Institute and Faculty of Actuaries

Reserve Risk

We had a good year, but why has the CoV increased?

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Kevin Chan

22 October 2015

Agenda

- Reserve Risk basics - MSEP and Mack's Model (1993)

- Illustration of the Reserves movement
  - Volume Impact
  - Parameter Impact (link ratios)

- Illustration of the Reserve Risk movement
  - Maturity
  - Volume
  - Parameters (link ratios and noise)
  - One Additional Year

- Example of Reserve Risk movement

- How volatile is the CoV with an additional Calendar Year experience?

MSEP and CoV

- Reserve Risk is the risk of mis-estimation of the reserves.

- Reserve Risk assessment: Mean Squared Error of Prediction (MSEP) of Reserves

$$\text{MSEP}\left(\hat{R}\right) = E\left[(R - \hat{R})^2 \mid D\right]$$

  - R is the reserves required conditional on claim experience - stochastic since it is unknown as of now
  - $\hat{R}$ is the estimate of the mean of R using parameters derived from data (i.e. deterministic reserves set by reserving actuaries)
  - D is the data (e.g. claims triangle)

- Prediction Error is $\sqrt{\text{MSEP}\left(\hat{R}\right)}$

- The reserving actuaries do not provide the mean of the reserves. They provide an estimate of the mean which is dependent on data. The reserve risk is the risk associated with this estimate.

- *CoV* = $\sqrt{\text{MSEP}\left(\hat{R}\right)} / \hat{R}$

Mack's Model (1993)

- Key Assumptions
  - Different Origin years are independent
  - Next cell Cumulative value is a constant proportion to previous cell cumulative value
  - Variance of projected next cell cumulative value is also a constant proportion to previous cell cumulative value

$$C_{i,j+1} = C_{i,j}\ f_j\ +\ \sqrt{C_{i,j}}\ \sigma_j\ \varepsilon_{i,j} \qquad where\ \ \varepsilon_{i,j} \sim N\ (0,1)$$

i.e. $$E\left[C_{i,j+1} \middle| C_{i,1}, C_{i,2}, \dots, C_{i,j}\right] = C_{i,j} f_j \quad and \quad Var\left[C_{i,j+1} \middle| C_{i,1}, C_{i,2}, \dots, C_{i,j}\right] = C_{i,j}\ \sigma_j^2$$

- Key parameters
  - Individual Development Factors - f_j
  - Volatility parameter - σ_j

Illustration of Reserves Movement

	Development Year									
	1	2	3	4	5	6	7	8	9	10
2004										
2005										
2006										
2007										
2008										
2009										
2010										
2011										
2012										
2013										

Illustration of Reserves Movement

	Development Year									
	1	2	3	4	5	6	7	8	9	10
2004										
2005										E
2006									E	E
2007								E	E	E
2008							E	E	E	E
2009						E	E	E	E	E
2010					E	E	E	E	E	E
2011				E	E	E	E	E	E	E
2012			E	E	E	E	E	E	E	E
2013		E	E	E	E	E	E	E	E	E

$\hat{f}_1$ $\hat{f}_2$ $\hat{f}_3$ $\hat{f}_4$ $\hat{f}_5$ $\hat{f}_6$ $\hat{f}_7$ $\hat{f}_8$ $\hat{f}_9$

Illustration of Reserves Movement

	Development Year									
	1	2	3	4	5	6	7	8	9	10
2004										
2005										E
2006									E	E
2007								E	E	E
2008							E	E	E	E
2009						E	E	E	E	E
2010					E	E	E	E	E	E
2011				E	E	E	E	E	E	E
2012			E	E	E	E	E	E	E	E
2013		E	E	E	E	E	E	E	E	E

Total Reserves	Prediction Error	CoV
0	0	0%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%

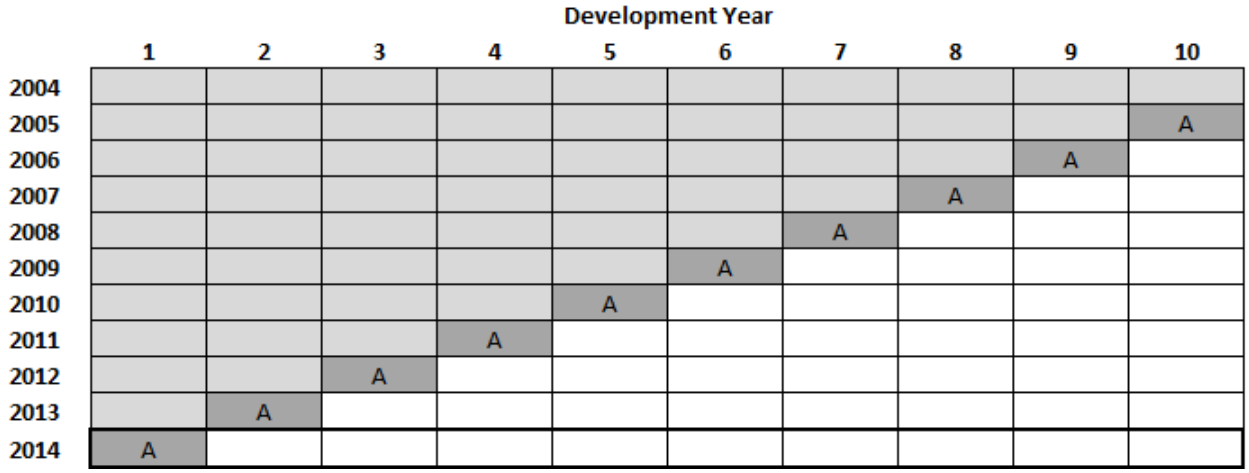
$\hat{f}_1$ $\hat{f}_2$ $\hat{f}_3$ $\hat{f}_4$ $\hat{f}_5$ $\hat{f}_6$ $\hat{f}_7$ $\hat{f}_8$ $\hat{f}_9$

Σ	$	%

Illustration of Reserves Movement

	Development Year									
	1	2	3	4	5	6	7	8	9	10
2004										
2005										A
2006									A	
2007								A		
2008							A			
2009						A				
2010					A					
2011				A						
2012			A							
2013		A								
2014	A									

Illustration of Reserves Movement



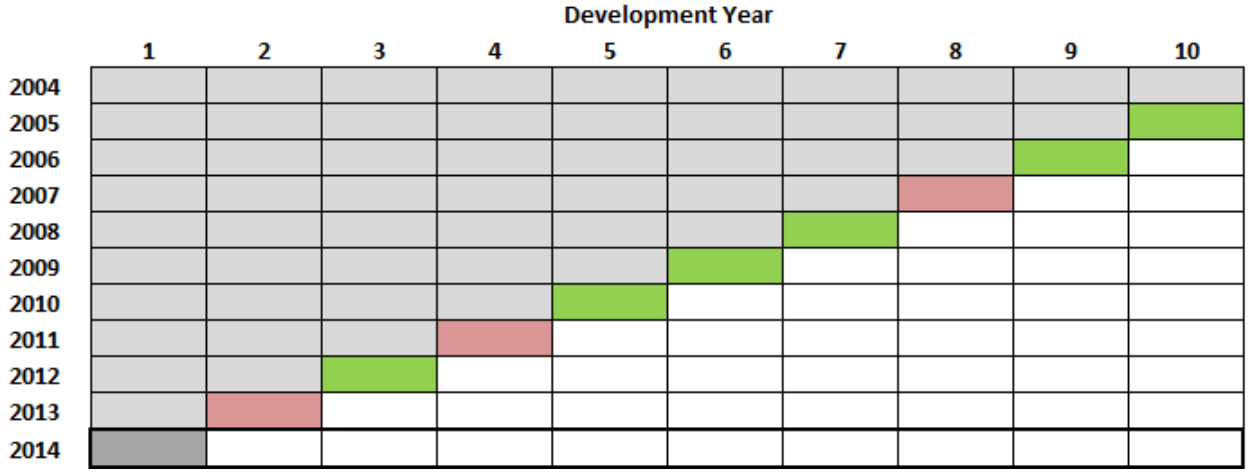
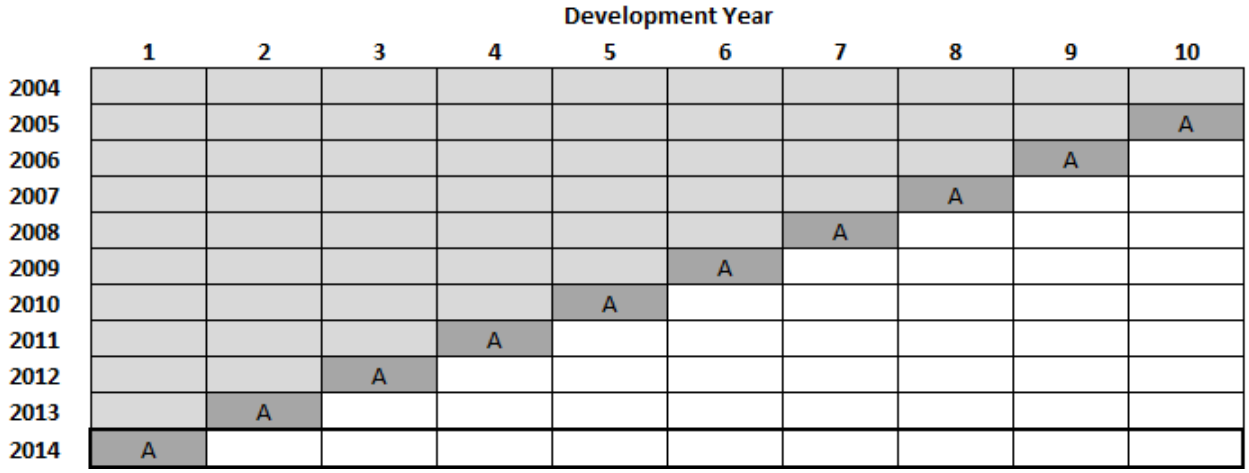


Illustration of Reserves Movement



Total Reserves	Prediction Error	CoV
0	0	0%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%

Σ	$	%

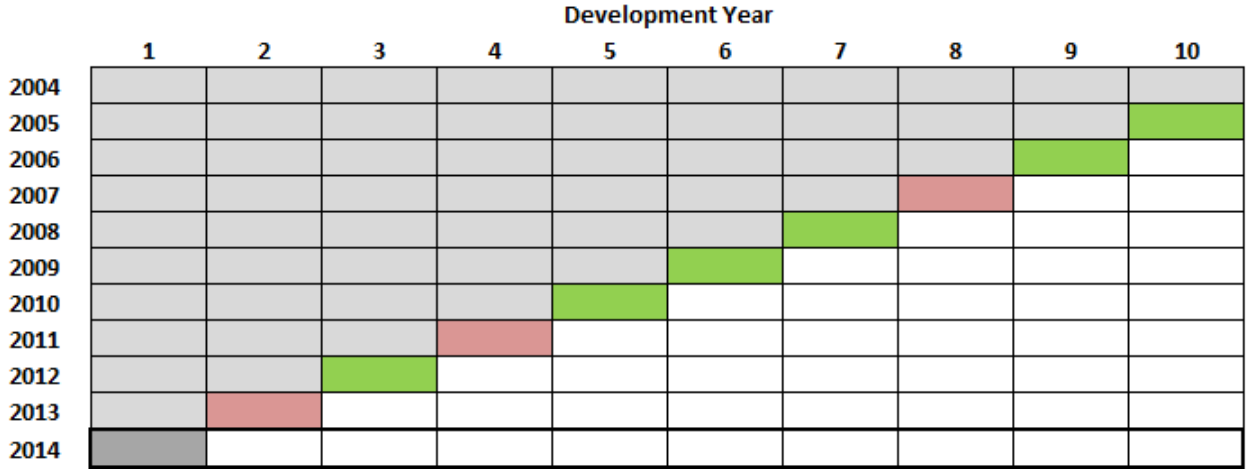


Illustration of Reserves Movement

	Development Year									
	1	2	3	4	5	6	7	8	9	10
2004										
2005										A
2006									A	
2007								A		
2008							A			
2009						A				
2010					A					
2011				A						
2012			A							
2013		A								
2014	A									

Total Reserves	Prediction Error	CoV
0	0	0%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
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Σ	$	%
Σ	$	%

Σ	$	%

Illustration of Reserves Movement

	Development Year									
	1	2	3	4	5	6	7	8	9	10
2004										
2005										A
2006									A	
2007								A		
2008							A			
2009						A				
2010					A					
2011				A						
2012			A							
2013		A								
2014	A									

Total Reserves	Prediction Error	CoV
0	0	0%
Σ	$	%
Σ	$	%
Σ	$	%
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Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%
Σ	$	%

Σ	$	%

- Is CoV a meaningful measure? The reserves (denominator) also moved!
- Additional origin year contributing to Reserves and Prediction Error
- Focus on one origin year might provide better insight
- An origin year consists of many development periods
- One less development than last year

Illustration of Reserves Movement

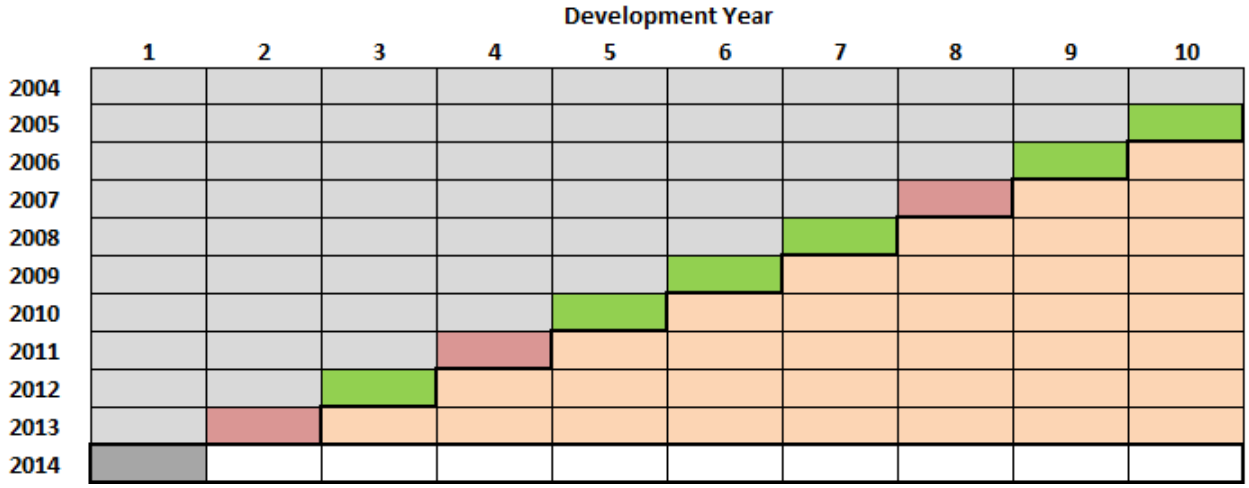
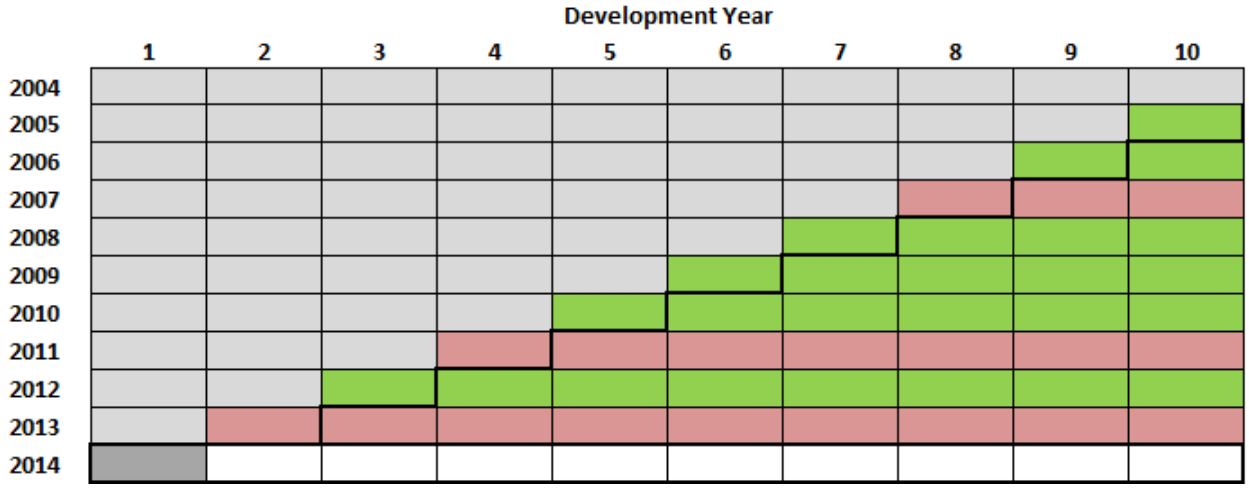


Illustration of Reserves Movement



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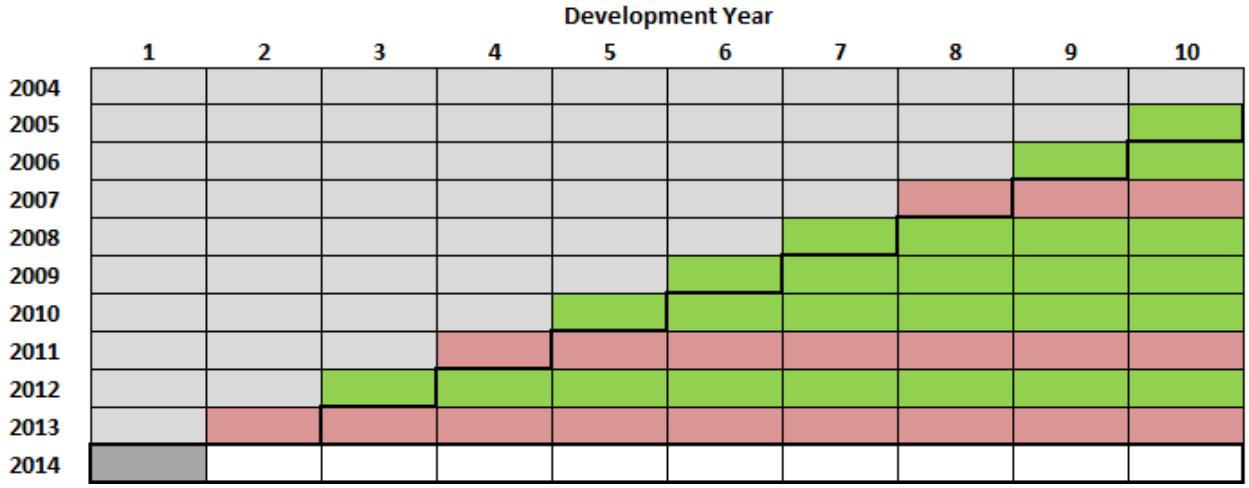
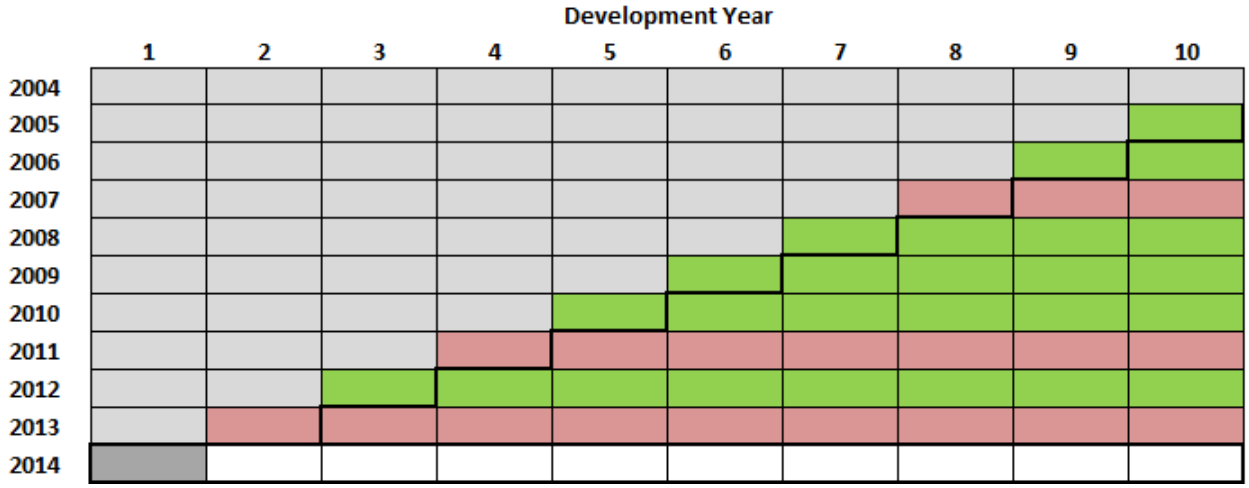
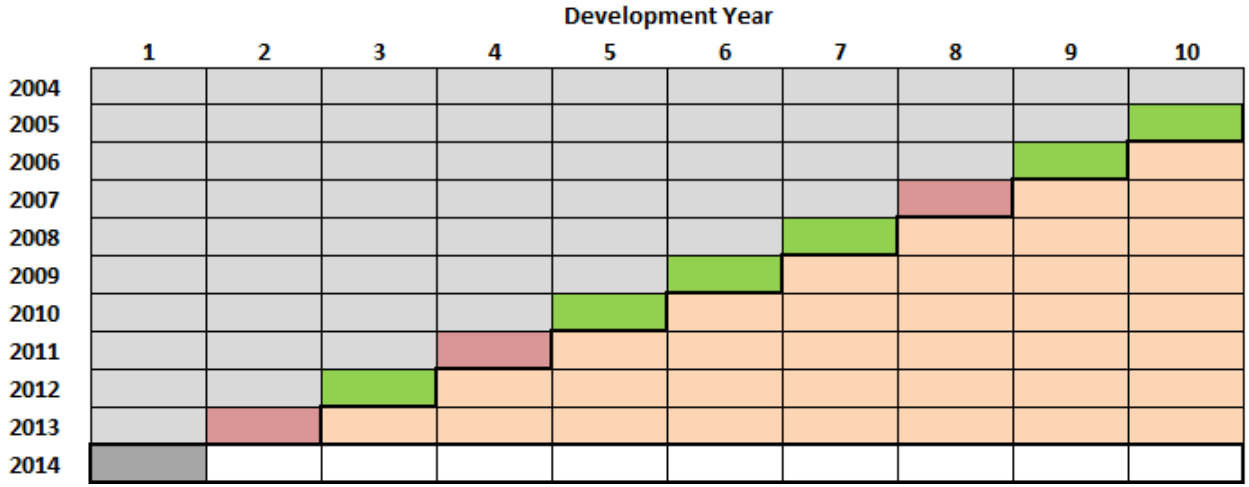


Volume Impact (Horizontal)

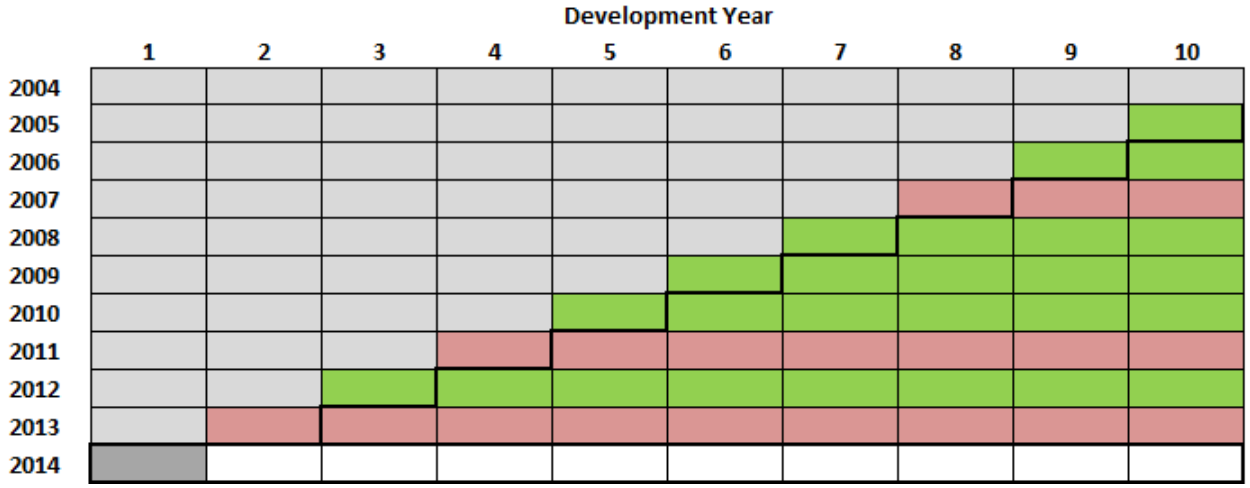
Illustration of Reserves Movement

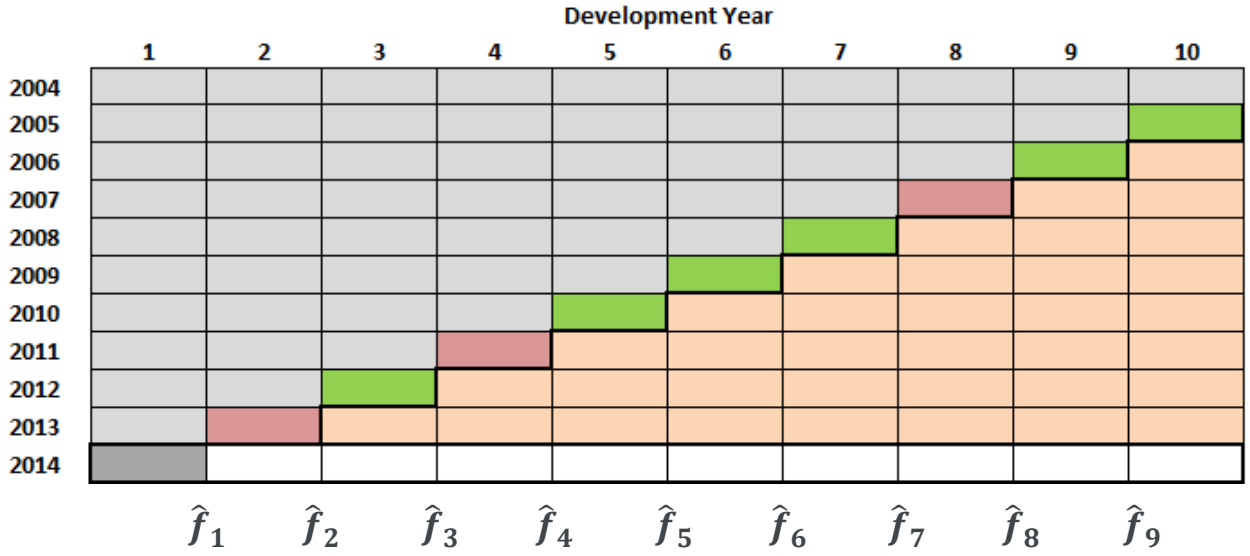




Volume Impact (Horizontal)

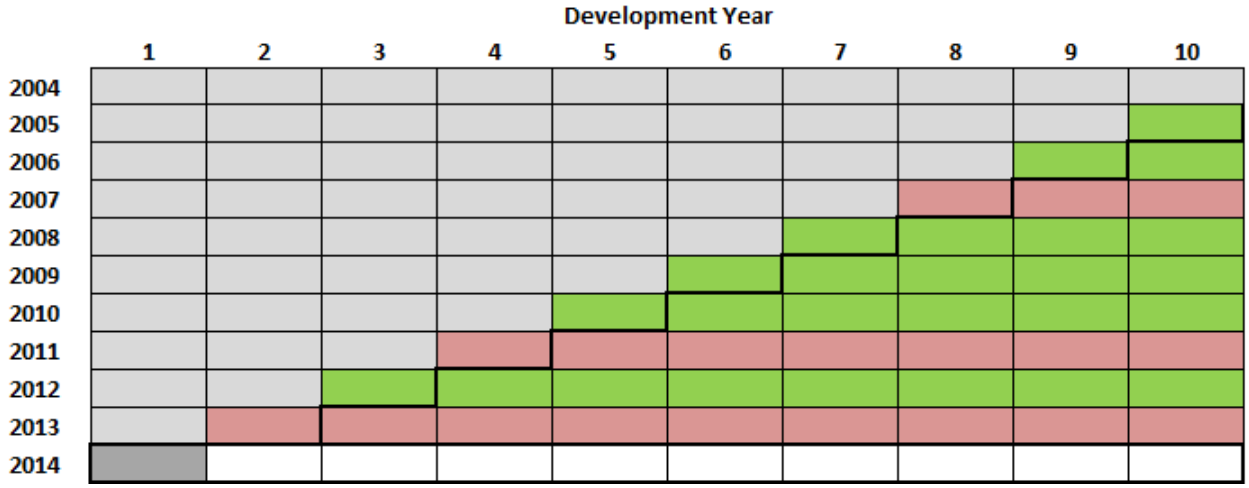
Illustration of Reserves Movement

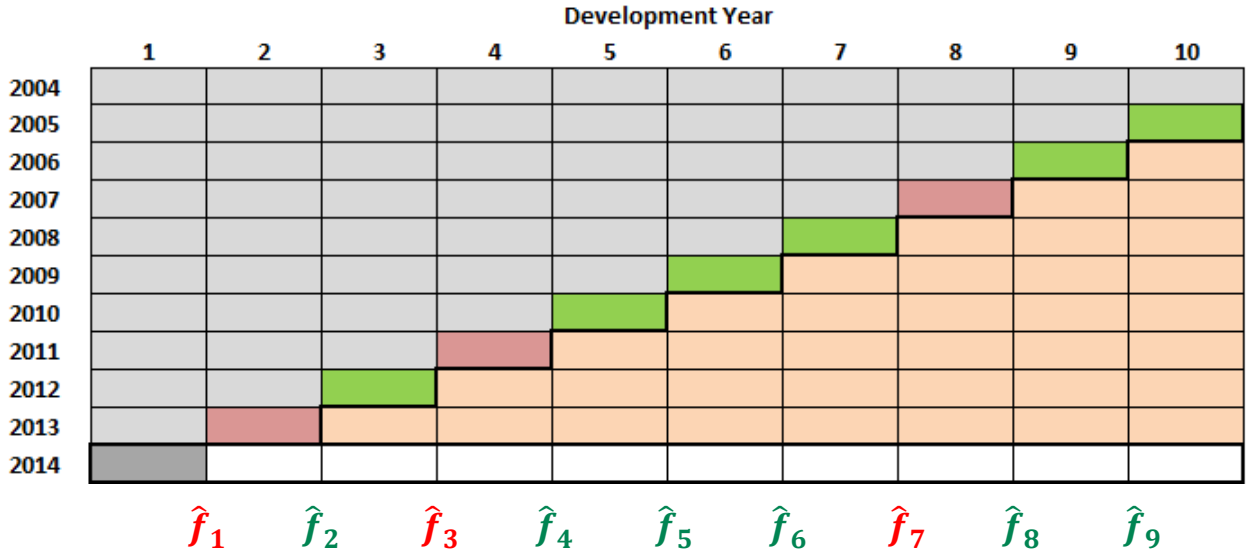




Volume Impact (Horizontal)

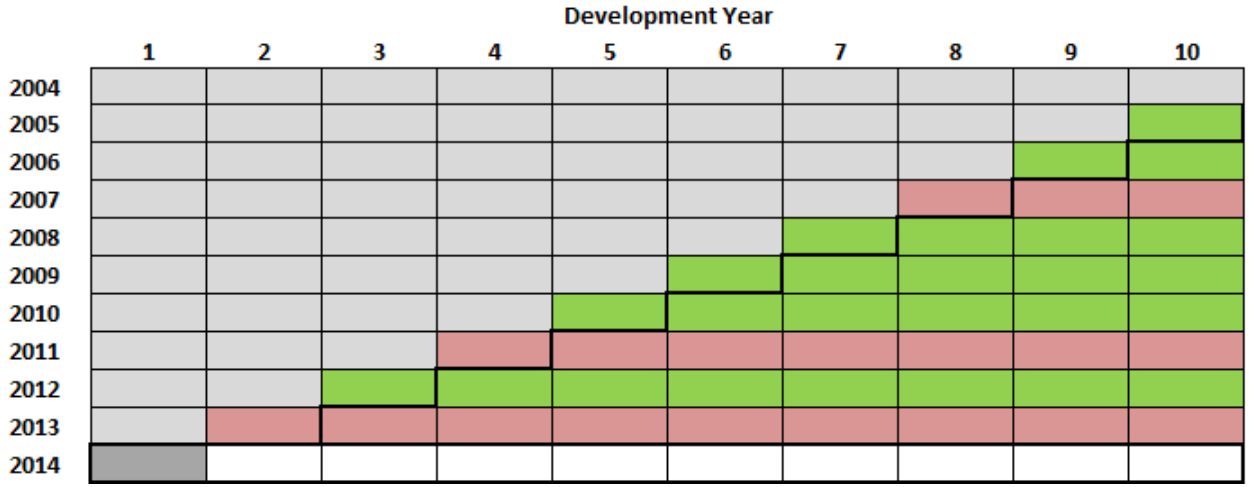
Illustration of Reserves Movement

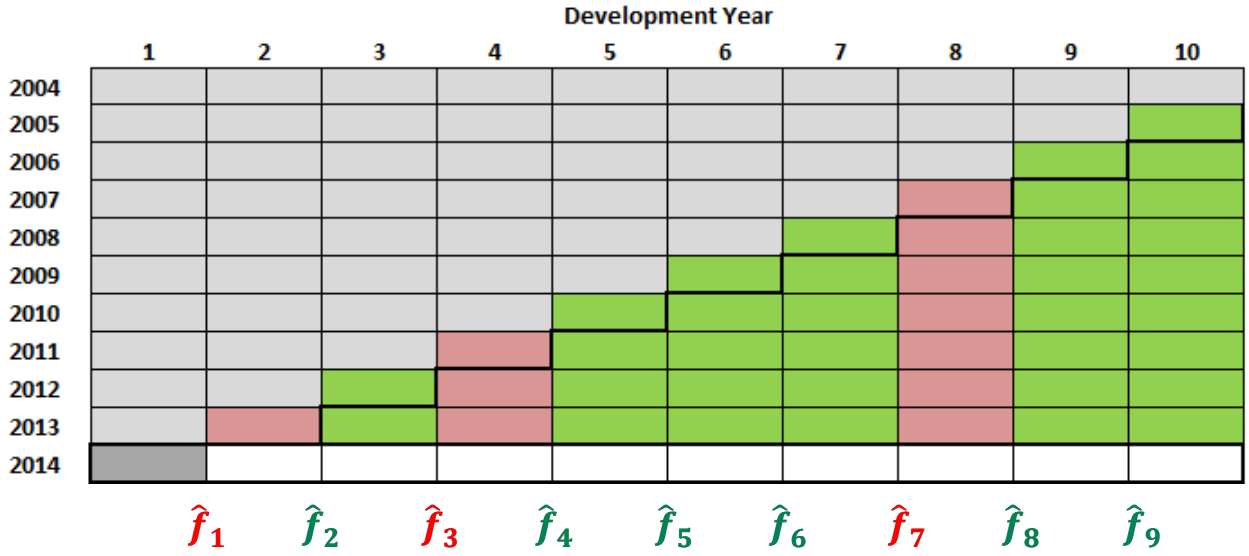




Volume Impact (Horizontal)

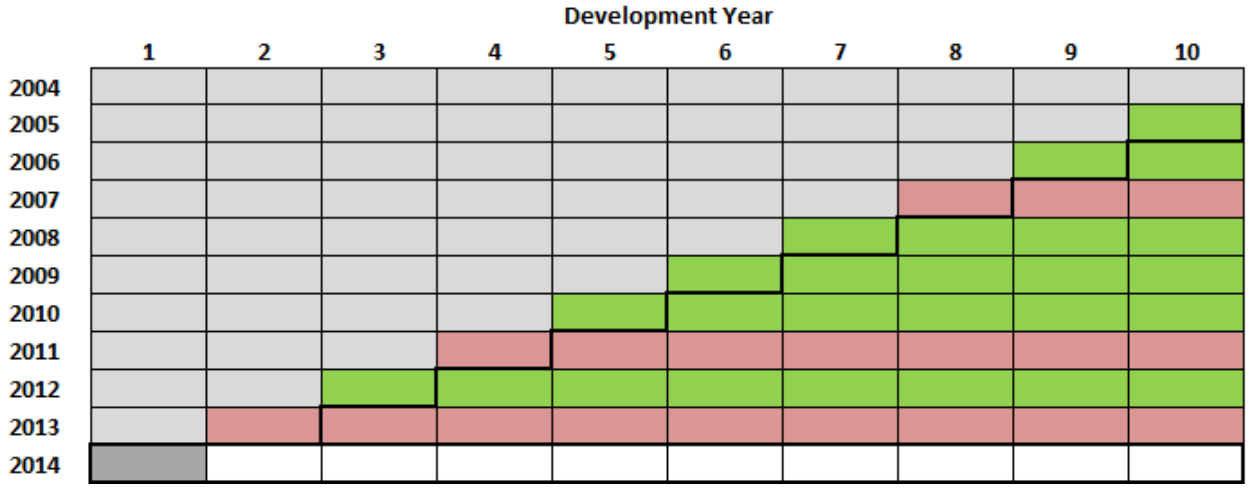
Illustration of Reserves Movement



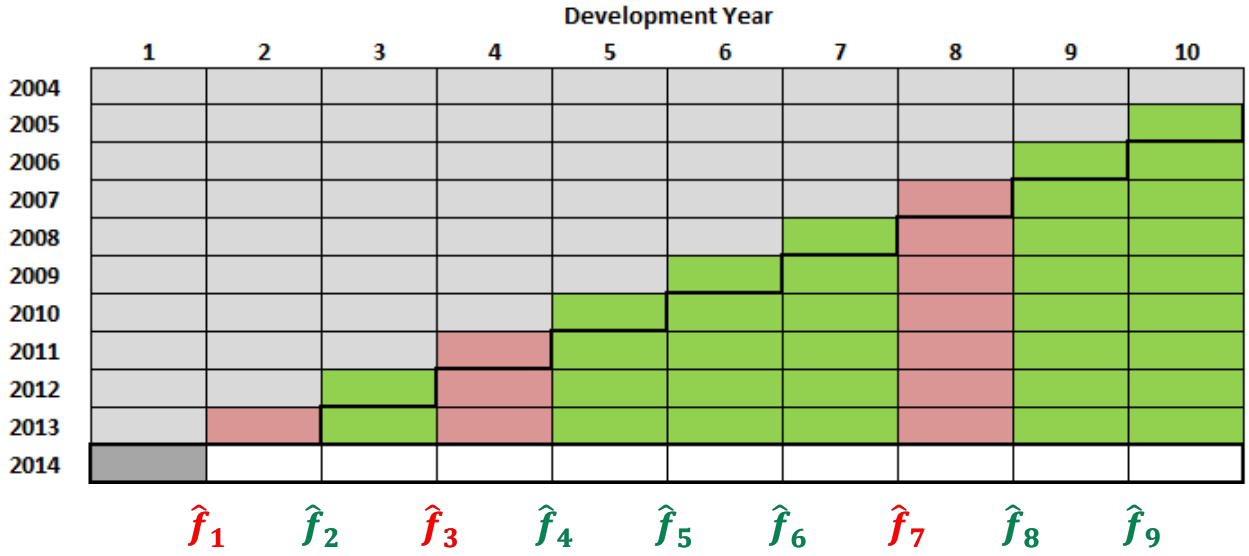


Volume Impact (Horizontal)

Illustration of Reserves Movement



Volume Impact (Horizontal)



Parameter Impact (Vertical)

Key Components of Reserve Risk

- Process Error
  - Risk: Outcome is not as expected given correct parameters
  - Reasons – Real world is dynamic and changing very quickly

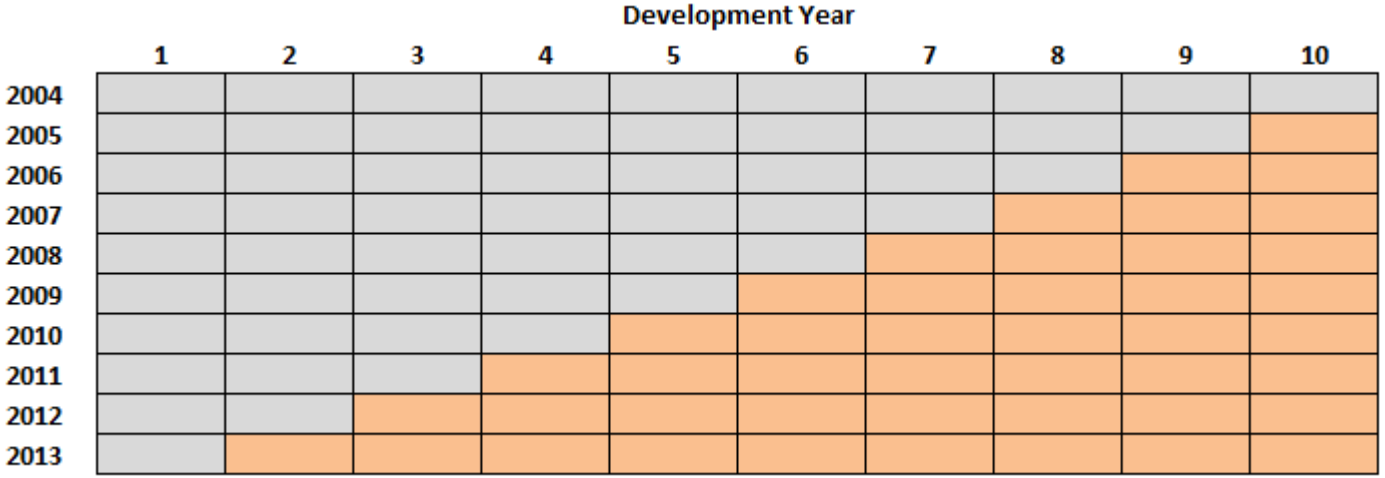
$$Process.VAR\left[C_{i,j+1}\middle|D\right] = \hat{C}_{i,j}\hat{\sigma}_j^2 + Process.VAR\left[C_{i,j}\middle|D\right] \times \hat{f}_j^2$$

- Parameter Error
  - Risk – Parameters used to define the model are incorrect
  - Reasons – Limited amount of data to estimate the parameters, Parameters will evolve/change over time

$$Parameter.VAR\left[C_{i,j+1}\middle|D\right] = \hat{C}_{i,j}^2 \times \frac{\hat{\sigma}_j^2}{\sum_{k=1}^{i-1} C_{k,j}} + Parameter.VAR\left[C_{i,j}\middle|D\right] \times \hat{f}_j^2$$

- Error estimates dependent not only on parameter estimates but on Triangle latest position also.

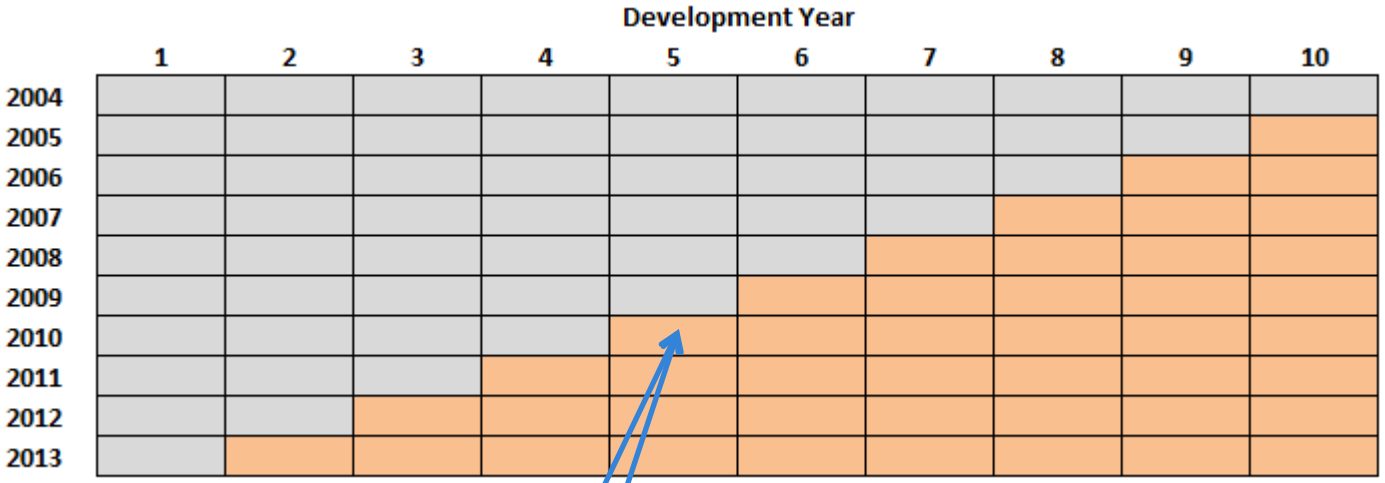
Illustration of Reserves Risk Movement



$\hat{f}_1$ $\hat{f}_2$ $\hat{f}_3$ $\hat{f}_4$ $\hat{f}_5$ $\hat{f}_6$ $\hat{f}_7$ $\hat{f}_8$ $\hat{f}_9$

$\hat{\sigma}_1$ $\hat{\sigma}_2$ $\hat{\sigma}_3$ $\hat{\sigma}_4$ $\hat{\sigma}_5$ $\hat{\sigma}_6$ $\hat{\sigma}_7$ $\hat{\sigma}_8$ $\hat{\sigma}_9$

Illustration of Reserves Risk Movement



$\hat{f}_1$ $\hat{f}_2$ $\hat{f}_3$ $\hat{f}_4$ $\hat{f}_5$ $\hat{f}_6$ $\hat{f}_7$ $\hat{f}_8$ $\hat{f}_9$

$\hat{\sigma}_1$ $\hat{\sigma}_2$ $\hat{\sigma}_3$ $\hat{\sigma}_4$ $\hat{\sigma}_5$ $\hat{\sigma}_6$ $\hat{\sigma}_7$ $\hat{\sigma}_8$ $\hat{\sigma}_9$

Process: $C_4\hat{\sigma}_4^2$

Illustration of Reserves Risk Movement

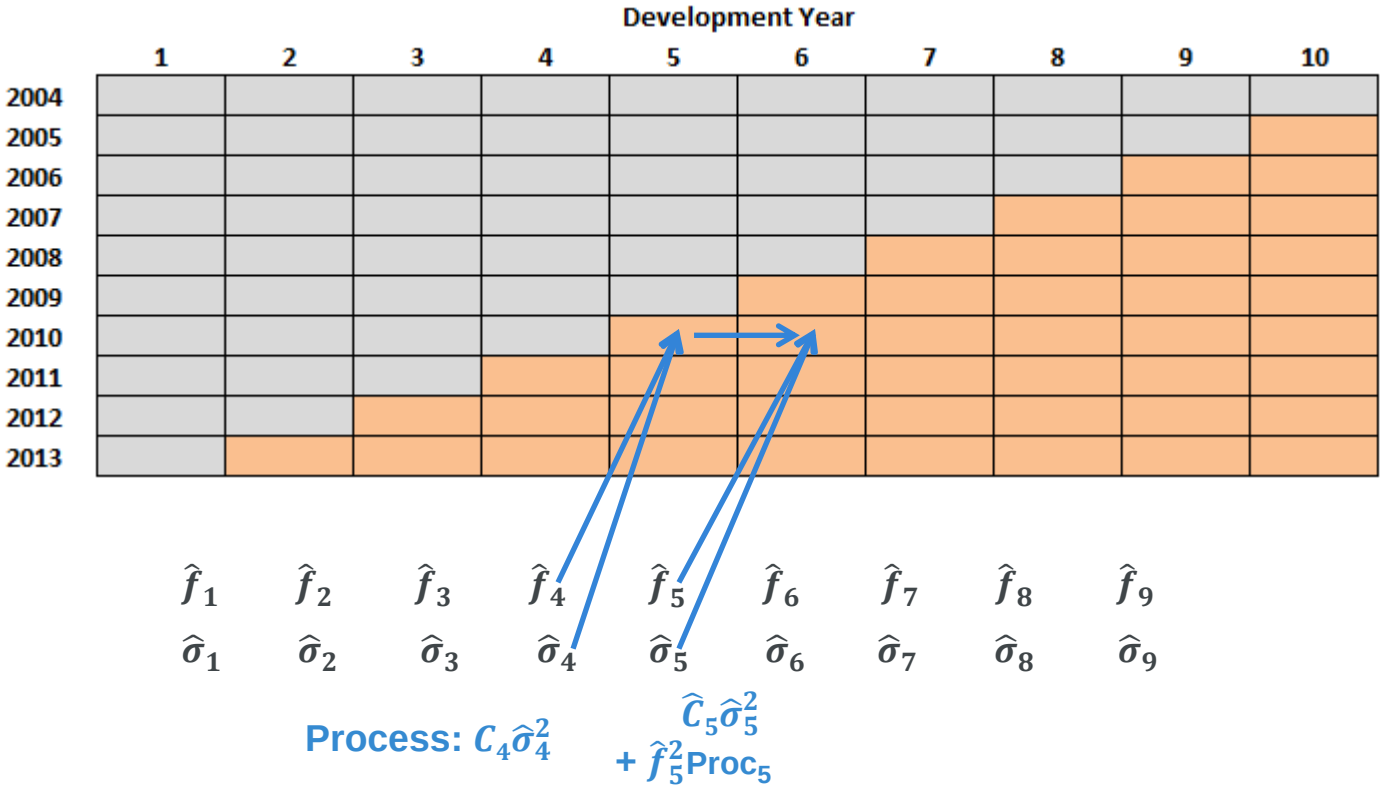
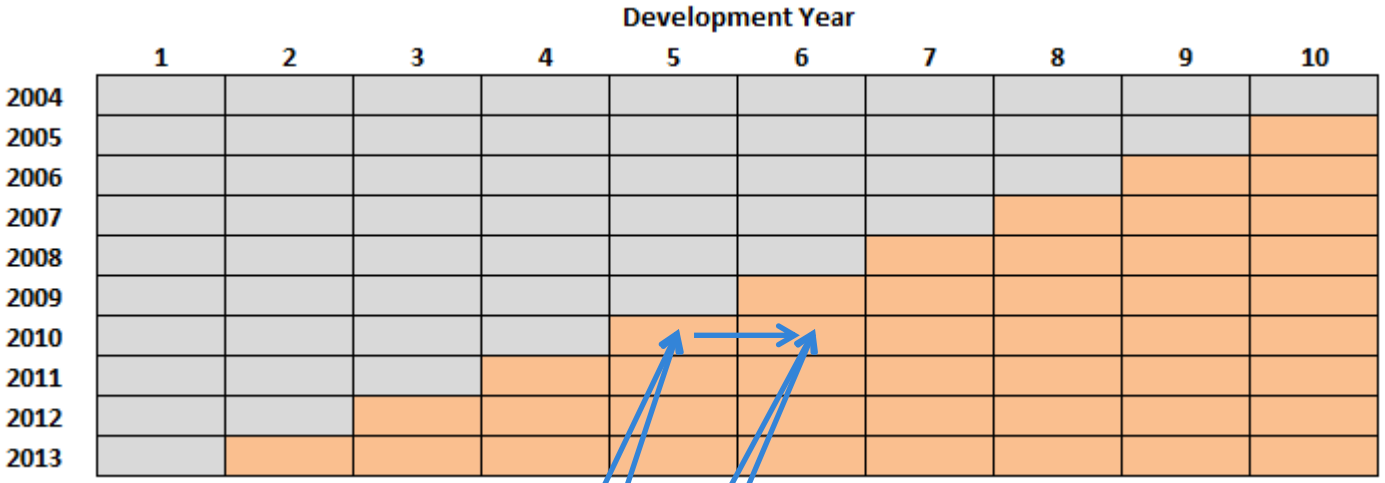


Illustration of Reserves Risk Movement



$\hat{f}_1$ $\hat{f}_2$ $\hat{f}_3$ $\hat{f}_4$ $\hat{f}_5$ $\hat{f}_6$ $\hat{f}_7$ $\hat{f}_8$ $\hat{f}_9$

$\hat{\sigma}_1$ $\hat{\sigma}_2$ $\hat{\sigma}_3$ $\hat{\sigma}_4$ $\hat{\sigma}_5$ $\hat{\sigma}_6$ $\hat{\sigma}_7$ $\hat{\sigma}_8$ $\hat{\sigma}_9$

Process: $C_4\hat{\sigma}_4^2$ $\quad \widehat{C}_5\hat{\sigma}_5^2 + \hat{f}_5^2\text{Proc}_5$

Parameter: $C_4^2\hat{\sigma}_4^2/\sum C$ $\quad \widehat{C_5^2}\hat{\sigma}_5^2/\sum C + \hat{f}_5^2\text{Para}_5$

Illustration of Reserves Risk Movement

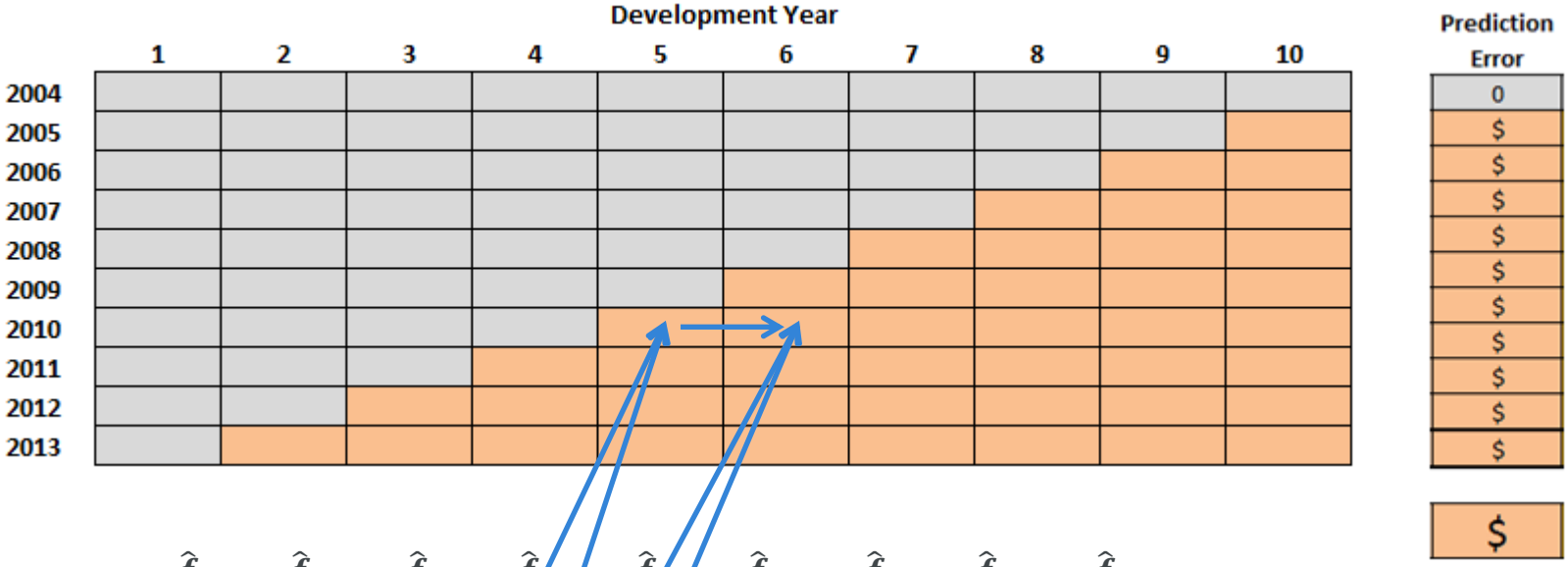


Illustration of Reserves Risk Movement

Maturity Impact

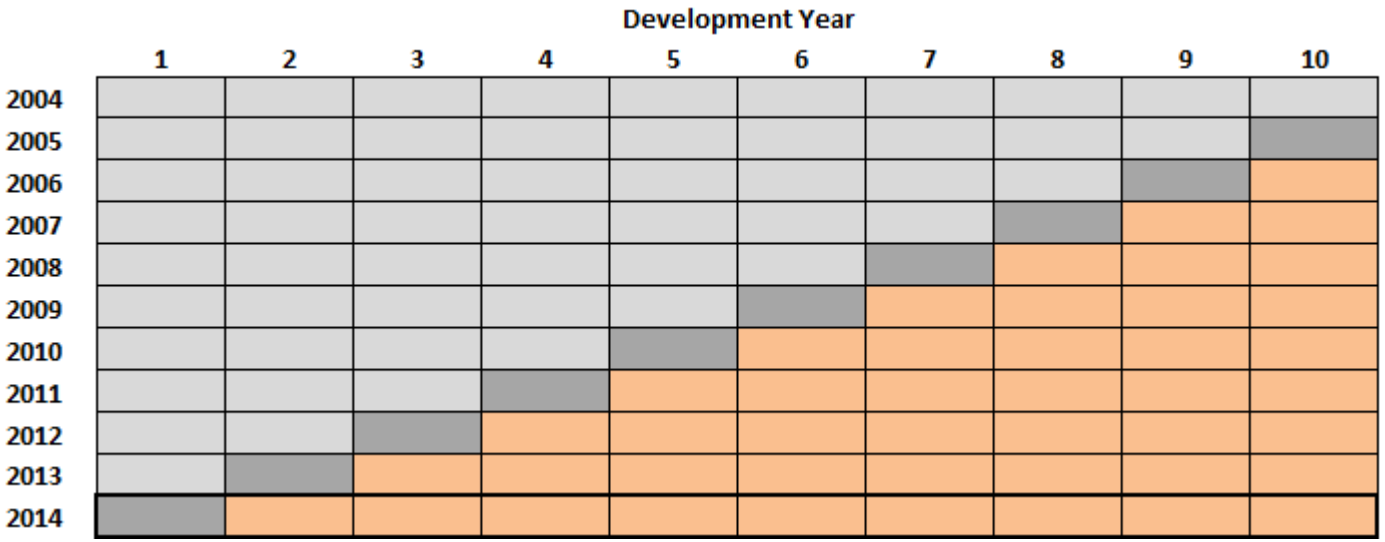


Illustration of Reserves Risk Movement

Maturity Impact

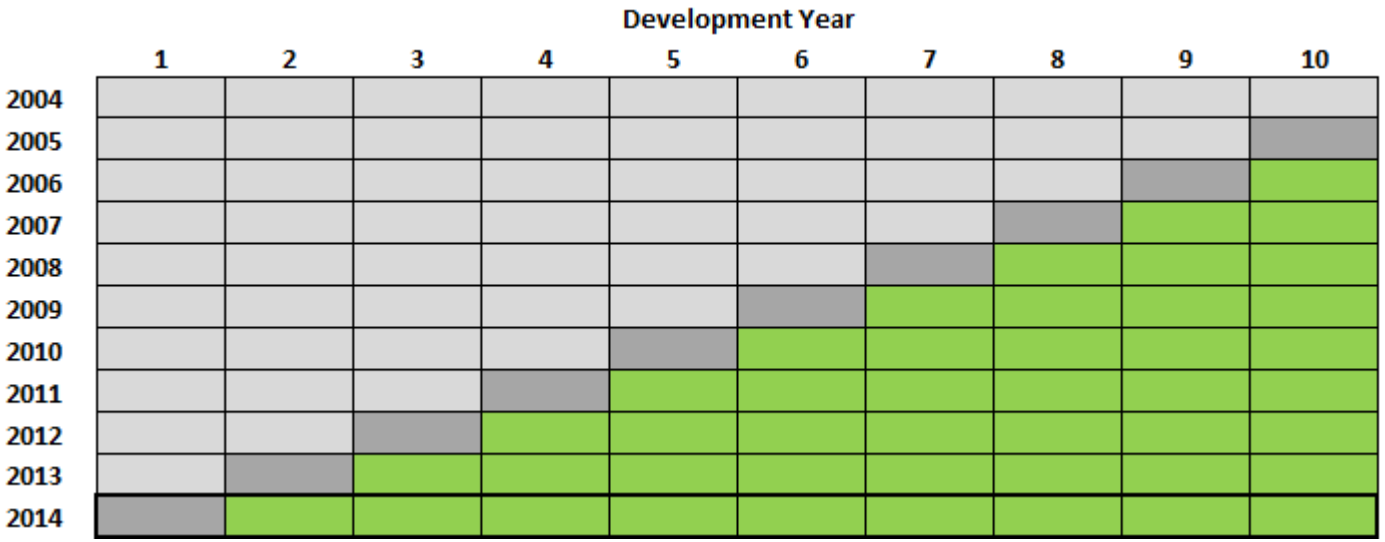


Illustration of Reserves Risk Movement

Volume Impact

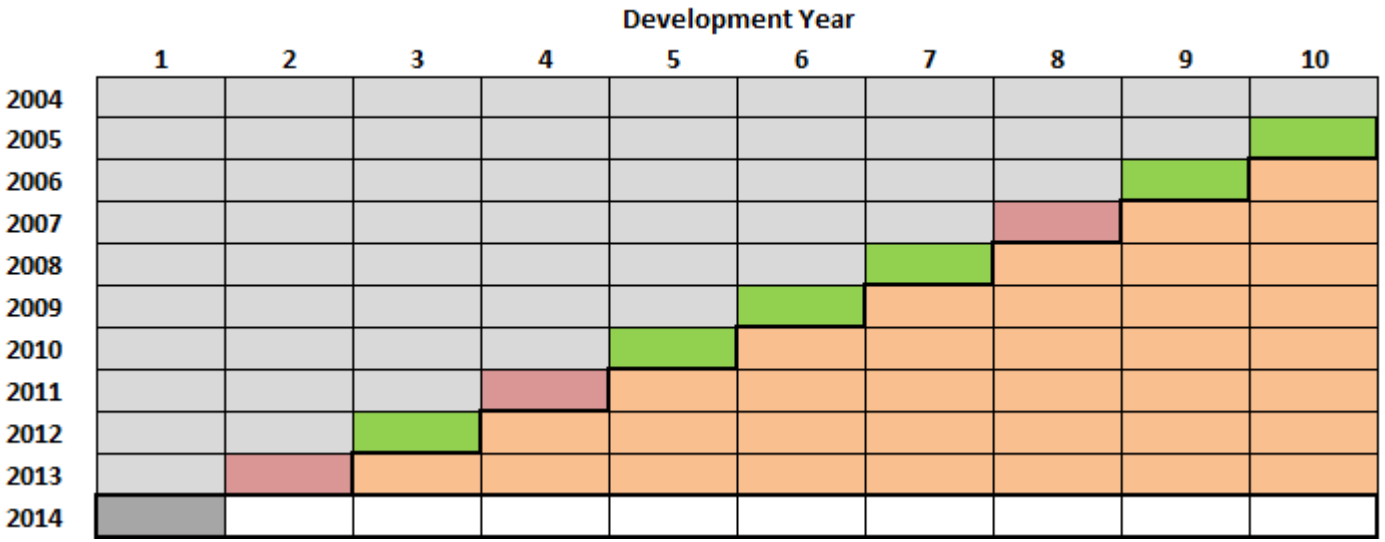


Illustration of Reserves Risk Movement

Volume Impact

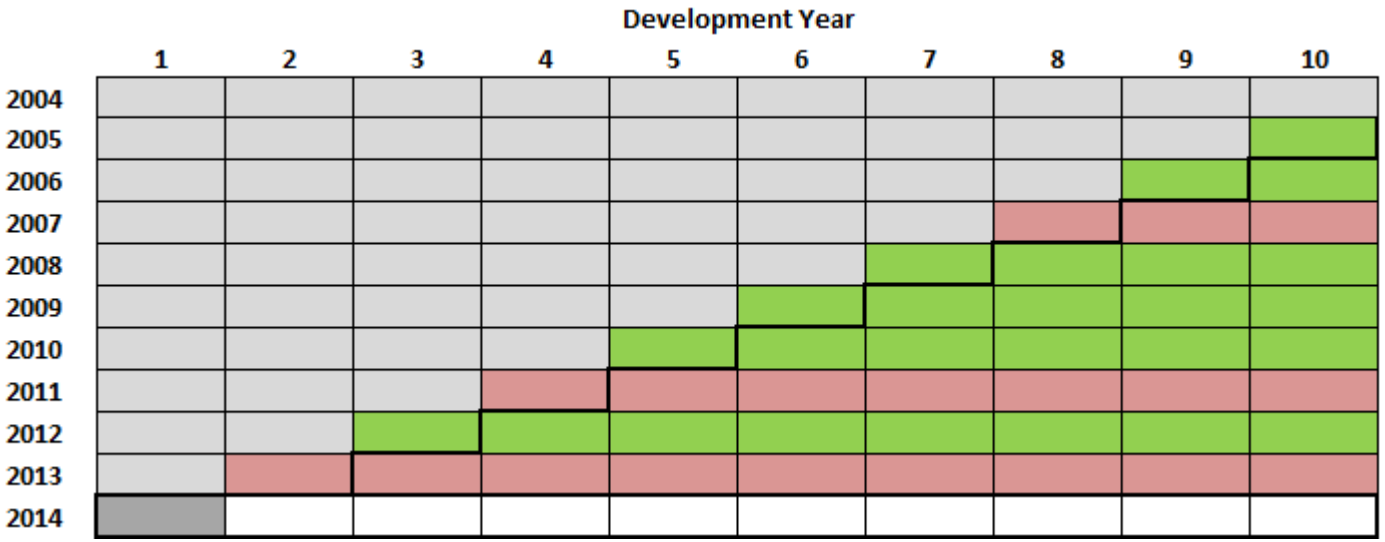


Illustration of Reserves Risk Movement

Parameter Impact - $\hat{f}$

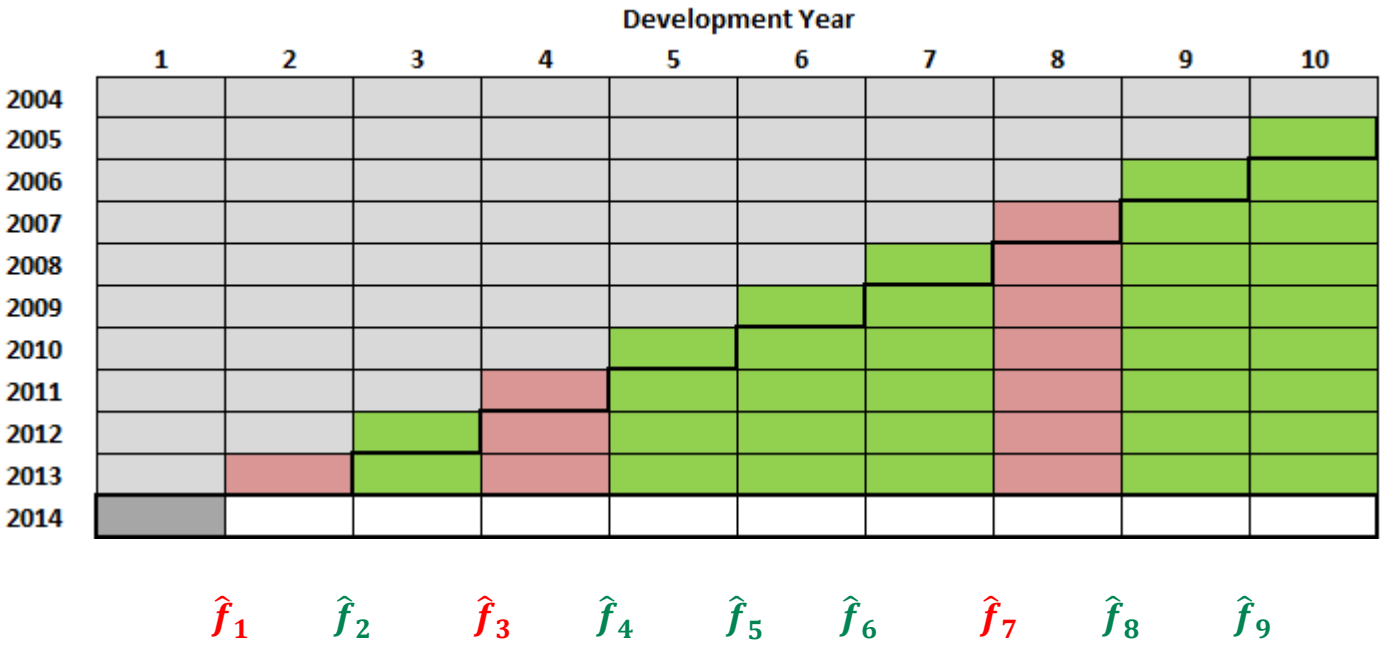


Illustration of Reserves Risk Movement

Good/Bad Development vs **Good/Bad Noise**

	n=5
	1.50
	1.30
	1.40
	1.60
	1.70
$\hat{f}$	1.50
$\hat{\sigma}$	0.16

Illustration of Reserves Risk Movement

Good/Bad Development vs **Good/Bad Noise**

	n=5	n=6							
	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
		1.15	1.25	1.35	1.45	1.55	1.65	1.75	1.85
$\hat{f}$	1.50	1.44	1.46	1.48	1.49	1.51	1.53	1.54	1.56
$\hat{\sigma}$	0.16								

Illustration of Reserves Risk Movement

Good/Bad Development vs **Good/Bad Noise**

	n=5				n=6				
	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
		1.15	1.25	1.35	1.45	1.55	1.65	1.75	1.85
$\hat{f}$	1.50	1.44	1.46	1.48	1.49	1.51	1.53	1.54	1.56
$\hat{\sigma}$	0.16								

Illustration of Reserves Risk Movement

Good/Bad Development vs **Good/Bad Noise**

	n=5	n=6							
	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
		1.15	1.25	1.35	1.45	1.55	1.65	1.75	1.85
$\hat{f}$	1.50								
$\hat{\sigma}$	0.16	0.20	0.17	0.15	0.14	0.14	0.15	0.17	0.20

Illustration of Reserves Risk Movement

Good/Bad Development vs **Good/Bad Noise**

	n=5	n=6							
	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
		1.15	1.25	1.35	1.45	1.55	1.65	1.75	1.85
$\hat{f}$	1.50								
$\hat{\sigma}$	0.16	0.20	0.17	0.15	0.14	0.14	0.15	0.17	0.20

Illustration of Reserves Risk Movement

Good/Bad Development vs **Good/Bad Noise**

	n=5	n=6							
	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30
	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70
		1.15	1.25	1.35	1.45	1.55	1.65	1.75	1.85
$\hat{f}$	1.50	1.44	1.46	1.48	1.49	1.51	1.53	1.54	1.56
$\hat{\sigma}$	0.16	0.20	0.17	0.15	0.14	0.14	0.15	0.17	0.20

Illustration of Reserves Risk Movement

Parameter Impact - $\hat{\sigma}$

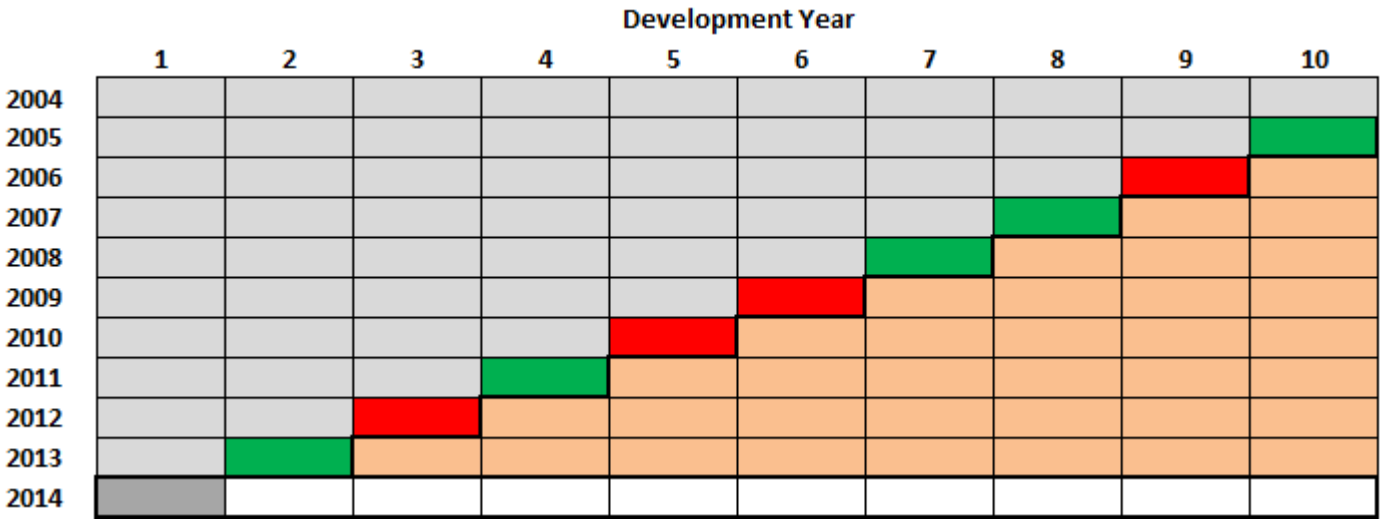


Illustration of Reserves Risk Movement

Parameter Impact - $\hat{\sigma}$

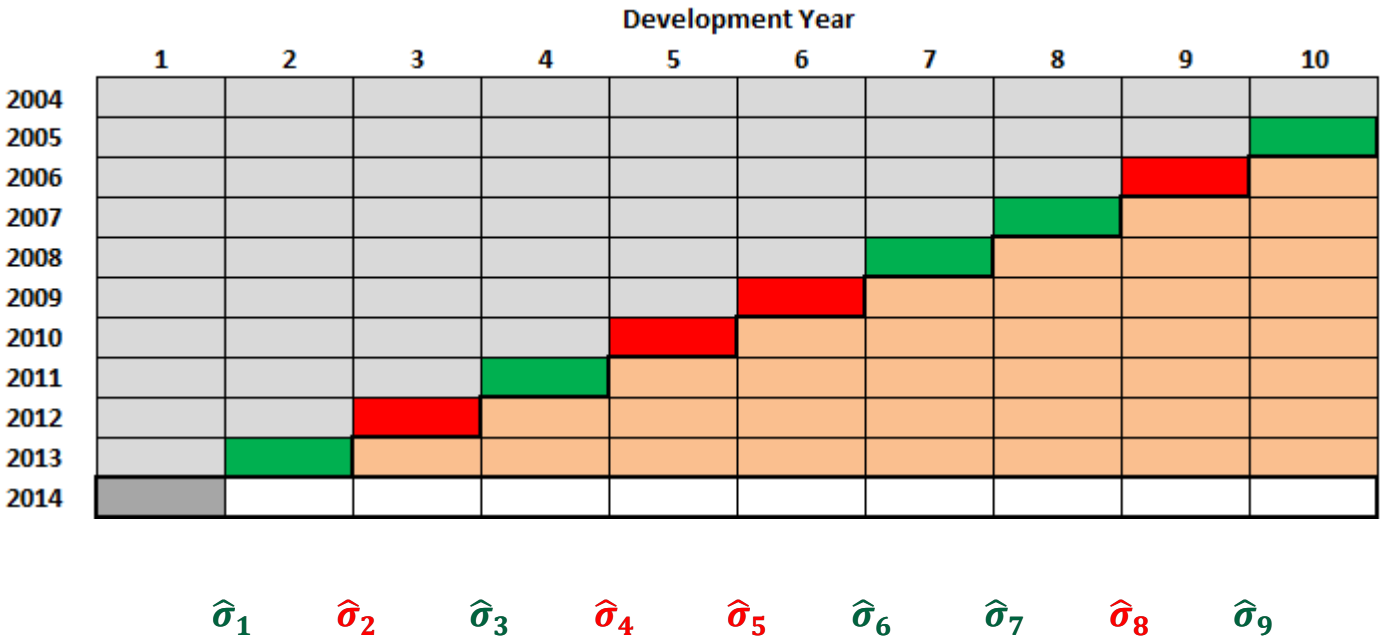


Illustration of Reserves Risk Movement

Parameter Impact - $\hat{\sigma}$

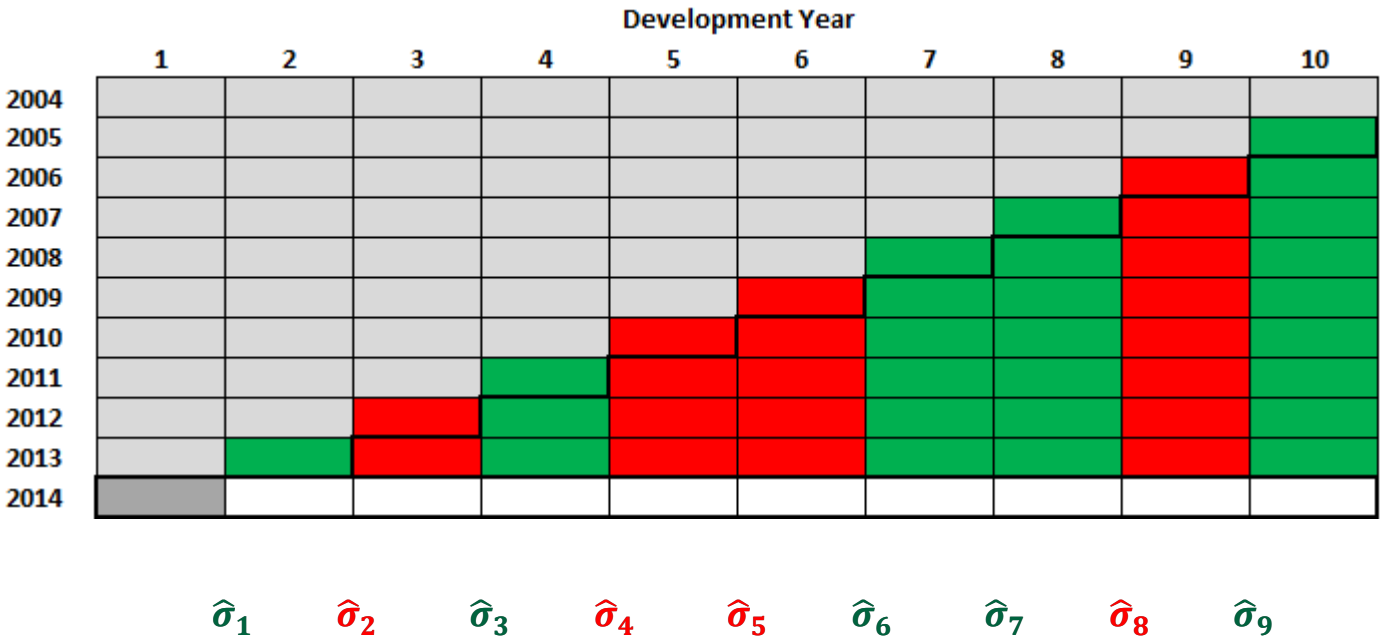
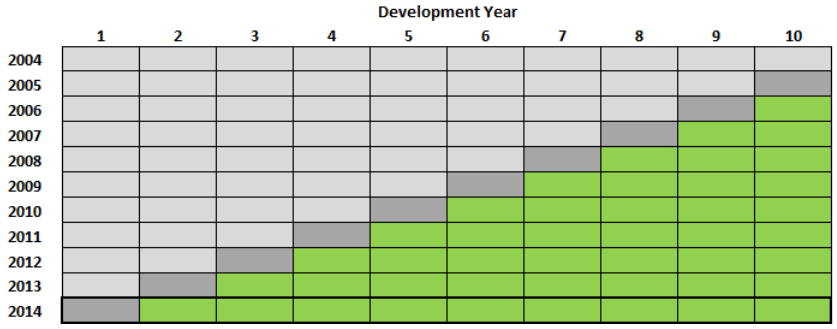
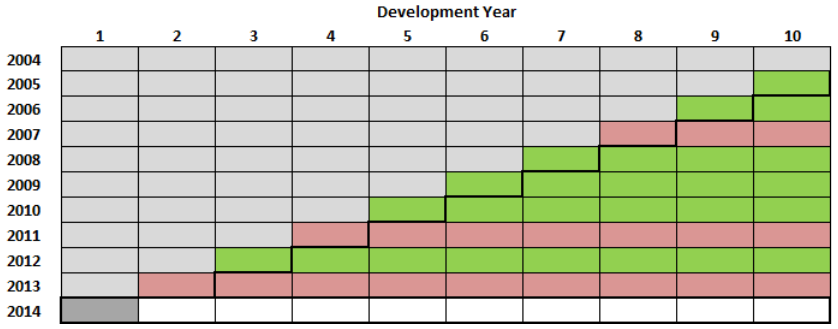


Illustration of Reserves Risk Movement

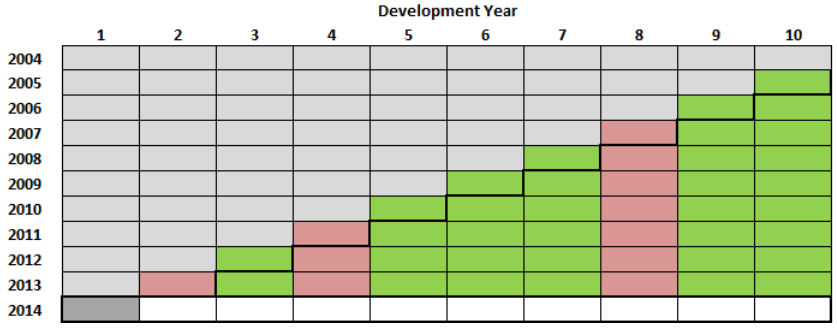
Maturity Impact



Volume Impact



Parameter Impact - $\hat{f}$



Parameter Impact - $\hat{\sigma}$

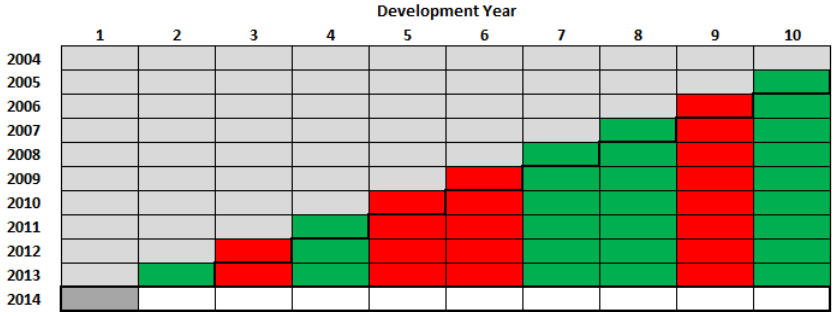


Illustration of Reserves Risk Movement

Combined effect

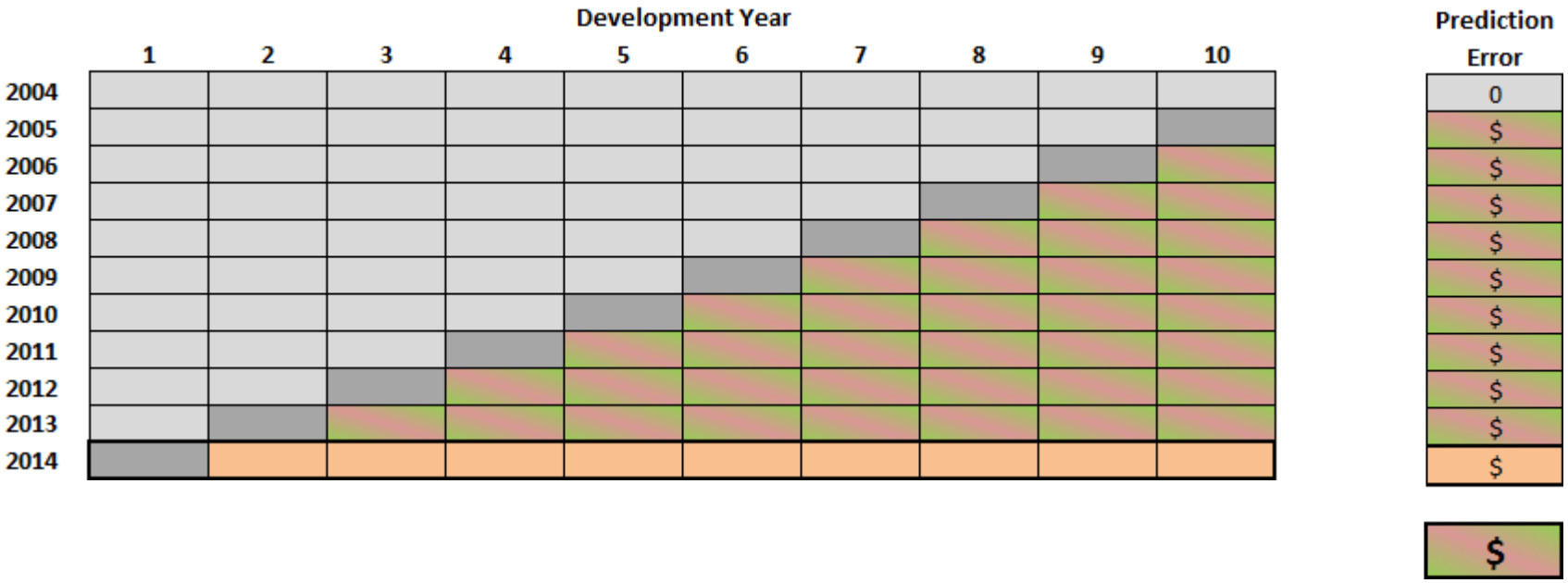


Illustration of Reserves Risk Movement

Combined effect

Illustration of Reserves Risk Movement

Combined effect

- *Maturity*
- *Volume*
- *Parameters*
- *One Additional Year*

Sample Triangle

Gross Incurred Loss as at 2013Q4

AY	12 m	24 m	36 m	48 m	60 m	72 m	84 m	96 m	108 m	120 m
2004	41,181	84,728	125,326	127,743	130,846	131,369	142,318	139,439	139,393	139,386
2005	14,737	78,533	128,022	181,150	206,929	195,143	194,115	192,391	192,223	
2006	8,435	65,358	134,518	181,253	213,178	208,910	239,276	238,227		
2007	25,002	92,659	118,786	169,411	212,895	203,770	219,871			
2008	18,105	77,016	120,857	209,701	243,582	272,667				
2009	22,846	97,509	142,916	207,655	303,531					
2010	17,356	85,120	191,387	289,970						
2011	19,251	154,227	222,430							
2012	43,100	206,423								
2013	25,276									
Total										

Loss Development Factors

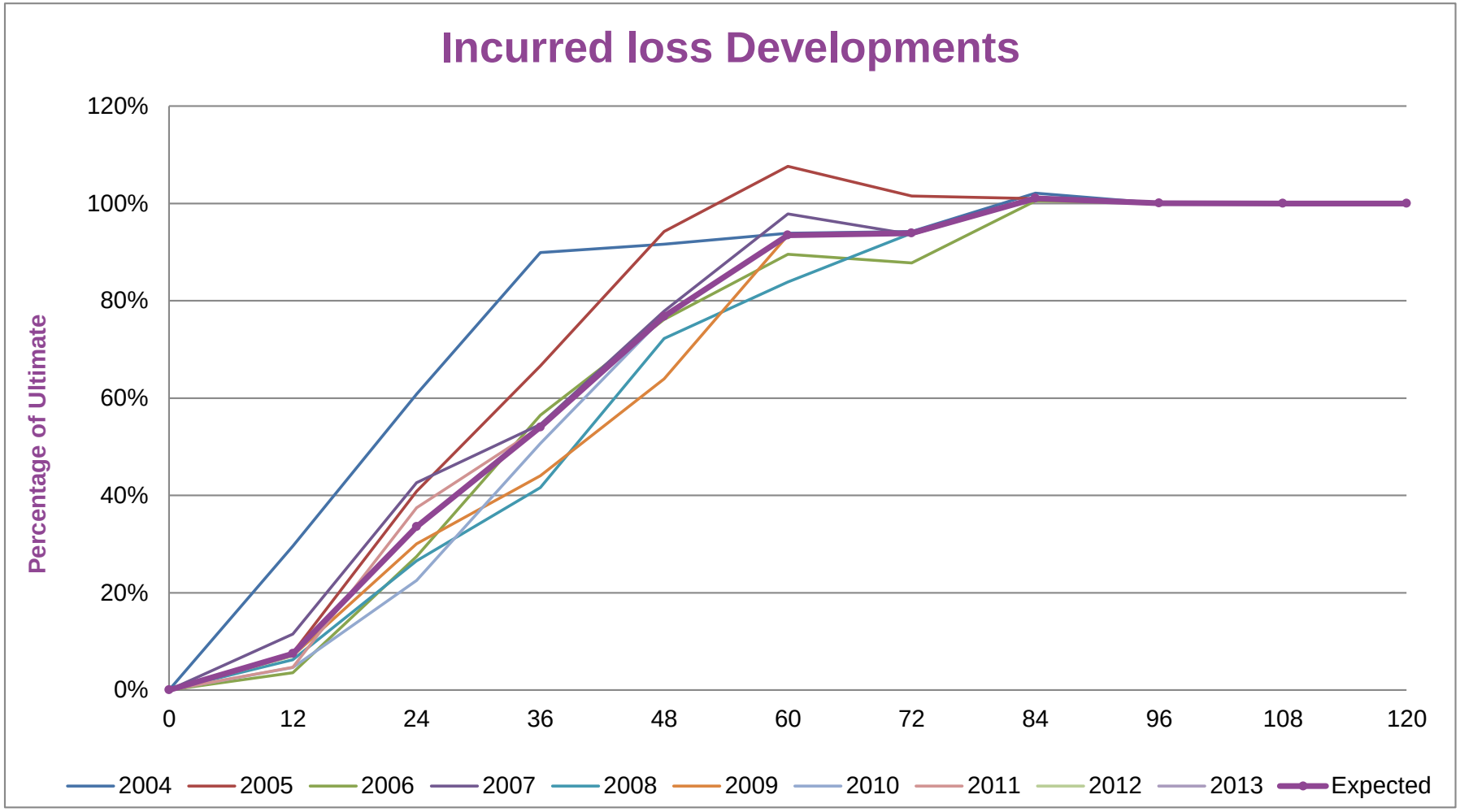
AY	12-24 m	24-36 m	36-48 m	48-60 m	60-72 m	72-84 m	84-96 m	96-108 m	108-120 m
2004	2.057	1.479	1.019	1.024	1.004	1.083	0.980	1.000	1.000
2005	5.329	1.630	1.415	1.142	0.943	0.995	0.991	0.999	
2006	7.748	2.058	1.347	1.176	0.980	1.145	0.996		
2007	3.706	1.282	1.426	1.257	0.957	1.079			
2008	4.254	1.569	1.735	1.162	1.119				
2009	4.268	1.466	1.453	1.462					
2010	4.904	2.248	1.515						
2011	8.011	1.442							
2012	4.789								
2013									

Parameters	12-24	24-36	36-48	48-60	60-72	72-84	84-96	96-108	108-120	120-132
LDFs (f^j)	4.483	1.611	1.421	1.217	1.004	1.076	0.990	0.999	1.000	1.000
Sigma^2	75,832	9,397	5,788	3,881	1,151	768	11	0.02	0.02	

Mack Model Result

Latest	% Developed	Reserves	St Dev	CoV
139,386	100.0%	-	-	0.0%
192,223	100.0%	(10)	104	1082.2%
238,227	100.1%	(166)	159	95.8%
219,871	101.1%	(2,310)	1,860	80.5%
272,667	93.9%	17,717	16,898	95.4%
303,531	93.5%	21,143	29,069	137.5%
289,970	76.8%	87,608	51,554	58.8%
222,430	54.0%	189,183	75,151	39.7%
206,423	33.5%	408,921	133,737	32.7%
25,276	7.5%	312,537	166,554	53.3%
2,110,004		1,034,624	272,261	26.3%

Sample Triangle DFM



2013Q4 + One More Year Mature

- Next diagonal is as expected based on triangle and pattern selected
- No change in parameters
- Re-do volatility estimation using Mack Model and same Parameter estimates

	2013Q4 Result				
Year	Incurred	% Developed	Reserves	St Dev	CoV
2004	139,386	100.0%	-	-	0.0%
2005	192,223	100.0%	(10)	104	-1082.2%
2006	238,227	100.1%	(166)	159	-95.8%
2007	219,871	101.1%	(2,310)	1,860	-80.5%
2008	272,667	93.9%	17,717	16,898	95.4%
2009	303,531	93.5%	21,143	29,069	137.5%
2010	289,970	76.8%	87,608	51,554	58.8%
2011	222,430	54.0%	189,183	75,151	39.7%
2012	206,423	33.5%	408,921	133,737	32.7%
2013	25,276	7.5%	312,537	166,554	53.3%
2014					
Total	2,110,004		1,034,624	272,261	26.3%
2013 &Prior	2,110,004		1,034,624	272,261	26.3%

2013Q4 + One More Year Mature - Result				
Incurred	% Developed	Reserves	St Dev	CoV
139,386	100.0%	-	-	0.0%
192,213	100.0%	-	-	0.0%
238,073	100.0%	(12)	124	-1037.5%
217,712	100.1%	(151)	148	-97.8%
293,467	101.1%	(3,083)	2,247	-72.9%
304,865	93.9%	19,809	18,151	91.6%
352,990	93.5%	24,589	31,994	130.1%
316,107	76.8%	95,505	54,407	57.0%
332,524	54.0%	282,820	96,842	34.2%
113,323	33.5%	224,490	93,047	41.4%
24,176	7.5%	298,935	162,446	54.3%
2,524,837		942,902	257,085	27.3%
2,500,661		643,967	179,291	27.8%

- Purely from maturity (one less cell)
- Is CoV an appropriate measure to look at?

Actual Diagonal – Volume Impact

- No change in parameter estimates
- Actual diagonal value being used to project Reserves and Standard Deviation

	2014Q4 Actual VS Expected			2013Q4 + One More Year Mature - Result					2014Q4 Actual - Volume Impact				
Year	Expected	Actual	Differences	Incurred	% Developed	Reserves	St Dev	CoV	Incurred	% Developed	Reserves	St Dev	CoV
2004	139,386	139,386	-	139,386	100.0%	-	-	0.0%	139,386	100.0%	-	-	0.0%
2005	192,213	192,272	(59)	192,213	100.0%	-	-	0.0%	192,272	100.0%	-	-	0.0%
2006	238,073	238,290	(217)	238,073	100.0%	(12)	124	-1037.5%	238,290	100.0%	(12)	124	-1037.3%
2007	217,712	218,033	(321)	217,712	100.1%	(151)	148	-97.8%	218,033	100.1%	(152)	148	-97.8%
2008	293,467	292,120	1,347	293,467	101.1%	(3,083)	2,247	-72.9%	292,120	101.1%	(3,069)	2,240	-73.0%
2009	304,865	334,609	(29,744)	304,865	93.9%	19,809	18,151	91.6%	334,609	93.9%	21,742	19,286	88.7%
2010	352,990	310,102	42,888	352,990	93.5%	24,589	31,994	130.1%	310,102	93.5%	21,601	29,463	136.4%
2011	316,107	338,295	(22,188)	316,107	76.8%	95,505	54,407	57.0%	338,295	76.8%	102,209	56,788	55.6%
2012	332,524	281,089	51,435	332,524	54.0%	282,820	96,842	34.2%	281,089	54.0%	239,074	86,938	36.4%
2013	113,323	91,300	22,023	113,323	33.5%	224,490	93,047	41.4%	91,300	33.5%	180,864	82,182	45.4%
2014		24,176		24,176	7.5%	298,935	162,446	54.3%	24,176	7.5%	298,935	162,446	54.3%
Total	2,500,661	2,459,672	65,165	2,524,837		942,902	257,085	27.3%	2,459,672		861,192	244,433	28.4%
2013 &Prior	2,500,661	2,435,496	65,165	2,500,661		643,967	179,291	27.8%	2,435,496		562,257	163,533	29.1%

Actual Diagonal – Change in Parameters

Gross Incurred Loss as at 2014Q4											
AY	12 m	24 m	36 m	48 m	60 m	72 m	84 m	96 m	108 m	120 m	132 m
2004	41,181	84,728	125,326	127,743	130,846	131,369	142,318	139,439	139,393	139,386	139,386
2005	14,737	78,533	128,022	181,150	206,929	195,143	194,115	192,391	192,223	192,272	
2006	8,435	65,358	134,518	181,253	213,178	208,910	239,276	238,227	238,290		
2007	25,002	92,659	118,786	169,411	212,895	203,770	219,871	218,033			
2008	18,105	77,016	120,857	209,701	243,582	272,667	292,120				
2009	22,846	97,509	142,916	207,655	303,531	334,609					
2010	17,356	85,120	191,387	289,970	310,102						
2011	19,251	154,227	222,430	338,295							
2012	43,100	206,423	281,089								
2013	25,276	91,300									
2014	24,176										

Loss Development Factors											
AY	12-24m	24-36m	36-48m	48-60m	60-72m	72-84m	84-96m	96-108m	108-120m	120-132m	132-144m
2004	2.057	1.479	1.019	1.024	1.004	1.083	0.980	1.000	1.000	1.000	
2005	5.329	1.630	1.415	1.142	0.943	0.995	0.991	0.999	1.000		
2006	7.748	2.058	1.347	1.176	0.980	1.145	0.996	1.000			
2007	3.706	1.282	1.426	1.257	0.957	1.079	0.992				
2008	4.254	1.569	1.735	1.162	1.119	1.071					
2009	4.268	1.466	1.453	1.462	1.102						
2010	4.904	2.248	1.515	1.069							
2011	8.011	1.442	1.521								
2012	4.789	1.362									
2013	3.612										
2014											

2013Q4 LDFs	4.483	1.611	1.421	1.217	1.004	1.076	0.990	0.999	1.000	1.000	
2014Q4 LDFs	4.390	1.556	1.440	1.186	1.027	1.075	0.991	1.000	1.000	1.000	1.000
Change	Decrease	Decrease	Increase	Decrease	Increase	Decrease	Flat	Flat	Flat	Flat	

2013Q4 Sigma^2	75,832	9,397	5,788	3,881	1,151	768	11	0	0		
2014Q4 Sigma^2	69,309	9,473	5,218	4,067	1,369	577	8	0	0.0	0.0	
Change	Decrease	Increase	Decrease	Increase	Increase	Decrease	Decrease	Increase	Decrease		

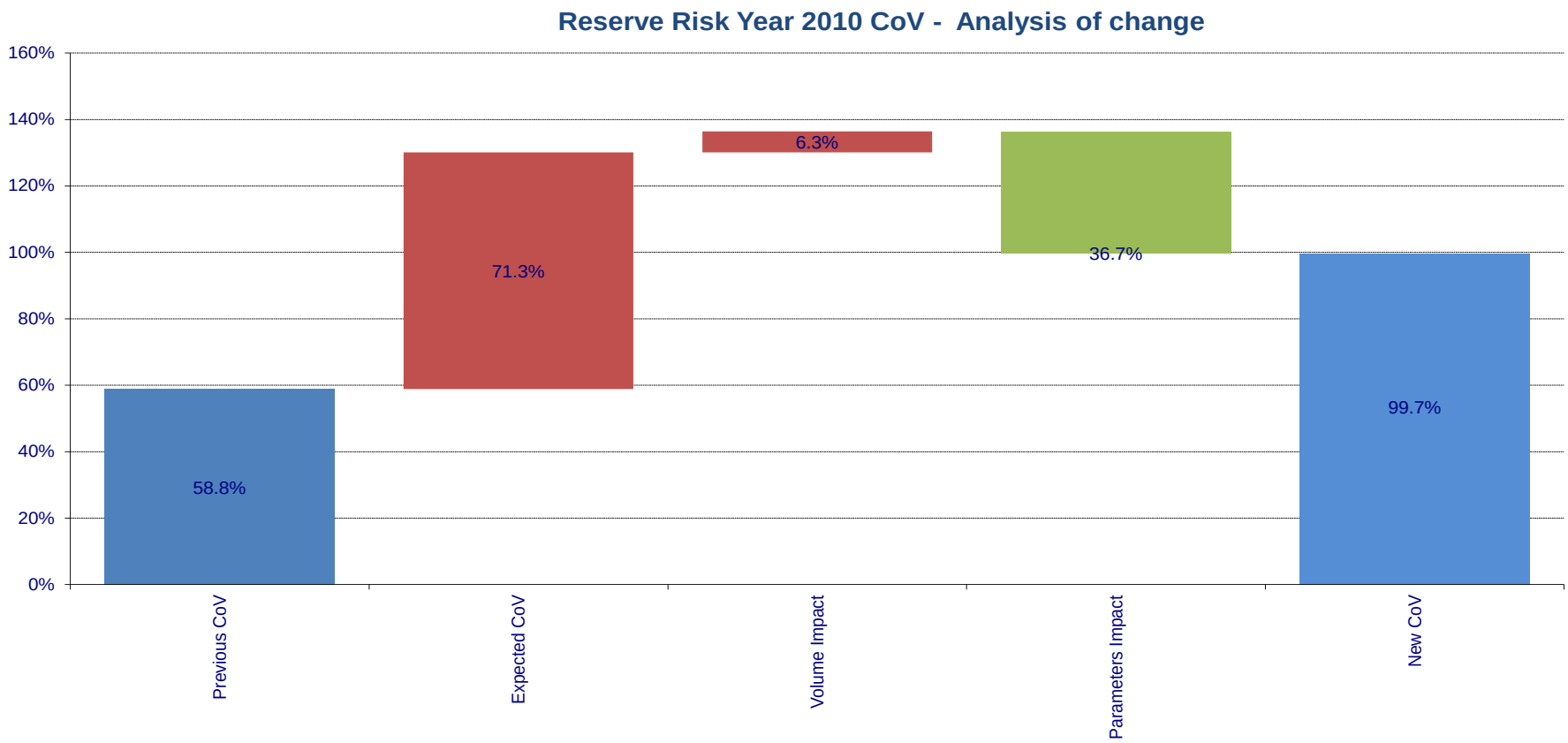
Actual Diagonal – Parameters Impact

- Revise parameters with respect to new diagonal
- Actual diagonal value being used to project Reserves and Standard Deviation

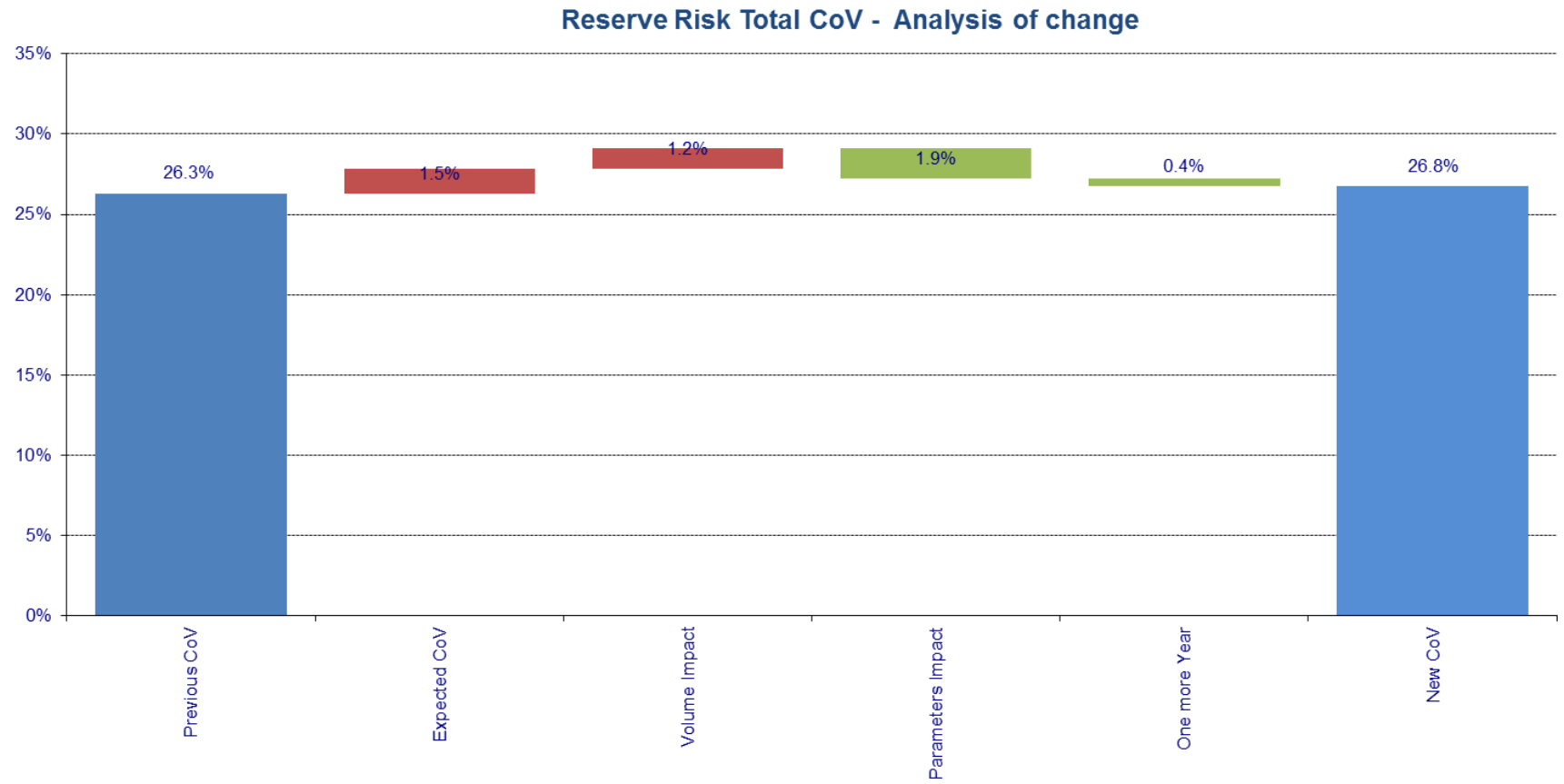
	2014Q4 Actual - Volume Impact				
Year	Incurred	% Developed	Reserves	St Dev	CoV
2004	139,386	100.0%	-	-	0.0%
2005	192,272	100.0%	-	-	0.0%
2006	238,290	100.0%	(12)	124	-1037.3%
2007	218,033	100.1%	(152)	148	-97.8%
2008	292,120	101.1%	(3,069)	2,240	-73.0%
2009	334,609	93.9%	21,742	19,286	88.7%
2010	310,102	93.5%	21,601	29,463	136.4%
2011	338,295	76.8%	102,209	56,788	55.6%
2012	281,089	54.0%	239,074	86,938	36.4%
2013	91,300	33.5%	180,864	82,182	45.4%
2014	24,176	7.5%	298,935	162,446	54.3%
Total	2,459,672		861,192	244,433	28.4%
2013 &Prior	2,435,496		562,257	163,533	29.1%

	2014Q4 Actual - Parameters Impact				
	Incurred	% Developed	Reserves	St Dev	CoV
2004	139,386	100.0%	-	-	0.0%
2005	192,272	100.0%	-	59	0.0%
2006	238,290	100.0%	30	89	295.2%
2007	218,033	100.0%	(30)	167	-553.1%
2008	292,120	101.0%	(2,790)	1,761	-63.1%
2009	334,609	93.9%	21,644	16,001	73.9%
2010	310,102	91.4%	29,001	28,908	99.7%
2011	338,295	77.1%	100,429	56,557	56.3%
2012	281,089	53.6%	243,802	83,919	34.4%
2013	91,300	34.4%	174,025	80,456	46.2%
2014	24,176	7.8%	284,240	152,515	53.7%
Total	2,459,672		850,350	227,734	26.8%
2013 &Prior	2,435,496		566,111	154,033	27.2%

Analysis of Change – Year 2010



Analysis of Change – Total



Study on Calendar Year Stability of CoV

Calendar Year Stability of CoV

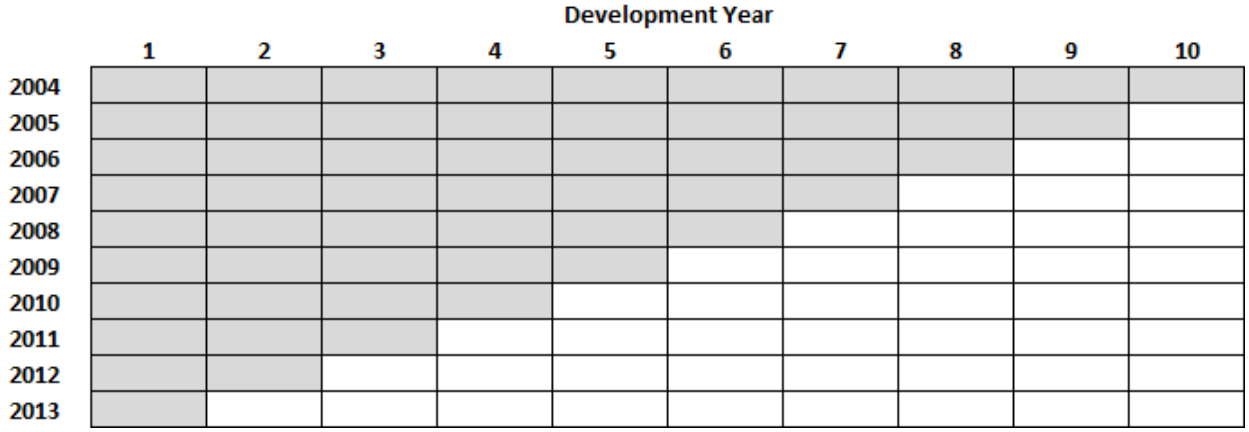
- How volatile is the CoV with an additional Calendar Year experience?

Calendar Year Stability of CoV

- How volatile is the CoV with an additional Calendar Year experience?
- Methodology:
  - “Pure Mack” triangles for a fixed set of parameters (medium tail line)

Calendar Year Stability of CoV

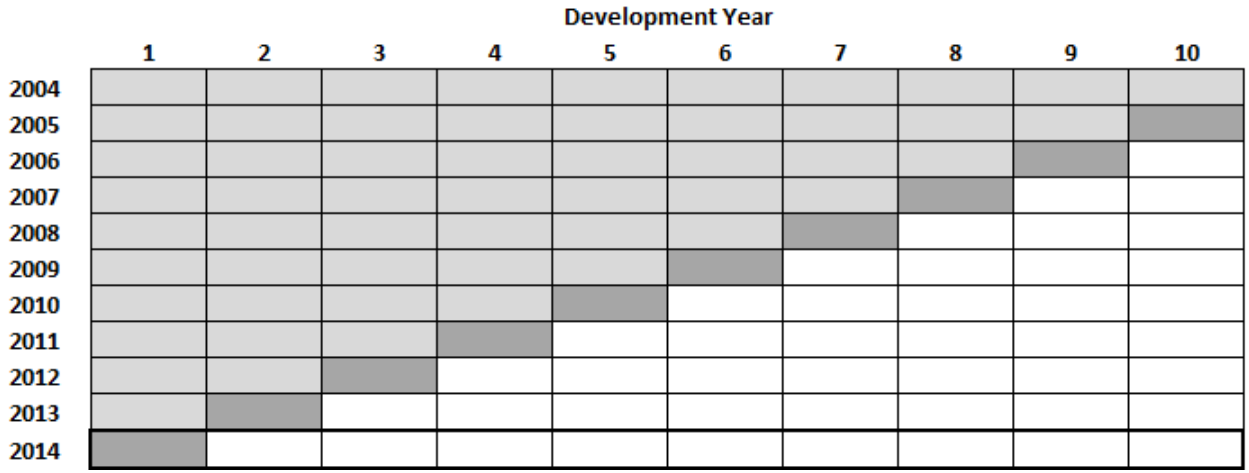
- How volatile is the CoV with an additional Calendar Year experience?
- Methodology:
  - "Pure Mack" triangles for a fixed set of parameters (medium tail line)
  - Generate 500 triangles and estimate the CoV



$CoV_{t=10}$

Calendar Year Stability of CoV

- How volatile is the CoV with an additional Calendar Year experience?
- Methodology:
  - "Pure Mack" triangles for a fixed set of parameters (medium tail line)
  - Generate 500 triangles and estimate the CoV
  - Generate a next diagonal and re-estimate the CoV. Repeat for 100 times to get a distribution of CoV.

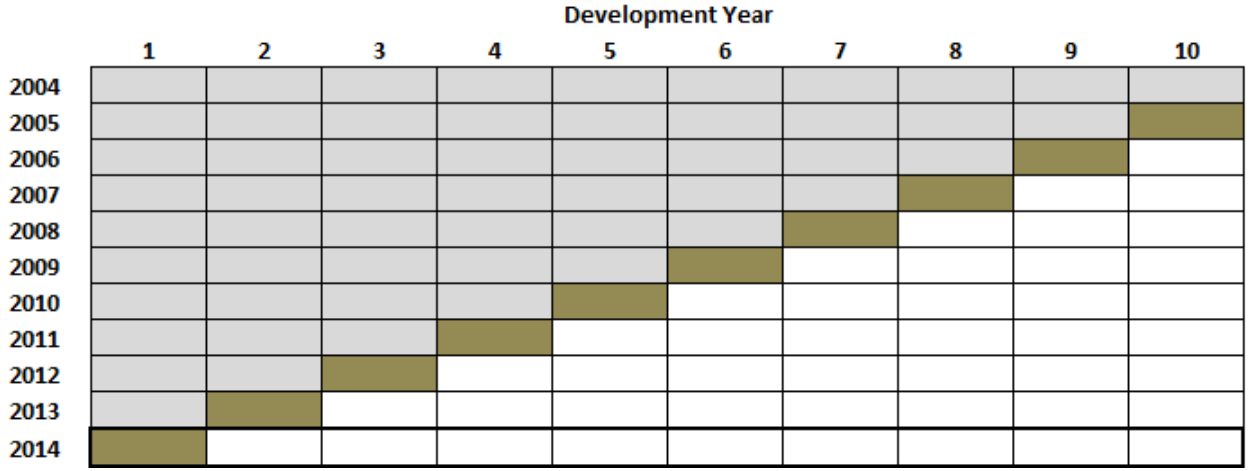


$CoV_{t=10}$

$CoV_{t=11}$

Calendar Year Stability of CoV

- How volatile is the CoV with an additional Calendar Year experience?
- Methodology:
  - "Pure Mack" triangles for a fixed set of parameters (medium tail line)
  - Generate 500 triangles and estimate the CoV
  - Generate a next diagonal and re-estimate the CoV. Repeat for 100 times to get a distribution of CoV.



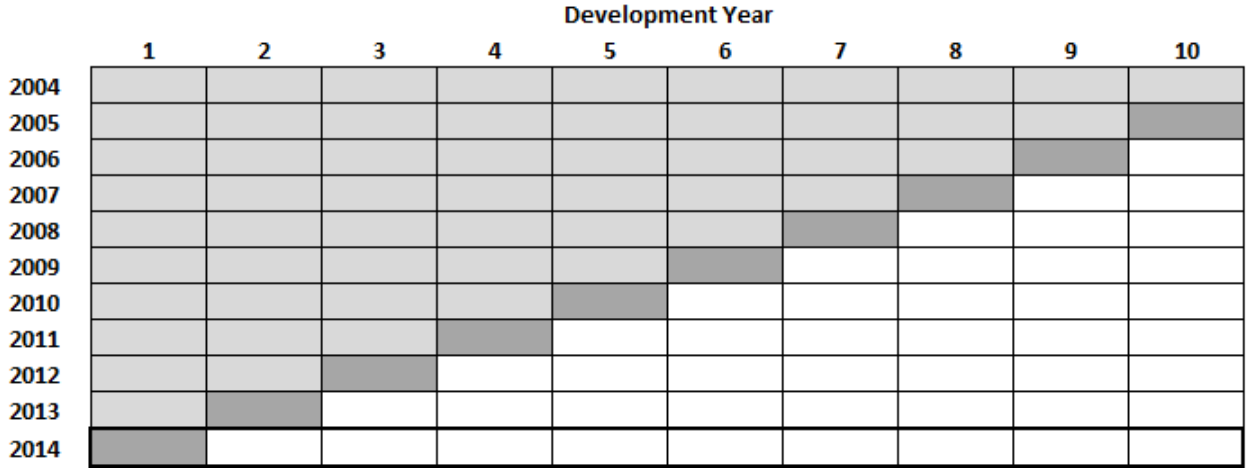
$CoV_{t=10}$

$CoV_{t=11}$

$CoV_{t=11}$

Calendar Year Stability of CoV

- How volatile is the CoV with an additional Calendar Year experience?
- Methodology:
  - "Pure Mack" triangles for a fixed set of parameters (medium tail line)
  - Generate 500 triangles and estimate the CoV
  - Generate a next diagonal and re-estimate the CoV. Repeat for 100 times to get a distribution of CoV.

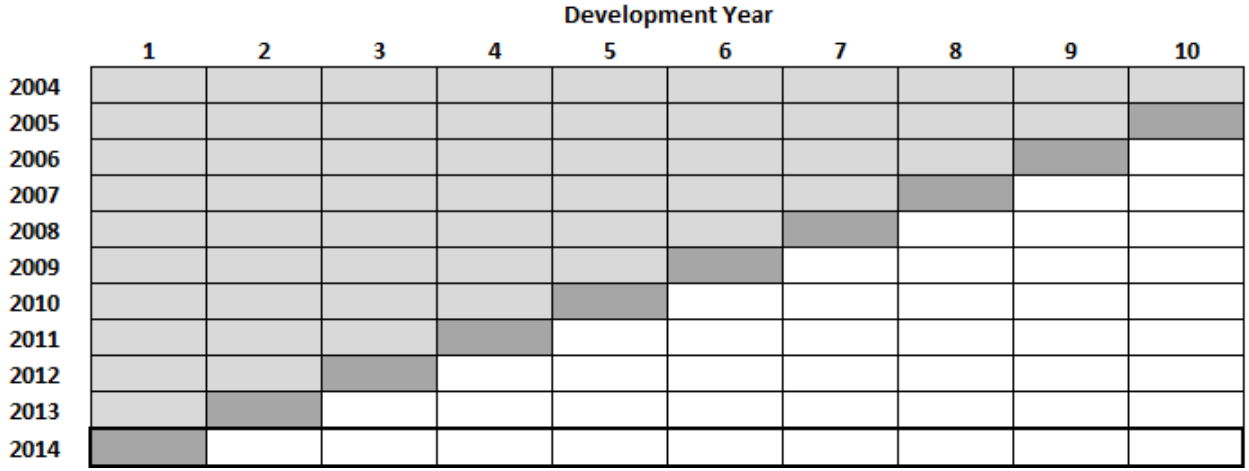


$$CoV_{t=10}$$

$$100X \begin{cases} CoV_{t=11} \\ CoV_{t=11} \\ \vdots \\ CoV_{t=11} \\ CoV_{t=11} \end{cases}$$

Calendar Year Stability of CoV

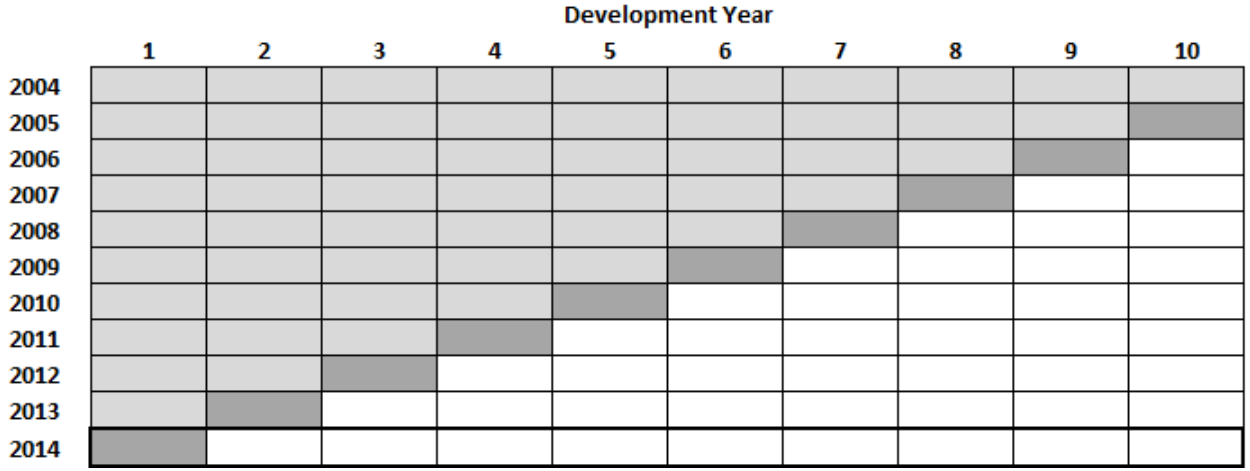
- How volatile is the CoV with an additional Calendar Year experience?
- Methodology:
  - "Pure Mack" triangles for a fixed set of parameters (medium tail line)
  - Generate 500 triangles and estimate the CoV
  - Generate a next diagonal and re-estimate the CoV. Repeat for 100 times to get a distribution of CoV.
  - Repeat this study for N=10, 12, 15.



$$100X \left\{ \begin{array}{l} CoV_{t=10} \\ CoV_{t=11} \\ CoV_{t=11} \\ \vdots \\ CoV_{t=11} \\ CoV_{t=11} \end{array} \right.$$

Calendar Year Stability of CoV

- How volatile is the CoV with an additional Calendar Year experience?
- Methodology:
  - "Pure Mack" triangles for a fixed set of parameters (medium tail line)
  - Generate 500 triangles and estimate the CoV
  - Generate a next diagonal and re-estimate the CoV. Repeat for 100 times to get a distribution of CoV.
  - Repeat this study for N=10, 12, 15.

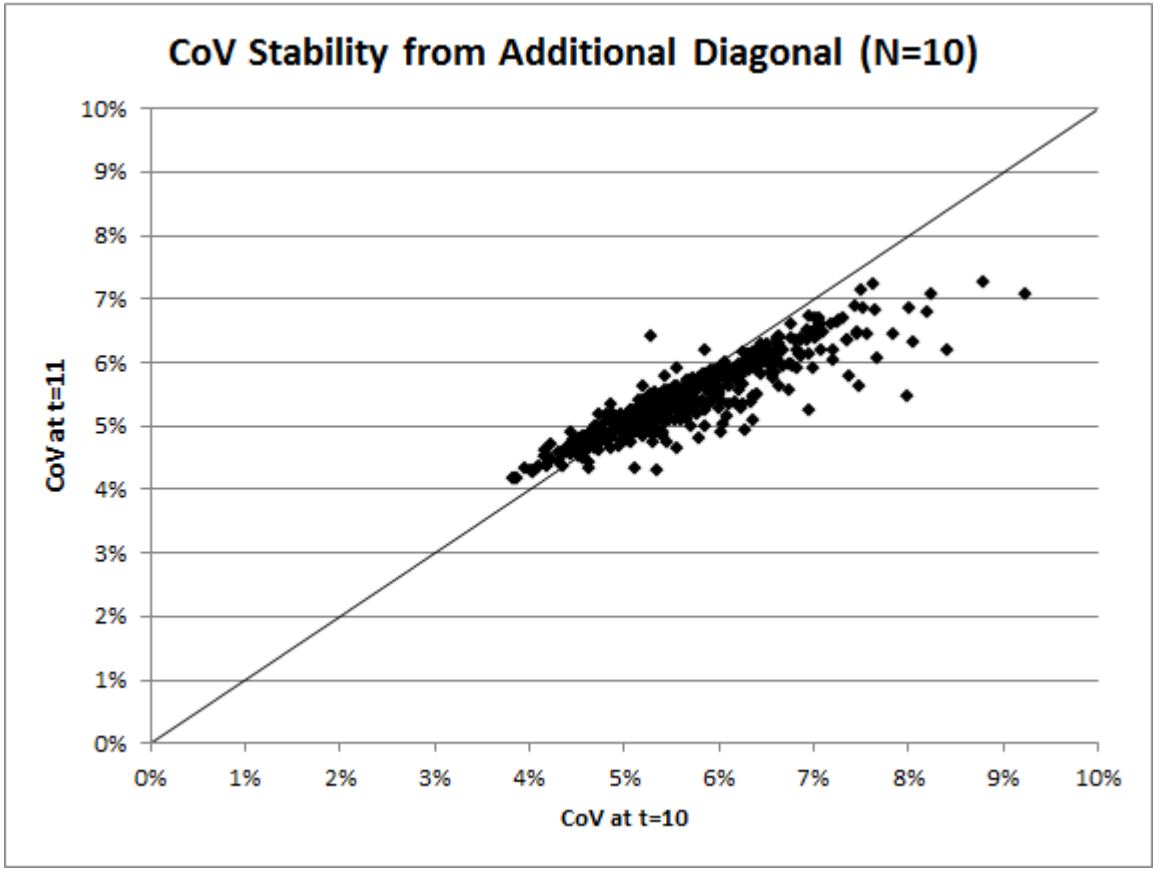


$$100X \begin{cases} CoV_{t=10} \\ CoV_{t=11} \\ CoV_{t=11} \\ \vdots \\ CoV_{t=11} \\ CoV_{t=11} \end{cases}$$

- Graph the result to see the expected CoV from an addition of one new diagonal

Calendar Year Stability

Mean

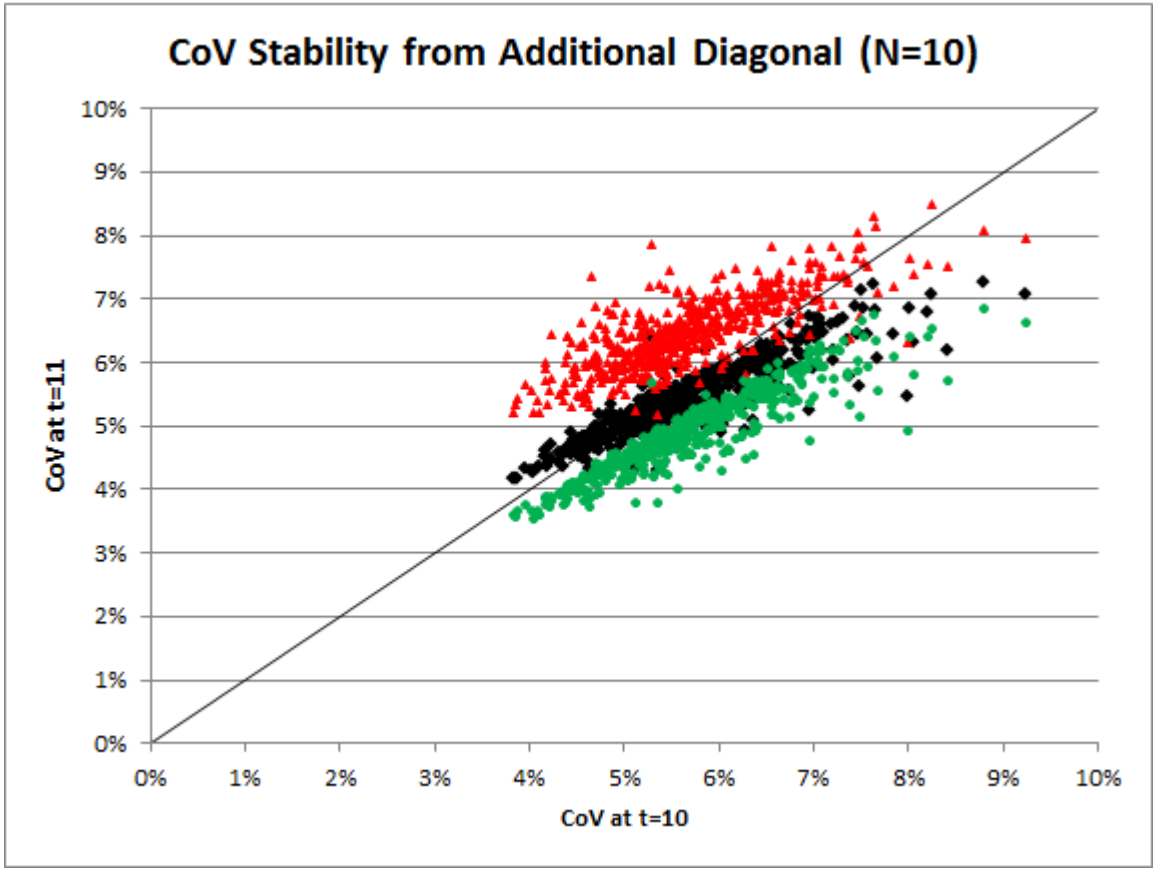


Calendar Year Stability

Max

Mean

Min

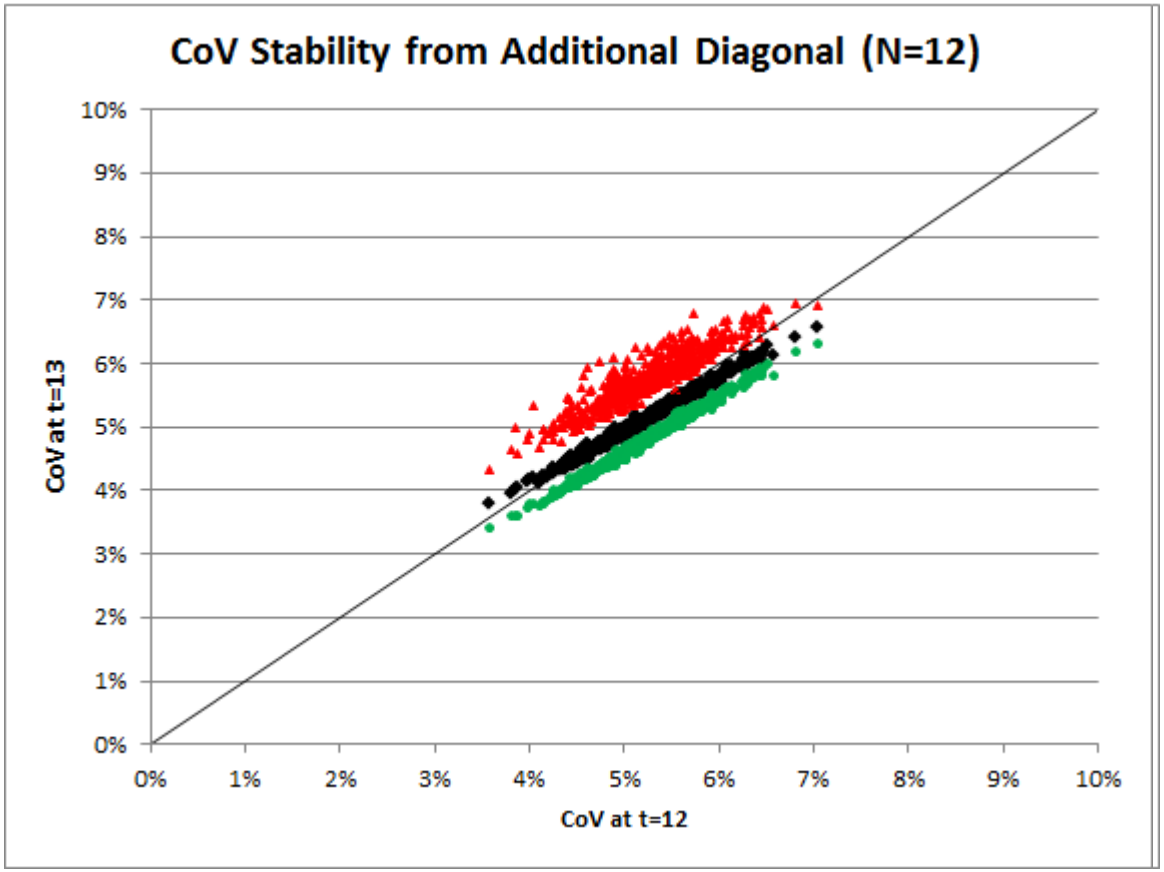


Calendar Year Stability

Max

Mean

Min

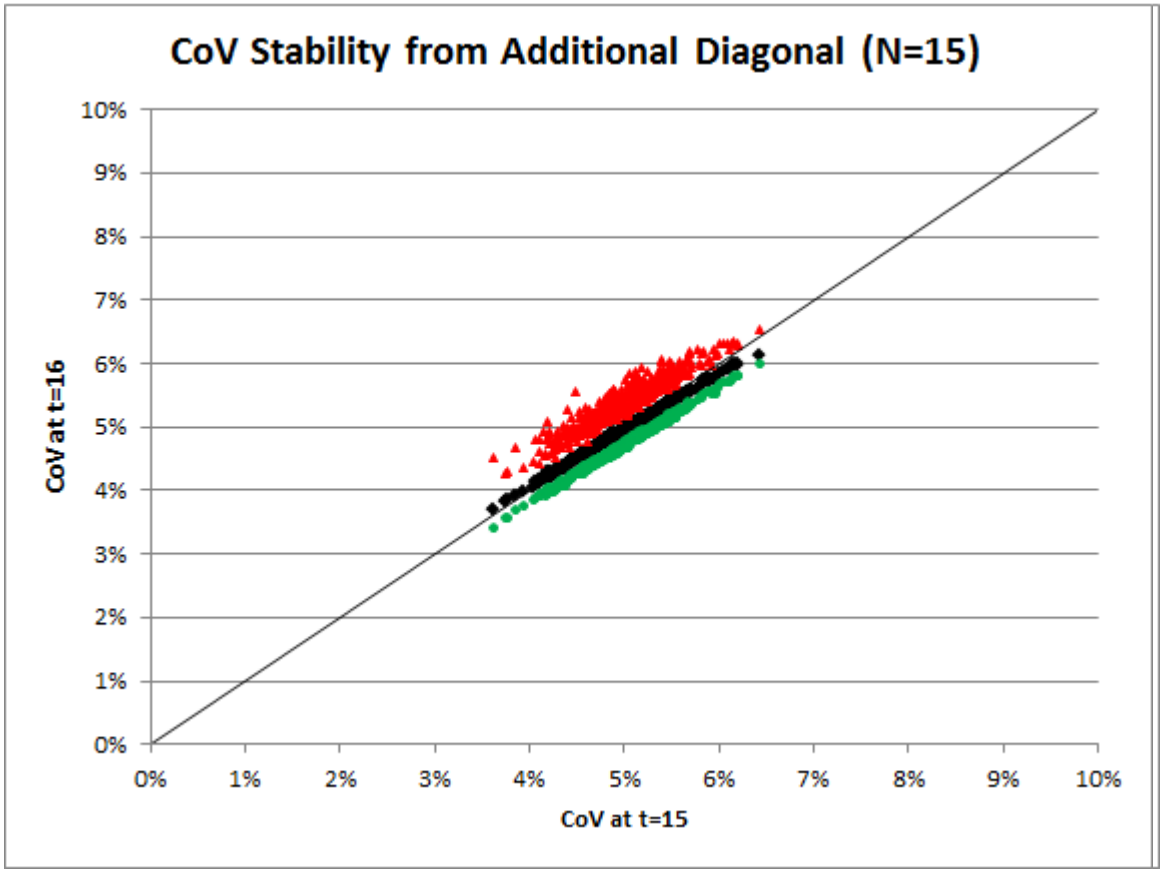


Calendar Year Stability

Max

Mean

Min



Remarks

- A good calendar year is often referring to development, it does not necessarily mean a reduction in reserve risk.
- CoV might not be a good measure in all situations. Don't use it in isolation!
- Prediction Error movement consists of:
  - Maturity Impact
  - Volume Impact
  - Parameters Impact
  - One Additional Year
- Encourage reserving actuaries to consider not just good/bad development but good/bad noise too
- More study using pure model data (e.g. "Pure Mack") need to be conducted by the industry