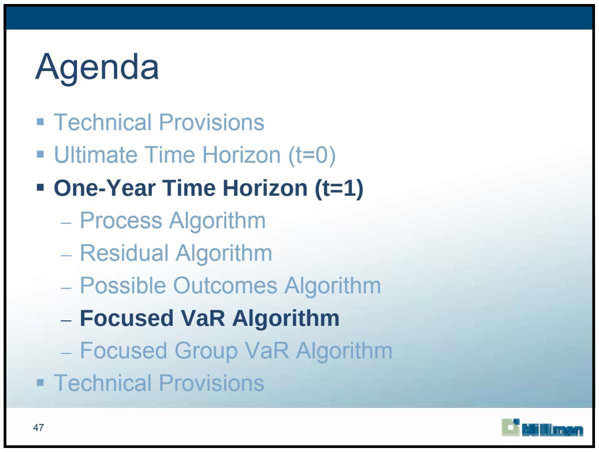


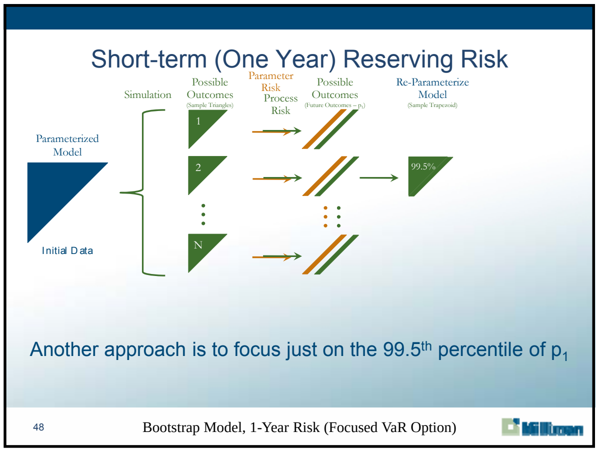
- In general, $E[p_1 + BE_1^{2+}] \neq BE_0$ (Difference may be larger)

45 Bootstrap Model, 1-Year Risk (Possible Outcomes Algorithm) Milliman

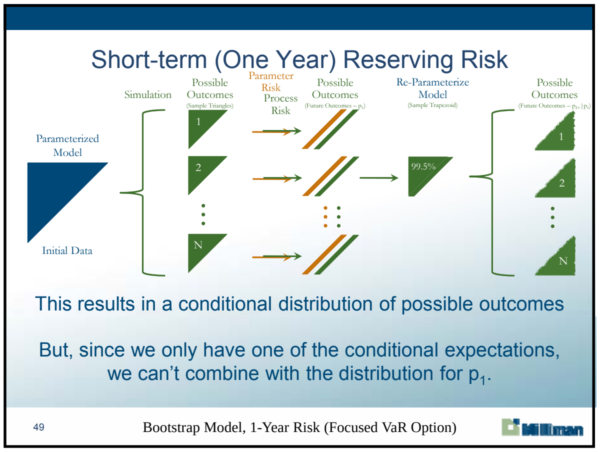
Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon

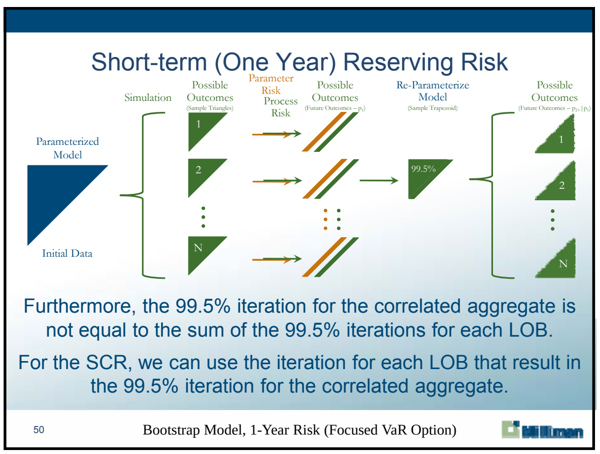


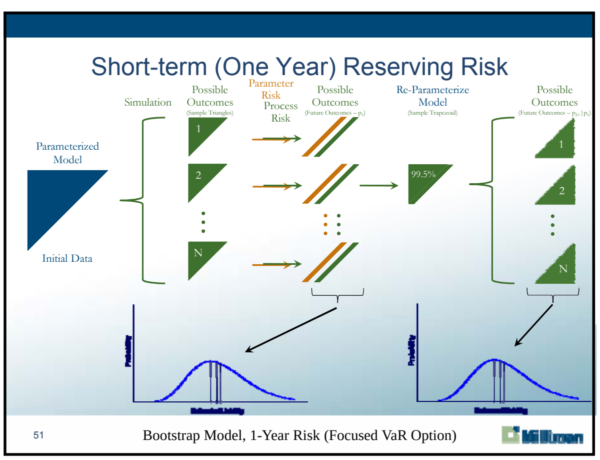




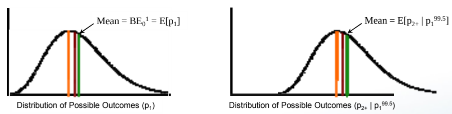
Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon







Short-term (One Year) Reserving Risk

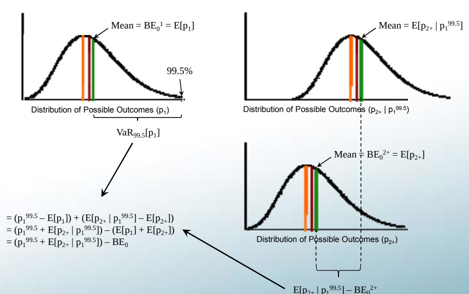


The "original" distribution of the outcomes of p_1 and a new focused "conditional distribution" are the result.

We can then compare the focused "conditional expected value" to the "original" result after the first diagonal (BE_0^{2+}) and then combine the two results.

52 Bootstrap Model, 1-Year Risk (Focused VaR Option)

Short-term (One Year) Reserving Risk



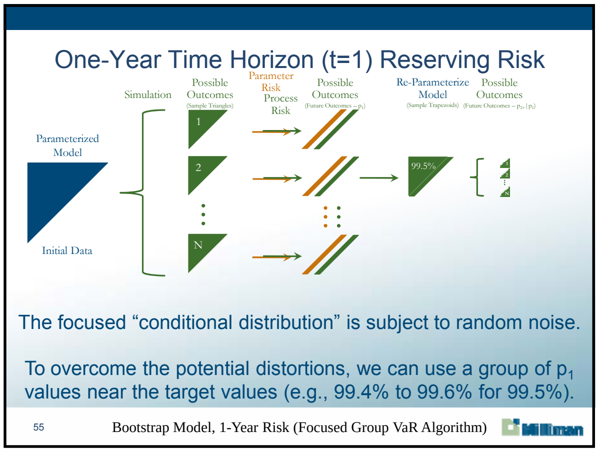
53 Bootstrap Model, 1-Year Risk (Focused VaR Option)

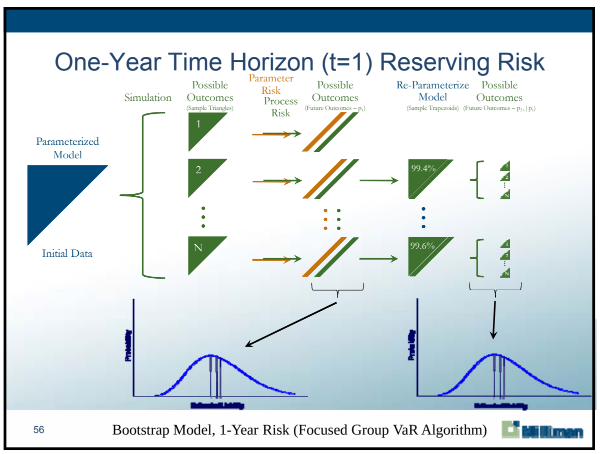
Agenda

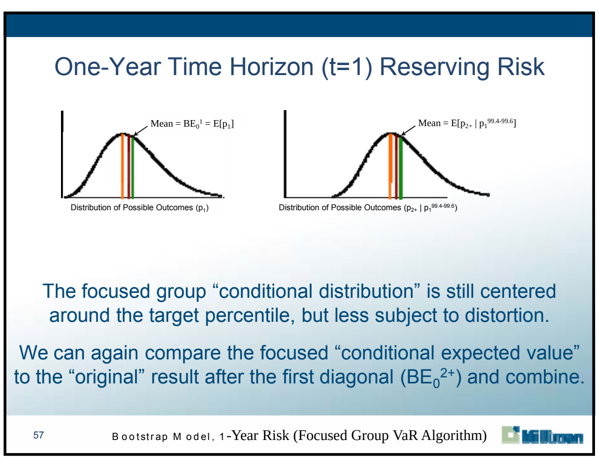
- Technical Provisions
- Ultimate Time Horizon (t=0)
- **One-Year Time Horizon (t=1)**
  - Process Algorithm
  - Residual Algorithm
  - Possible Outcomes Algorithm
  - Focused VaR Algorithm
  - **Focused Group VaR Algorithm**
- Technical Provisions

54

Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon

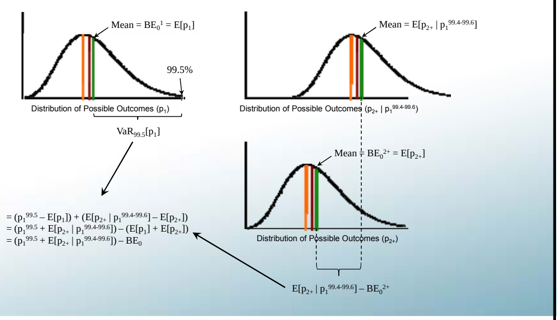






Solvency II: Calculating Reserve Risk Over a One-Year Time Horizon

One-Year Time Horizon (t=1) Reserving Risk



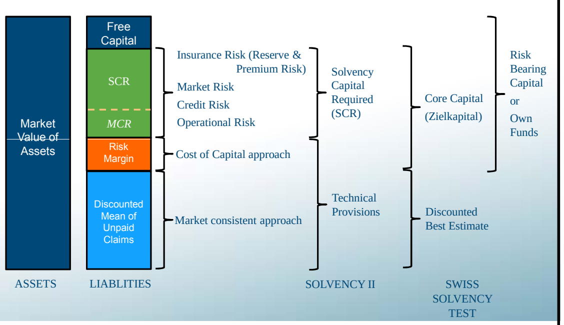
58 Bootstrap Model, 1-Year Risk (Focused Group VaR Algorithm) Milliman

Agenda

- Technical Provisions
- Ultimate Time Horizon (t=0)
- One-Year Time Horizon (t=1)
  - Process Algorithm
  - Residual Algorithm
  - Possible Outcomes Algorithm
  - Focused VaR Algorithm
  - Focused Group VaR Algorithm
- **Technical Provisions**

59 Milliman

Technical Provisions



60 Milliman

Technical Provisions

- Which Algorithm(s)?
- One-Year ➔ N-Year or All
- Iteration parameters vs. “standard” results
- Insuring apples-to-apples comparison (audit trail)
  - N diagonals based on “standard” model (Process)
  - Correlation based on “standard” model
  - Shifting based on “standard” model
- Cost of Capital / Reserve Risk Runoff

61

Technical Provisions

- Ultimate Time Horizon Output (in part)

Sample Insurance Company
Auto BI Liability
Estimated Unpaid
Best Estimate (Weighted)

Accident Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.5% Percentile
1999	303	289	95.2%	(15)	2,707	229	420	878	1,553
2000	533	455	85.3%	(439)	4,048	445	742	1,325	2,451
2001	1,176	662	56.3%	(85)	4,832	1,081	1,522	2,357	3,887
2002	3,205	1,039	32.4%	669	8,734	3,090	3,809	5,045	6,543
2003	8,377	1,670	19.9%	3,739	17,326	8,260	9,392	11,192	13,808
2004	22,071	3,101	14.0%	11,978	33,288	21,882	24,086	27,560	30,628
2005	58,464	5,573	9.5%	40,550	81,488	58,248	61,967	68,135	75,609
2006	138,876	11,194	8.1%	99,963	188,439	138,600	145,960	157,898	170,955
2007	306,604	42,458	13.8%	240,541	507,777	291,090	309,013	403,891	450,348
2008	553,041	92,394	16.7%	371,915	882,106	516,622	577,988	748,995	830,294
Totals	1,092,650	103,408	9.5%	872,930	1,483,066	1,056,066	1,153,441	1,298,864	1,417,922

62 Bootstrap Model (Ultimate Time Horizon @ t=0), Sample Results

Technical Provisions

- Ultimate Time Horizon Output (in part)

Sample Insurance Company
Auto BI Liability
Estimated Cash Flow
Best Estimate (Weighted)

Calendar Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.5% Percentile
2009	475,957	41,818	8.8%	376,133	650,477	462,556	502,091	558,444	609,801
2010	301,346	30,115	10.0%	236,798	415,533	292,902	318,696	360,426	396,917
2011	169,656	19,062	11.2%	128,781	252,073	164,736	180,296	207,635	231,112
2012	85,067	10,451	12.3%	60,471	127,769	82,759	90,499	105,126	118,453
2013	37,126	5,814	15.7%	22,536	60,173	36,227	40,395	48,044	55,133
2014	13,671	2,457	18.0%	7,071	25,287	13,444	15,100	18,126	20,869
2015	5,906	1,497	25.3%	2,229	13,167	5,754	6,773	8,636	10,496
2016	2,204	884	40.1%	(10)	6,683	2,133	2,735	3,772	4,906
2017	1,074	640	59.6%	(1,031)	3,848	993	1,454	2,222	3,120
2018	644	400	62.1%	(230)	2,841	564	861	1,403	2,054
Totals	1,092,650	103,408	9.5%	872,930	1,483,066	1,056,066	1,153,441	1,298,864	1,417,922

63 Bootstrap Model (Ultimate Time Horizon @ t=0), Sample Results

Technical Provisions

- Unpaid Claim Runoff

Sample Insurance Company
Auto BI Liability
Estimated Unpaid Claim Runoff
Best Estimate (Weighted)

Calendar Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.5% Percentile
2008	1,092,650	103,408	9.5%	872,930	1,483,066	1,056,066	1,153,441	1,298,864	1,417,922
2009	616,693	63,564	10.3%	477,558	857,970	596,302	652,788	744,243	815,996
2010	315,346	35,304	11.2%	229,034	444,548	305,634	335,361	385,670	425,292
2011	145,691	17,895	12.3%	98,871	215,088	142,031	155,200	180,545	202,205
2012	60,624	8,738	14.4%	38,400	92,369	59,378	65,757	77,385	87,146
2013	23,498	4,169	17.7%	11,497	39,380	23,156	26,024	30,946	36,020
2014	9,827	2,393	24.3%	3,310	19,323	9,669	11,266	14,109	16,628
2015	3,922	1,379	35.2%	(7)	9,974	3,857	4,771	6,344	8,085
2016	1,718	790	46.0%	(529)	5,088	1,635	2,185	3,129	4,228
2017	644	400	62.1%	(230)	2,841	564	861	1,403	2,054

- Ultimate (t=0) unpaid distribution, less successive diagonals

64 Bootstrap Model (Ultimate Time Horizon @ t=0), Sample Results

Technical Provisions

- Unpaid Claim Runoff

Sample Insurance Company
Auto BI Liability
Estimated Unpaid Claim Runoff
Best Estimate (Weighted)

Calendar Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	95.0% Percentile	99.5% Percentile		
2008	1,092,650	103,408	9.5%	872,930	1,483,066	1,298,864	1,417,922	325,272	100.0%
2009	616,693	63,564	10.3%	477,558	857,970	744,243	815,996	199,303	61.3%
2010	315,346	35,304	11.2%	229,034	444,548	385,670	425,292	109,945	33.8%
2011	145,691	17,895	12.3%	98,871	215,088	180,545	202,205	56,514	17.4%
2012	60,624	8,738	14.4%	38,400	92,369	77,385	87,146	26,522	8.2%
2013	23,498	4,169	17.7%	11,497	39,380	30,946	36,020	12,521	3.8%
2014	9,827	2,393	24.3%	3,310	19,323	14,109	16,628	6,800	2.1%
2015	3,922	1,379	35.2%	(7)	9,974	6,344	8,085	4,163	1.3%
2016	1,718	790	46.0%	(529)	5,088	3,129	4,228	2,509	0.8%
2017	644	400	62.1%	(230)	2,841	1,403	2,054	1,410	0.4%

- Ultimate (t=0) unpaid distribution, less successive diagonals
- "Baseline" or proxy for CDR Runoff

65 Bootstrap Model (Ultimate Time Horizon @ t=0), Sample Results

Technical Provisions

- 1 Year Risk Output (in part)

Sample Insurance Company
Auto BI Liability
Estimated Unpaid, 1-Year Time Horizon, Process Algorithm
Best Estimate (Weighted)

Accident Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.5% Percentile
1999	303	289	95.2%	(15)	2,707	229	420	878	1,553
2000	533	503	94.3%	(557)	5,294	433	747	1,342	3,078
2001	1,176	648	55.1%	(160)	6,410	1,083	1,499	2,326	3,662
2002	3,205	1,017	31.7%	672	10,554	3,094	3,776	4,968	6,940
2003	8,377	1,567	18.7%	4,237	17,520	8,337	9,294	11,044	13,528
2004	22,071	2,948	13.4%	11,645	34,264	21,919	24,009	27,177	30,026
2005	58,464	4,986	8.5%	40,067	76,535	58,223	61,528	67,148	72,527
2006	138,876	10,741	7.7%	99,690	182,833	138,420	145,531	157,086	169,379
2007	306,604	34,652	11.3%	(1,002,417)	418,774	305,671	315,112	345,685	387,609
2008	553,041	51,813	9.4%	403,504	933,469	542,255	562,102	660,179	737,297
Totals	1,092,650	65,407	6.0%	(235,373)	1,468,862	1,085,285	1,119,980	1,203,602	1,295,338

66 Bootstrap Model (1 Year Risk), Sample Results

Technical Provisions

- Claim Development Result

Sample Insurance Company
Auto BI Liability
Estimated Claim Development Result, 1-Year Time Horizon, Process Algorithm
Best Estimate (Weighted)

Accident Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.5% Percentile
1999	(0)	289	0.0%	(318)	2,404	(74)	116	574	1,249
2000	0	503	0.0%	(1,090)	4,761	(100)	214	808	2,545
2001	(0)	648	0.0%	(1,336)	5,234	(92)	324	1,151	2,487
2002	(0)	1,017	0.0%	(2,532)	7,349	(110)	571	1,764	3,736
2003	0	1,567	0.0%	(4,140)	9,142	(40)	917	2,666	5,151
2004	(0)	2,948	0.0%	(10,426)	12,193	(152)	1,938	5,106	7,955
2005	0	4,986	0.0%	(18,397)	18,071	(241)	3,064	8,684	14,063
2006	(0)	10,741	0.0%	(39,186)	43,958	(455)	6,656	18,210	30,503
2007	(0)	34,652	0.0%	(1,309,020)	112,170	(933)	8,509	39,082	81,005
2008	0	51,813	0.0%	(149,538)	380,428	(10,787)	9,060	107,137	184,256
Totals	(0)	65,407	0.0%	(1,328,022)	376,212	(7,364)	27,330	110,953	202,689

- The ultimate (t=0) mean is subtracted from every simulated value
- Shifted so CDR mean = ultimate mean

67 Bootstrap Model (1 Year Risk), Sample Results Milliman

Technical Provisions

- Current Output (in part)

Sample Insurance Company
Auto BI Liability
Estimated Cash Flow, 2-Year Time Horizon, Process Algorithm
Best Estimate (Weighted)

Calendar Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.5% Percentile
2009	483,429	41,818	8.7%	383,606	657,949	470,029	509,563	565,917	617,274
2010	306,422	30,115	9.8%	241,873	420,608	297,978	323,771	365,502	401,992
2011	162,962	10,979	6.7%	131,575	310,701	161,662	167,701	182,884	201,445
2012	81,489	6,165	7.6%	63,789	164,217	80,731	84,098	92,769	103,626
2013	35,612	3,420	9.6%	24,884	71,368	35,388	37,498	41,612	47,147
2014	13,206	1,584	12.0%	8,326	30,960	13,103	14,162	15,805	17,883
2015	5,767	1,098	19.0%	2,484	14,028	5,722	6,486	7,618	8,967
2016	2,156	751	34.9%	(117)	5,644	2,122	2,623	3,393	4,451
2017	1,022	573	56.1%	(752)	3,611	984	1,377	2,004	2,753
2018	585	385	65.8%	(84)	3,396	511	786	1,273	2,142
Totals	1,092,650	85,825	7.9%	880,772	1,487,434	1,067,001	1,140,315	1,266,247	1,369,324

68 Bootstrap Model (2 Year Risk), Sample Results Milliman

Technical Provisions

- Claim Development Result

Sample Insurance Company
Auto BI Liability
Estimated Claim Development Result, 2-Year Time Horizon, Process Algorithm
Best Estimate (Weighted)

Accident Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.5% Percentile
1999	(0)	289	0.0%	(318)	2,404	(74)	116	574	1,249
2000	0	455	0.0%	(972)	3,515	(88)	209	792	1,917
2001	(0)	639	0.0%	(1,277)	3,642	(82)	334	1,161	2,669
2002	0	1,019	0.0%	(2,300)	5,462	(94)	598	1,795	3,381
2003	(0)	1,649	0.0%	(4,630)	8,017	(113)	1,007	2,724	5,510
2004	0	3,035	0.0%	(10,094)	10,903	(163)	1,971	5,237	8,148
2005	(0)	5,477	0.0%	(17,190)	20,224	(271)	3,393	9,456	16,477
2006	0	10,868	0.0%	(39,905)	45,338	(507)	6,728	18,714	31,292
2007	0	33,762	0.0%	(64,706)	194,016	(10,334)	4,353	79,172	122,060
2008	0	76,607	0.0%	(170,215)	409,395	(26,727)	18,387	164,528	244,924
Totals	(0)	85,825	0.0%	(211,877)	394,784	(25,649)	47,666	173,597	276,675

69 Bootstrap Model (2 Year Risk), Sample Results Milliman

Technical Provisions

- Claim Development Result Runoff

Sample Insurance Company
Auto BI Liability
Estimated Claim Development Result Runoff, 1-Year Time Horizon, Process Algorithm
Best Estimate (Weighted)

Calendar Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.5% Percentile
2008	0	65,407	0.0%	(1,328,022)	376,212	(7,364)	27,330	110,953	202,689
2009	0	43,388	0.0%	(1,362,259)	320,710	3,125	19,474	48,221	92,944
2010	1,389	23,215	1671.8%	(675,301)	171,959	2,721	12,698	30,333	53,419
2011	2,452	11,813	481.9%	(289,217)	89,790	2,837	8,763	18,986	29,995
2012	1,952	6,113	313.1%	(97,801)	39,476	1,889	5,661	11,394	18,555
2013	981	3,622	369.1%	(42,728)	18,884	848	3,181	7,068	11,126
2014	320	2,424	758.5%	(15,737)	14,376	120	1,769	4,491	7,306
2015	70	1,591	2289.5%	(5,297)	9,301	(107)	940	2,911	5,440
2016	(61)	974	-1607.5%	(4,022)	6,490	(196)	428	1,790	3,273
2017	(21)	490	-2304.0%	(584)	3,744	(154)	185	917	2,152

- First row will match total CDR
- Sequential rows will remove cash flow diagonals
- For “All” option, each row is based on a different N

70 Bootstrap Model (1 Year Risk), Sample Results

Technical Provisions

- Claim Development Result Runoff

Sample Insurance Company
Auto BI Liability
Estimated Claim Development Result Runoff, 2-Year Time Horizon, Process Algorithm
Best Estimate (Weighted)

Calendar Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.5% Percentile
2008	0	85,825	0.0%	(211,877)	394,784	(25,649)	47,666	173,597	276,675
2009	0	47,177	0.0%	(121,714)	339,282	(11,123)	23,100	94,388	156,295
2010	0	21,767	0.0%	(62,275)	296,245	(2,660)	9,332	38,551	77,858
2011	2,042	11,584	567.3%	(30,759)	150,548	962	7,881	22,160	43,901
2012	2,025	6,114	301.9%	(16,408)	67,803	1,658	5,703	12,475	21,386
2013	1,364	3,458	253.5%	(8,494)	31,386	1,292	3,579	7,130	11,319
2014	588	2,246	381.7%	(5,585)	12,858	417	2,093	4,399	6,878
2015	184	1,416	769.4%	(3,670)	7,074	77	1,065	2,660	4,394
2016	27	830	3098.2%	(2,141)	4,586	(59)	522	1,487	2,686
2017	(3)	385	-12007.9%	(671)	2,809	(77)	198	685	1,554

71 Bootstrap Model (2 Year Risk), Sample Results

Technical Provisions

- Claim Development Result Runoff

Sample Insurance Company
Auto BI Liability
Estimated Claim Development Result Runoff, All-Year Time Horizon, Process Algorithm
Best Estimate (Weighted)

Calendar Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	50.0% Percentile	75.0% Percentile	95.0% Percentile	99.5% Percentile
2008	-	65,407	0.0%	(1,328,022)	376,212	(7,364)	27,330	110,953	202,689
2009	-	47,177	0.0%	(121,714)	339,282	(11,123)	23,100	94,388	156,295
2010	-	31,313	0.0%	(117,137)	254,109	(7,428)	14,591	62,074	103,168
2011	-	17,743	0.0%	(105,185)	151,822	(3,885)	9,135	35,166	55,738
2012	-	9,659	0.0%	(117,584)	85,590	(1,530)	5,210	17,560	28,663
2013	-	5,449	0.0%	(106,691)	68,188	(364)	2,666	8,446	15,005
2014	-	4,721	0.0%	(94,159)	149,532	(177)	1,557	4,920	9,465
2015	-	10,298	0.0%	(479,455)	66,468	96	1,113	3,060	6,618
2016	-	5,773	0.0%	(275,477)	20,432	15	611	1,779	4,001
2017	-	400	0.0%	(874)	2,197	(80)	216	759	1,410

72 Bootstrap Model (N Year Risk), Sample Results

Technical Provisions

- Claim Development Result Runoff

Sample Insurance Company
Auto BI Liability
Estimated Claim Development Result Runoff, All-Year Time Horizon, Process Algorithm
Best Estimate (Weighted)

Calendar Year	Mean Unpaid	Standard Error	Coefficient of Variation	Minimum	Maximum	75.0% Percentile	95.0% Percentile	99.5% Percentile	
2008	-	65,407	0.0%	(1,328,022)	376,212	27,330	110,953	202,689	100.0%
2009	-	47,177	0.0%	(121,714)	339,282	23,100	94,388	156,295	77.1%
2010	-	31,313	0.0%	(117,137)	254,109	14,591	62,074	103,168	50.9%
2011	-	17,743	0.0%	(105,185)	151,822	9,135	35,166	55,738	27.5%
2012	-	9,659	0.0%	(117,584)	85,590	5,210	17,560	28,663	14.1%
2013	-	5,449	0.0%	(106,691)	68,188	2,666	8,446	15,005	7.4%
2014	-	4,721	0.0%	(94,159)	149,532	1,557	4,920	9,465	4.7%
2015	-	10,298	0.0%	(479,455)	66,468	1,113	3,060	6,618	3.3%
2016	-	5,773	0.0%	(275,477)	20,432	611	1,779	4,001	2.0%
2017	-	400	0.0%	(874)	2,197	216	759	1,410	0.7%

73 Bootstrap Model (N Year Risk), Sample Results

Technical Provisions

- Each possible outcome is discounted using term rate structure
- Risk Margin is based on Cost of Capital for Runoff of CDR
- CDR also discounted using term rate structure

74

Technical Provisions

Accident Year	Mean Estimate	Discounted Mean	99.5% VaR CDR	Discounted CDR
2000	303	302	59	59
2001	533	526	127	125
2002	1,176	1,152	249	244
2003	3,205	3,145	751	734
2004	8,377	8,209	1,909	1,866
2005	22,071	21,663	5,022	4,912
2006	58,464	57,302	13,540	13,229
2007	138,876	135,687	32,775	31,916
2008	306,604	298,272	49,072	47,915
2009	553,041	534,775	99,185	96,078
Total	1,092,650	1,061,032	202,689	197,078

75

Technical Provisions

Runoff Approximated Using Mean Estimate Runoff

Calendar Year	CDR Runoff Percentage	CDR Runoff	Cost of Capital *	Discounted CoC
2009	100.0%	197,078	11,825	11,771
2010	61.3%	120,755	7,245	7,085
2011	33.8%	66,614	3,997	3,805
2012	17.4%	34,241	2,054	1,894
2013	8.2%	16,069	964	858
2014	3.8%	7,586	455	390
2015	2.1%	4,120	247	203
2016	1.3%	2,522	151	119
2017	0.8%	1,520	91	69
2018	0.4%	854	51	37
			27,082	26,231

Technical Provision = 1,087,263

76

Technical Provisions

Runoff Using CDR Runoff, Constant Discount

Calendar Year	CDR Runoff Percentage	CDR Runoff	Cost of Capital *	Discounted CoC
2009	100.0%	197,078	11,825	11,771
2010	75.6%	148,934	8,936	8,739
2011	48.6%	95,730	5,744	5,468
2012	25.4%	50,124	3,007	2,773
2013	12.6%	24,864	1,492	1,327
2014	6.3%	12,492	750	642
2015	3.8%	7,565	454	373
2016	2.6%	5,078	305	240
2017	1.5%	2,965	178	134
2018	0.5%	1,013	61	44
			32,751	31,510

Technical Provision = 1,092,543

77