ApolloMunich HEALTH INSURANCE

2nd Capacity Building Seminar in Health Insurance

Practical applications of stochastic modelling for a health insurance company

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Deterministic Models

- Input variable(s) value set at the outset
- Best estimate approach
- Formula specified
- Same outcome for Same input

Stochastic Models

- Allows for randomness in input variables
- Input variable can have a probability distribution
- Large number of simulations are run
- Outcome has a probability distribution

Use in Health Insurance

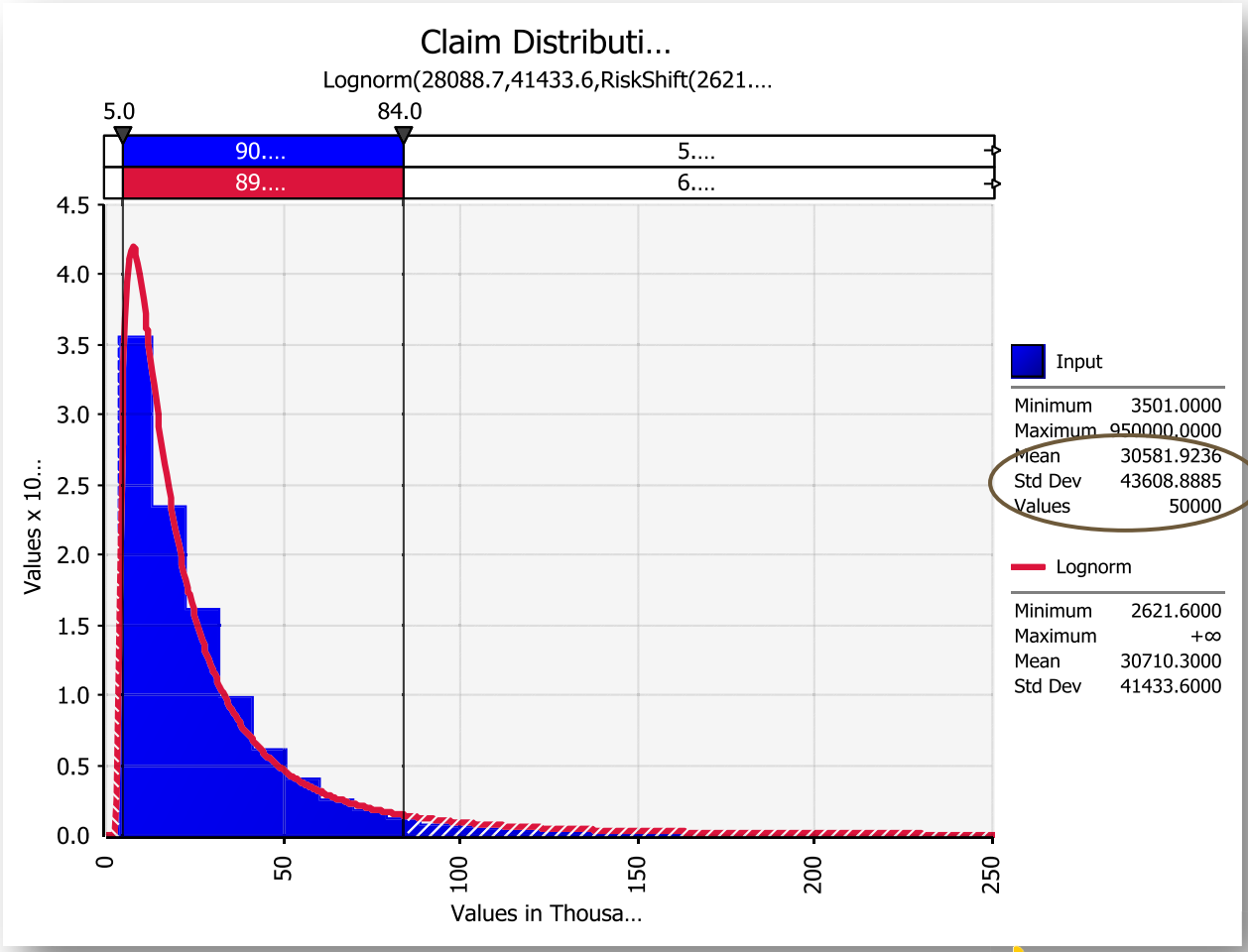
- Pricing
- Business Planning
- Reserving

Pricing

- Claim Distribution
- Risk Premium calculation
- Risk Premium matrix
- Medical Inflation
- Family Floater Discount

Claim Distribution

Health Inpatient claims follow lognormal distribution



Pricing

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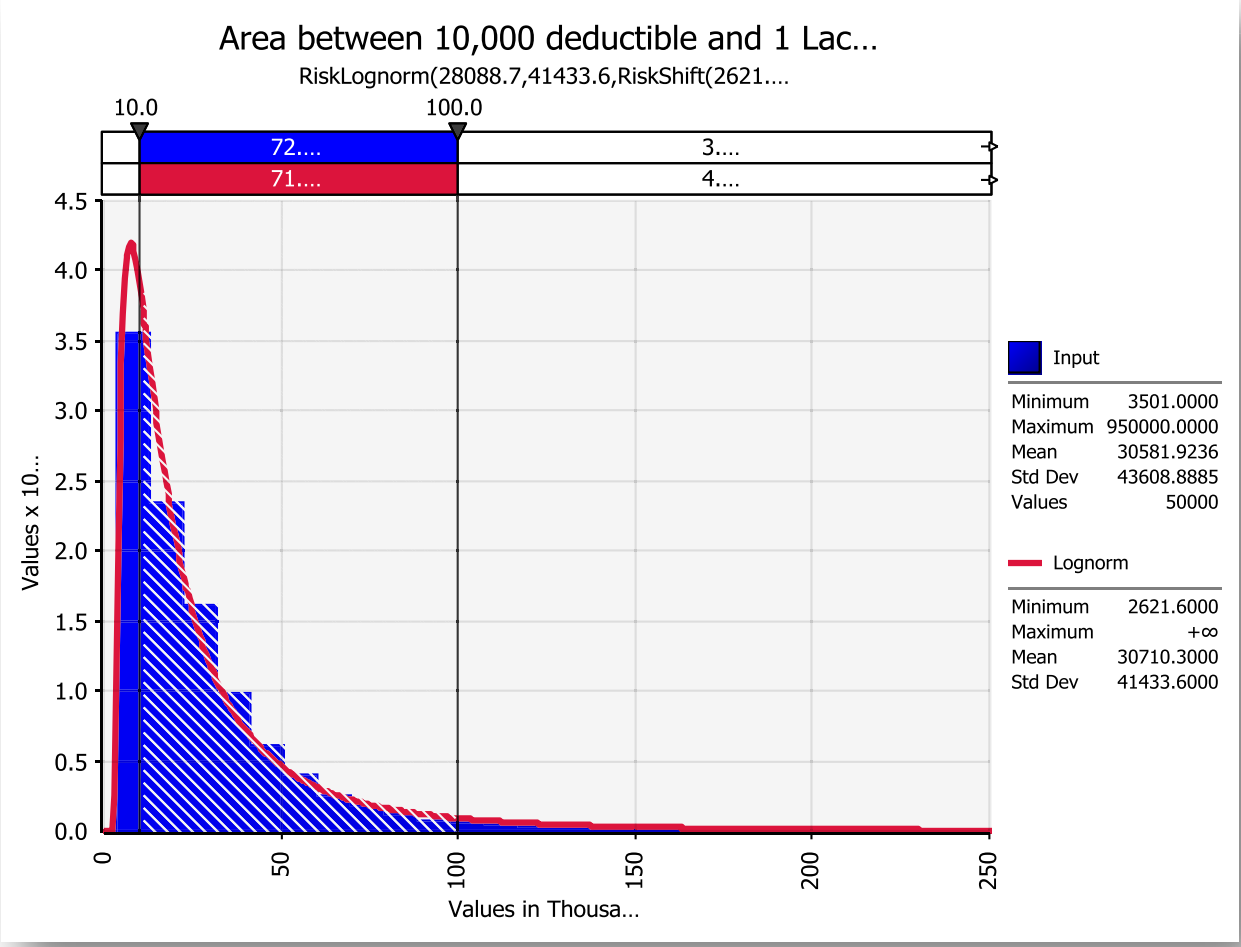
Risk Premium (Analytical Approach)



The shaded area is the total liability, multiplying this with probability of claiming gives us the risk premium

Risk Premium (Analytical Approach)

Risk Premium calculation with **Sum Insured U and Deductible D**:

Area under the graph $= \int_D^U h(x)\, f(x)dx$

where h(x) $=$ 0 if $X \le D$
X−D if $D < X \le U+D$
U if $X > U+D$

where X is the claim amount

Thus, Mean Paid Amount $= 0 + \int_D^{U+D}(X-D)\, f(x)dx + \int_{U+D}^{\infty} Uf(x)dx$

$$= 0 + \int_D^{U+D} xf(x)dx - D\int_D^{U+D} f(x)dx + \int_{U+D}^{\infty} Uf(x)dx$$

where $\int_L^U x^k f(x)dx = e^{\left(\mu+\frac{\sigma^2}{2}\right)k}[\Phi(U) - \Phi(L)]$

and $\Phi(U) = \frac{\log(U)-\mu}{\sigma}$ – kσ and $\Phi(L) = \frac{\log L-\mu}{\sigma} - k\sigma$, $f(x) \sim Lognorm(\mu, \sigma^2)$

Φ is the distribution function of the standard normal distribution

Risk Premium = Average claim size * Incidence Rate

Risk Premium (Analytical Approach)

Example:

Sum Insured Type– Individual

Sum Insured – 100,000

Deductible – 0

Claim amount follows lognormal with mean 30,582 and standard deviation 43,608

Risk Premium (Analytical Approach)

μ = 9.77
σ = 1.0534
U =100000
D = 0

Average Paid Amount $= \int_0^{100,000} xf(x)dx + 100{,}000 * \int_{100,000}^{\infty} f(x)dx$

$= 27{,}107$

Incidence Rate = 5%

Risk premium = 27,107 * 5% = 1,355

Let's see how to do it using Stochastic Approach

Risk Premium (Stochastic Approach)

Mean Paid Amount:

- Generate random claim amount using the claim distribution
- Calculate expected amount to be paid, for each claim amount generated in the step above
- Take mean of all the values

Risk Premium (Stochastic Method)

Incidence Rate:

- Generate claim count using the discrete distribution like Poisson
- Account for deductible impact
- Run Simulations
- Take mean of all the values

Risk Premium (Stochastic Method)

Risk Premium:

Risk premium = Mean paid amount * Incidence rate

Simulate the risk premium

Advantage of stochastic approach is that we may decide to take higher percentile (say, 70th) value rather than mean of average claim size to build prudency in pricing

Risk Premium (Stochastic Method)

Example:

Sum Insured Type– Individual

Sum Insured – 100,000

Deductible – 10,000

Claim amount follows lognormal with mean 30,582 and standard deviation 43,608

Simulation Results

Iteration / Cell	Random generation of claim amount	Expected Paid Amount	Claim made	Claim Pay out
1	2,818	-	-	-
2	48,017	38,017	-	-
3	4,301	-	-	-
4	28,165	18,165	-	-
5	8,741	-	-	-
6	17,168	7,168	-	-
7	7,559	-	-	-
8	6,953	-	-	-
9	19,524	9,524	-	-
10	31,636	21,636	-	-
11	1,80,386	1,00,000	-	-
12	8,910	-	-	-
13	34,497	24,497	-	-
14	25,556	15,556	-	-
15	4,782	-	-	-
16	13,605	3,605	-	-
17	50,930	40,930	-	-
18	10,679	679	1	679
19	65,449	55,449	1	55,449
.....				
10000	27,260	17,260	1	17,260
Mean	**30,549**	**24,792**	**3.6%**	**895**

Output

Incidence rate has reduced to 3.6% because of deductible

Risk premium = Expected paid amount * incidence rate = 24,792 * 3.6% = **895**

10,000 simulations run

Pricing

- Claim Distribution
- Risk Premium calculation
- Risk Premium matrix
- Medical Inflation
- Family Floater Discount

Matrix of risk premiums

- Same model can be run for multiple sum insured and deductible combinations easily

Mean Risk Premium						
	Sum Insured					
Deductible	100000	200000	300000	500000	1000000	Unlimited
0	1,370	1,492	1,533	1,564	1,591	1,596
10000	965	1,070	1,107	1,136	1,163	1,167
20000	704	798	832	860	886	890
50000	333	399	427	450	475	477
100000	122	163	184	201	226	226

- Premium increases with sum insured and reduce with deductible

- Can be used to price Top-Up products.

Pricing

- Claim Distribution
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Inflation impact

Risk premium for a product with

Premium effective date – 1 Jan, 2014

Valid until (3 years) – 31 Dec, 2016

Mid of exposure period – 1 Jul, 2015

Mid of experience period – 1 Jul, 2012

Inflation required for – 3 years

Inflation – 10% per annum

Inflation Impact

- Inflation impact is lower for lower Sum Insured and lower deductible

Impact on risk premium					
	Sum Insured				
Deductible	100000	200000	300000	1000000	Unlimited
0	8%	9%	10%	10%	10%
10000	10%	12%	13%	13%	13%
20000	13%	15%	15%	16%	16%
50000	18%	19%	21%	21%	21%
100000	28%	29%	31%	31%	31%

Impact of inflation Lower than 10% on average claim size

Impact of inflation Higher than 10% on incidence rate

- Impact on average paid amount
- Impact on incidence rate

Pricing

- Claim Distribution
- Risk Premium calculation
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Family Floater Discount

Example:

2 Adults and 1 Child dependant

Claim Amount	Husband	Wife	Child
Mean	55,000	40,000	30,000
Std Dev	80,000	70,000	40,000
Distribution		LogNormal	
Claim Count	**Husband**	**Wife**	**Child**
Mean	6%	5%	4%
Distribution		Poisson	

Sum Insured Type comparison- Individual & Floater

Family Floater Discount

Simulation Results for 1 Lac SI:

	Claim Made			Random generation of claim amount / LogNormal			Expected individual Paid Amount			Claim Outgo	
Iteration	Husband	Wife	Child	Husband	Wife	Child	Husband	Wife	Child	Individual SI	Floater SI
1	0	1	0	12,257	1,36,773	4,143	-	1,00,000	-	1,00,000	1,00,000
2	0	0	0	8,436	13,943	27,534	-	-	-	-	-
3	0	0	0	24,471	1,05,309	51,428	-	-	-	-	-
4	0	0	0	22,125	26,164	8,293	-	-	-	-	-
5	1	1	0	67,703	8,580	1,15,276	67,703	8,580	-	76,283	76,283
6	0	0	0	19,723	23,555	8,502	-	-	-	-	-
7	0	0	0	47,034	14,287	58,311	-	-	-	-	-
8	0	0	0	61,704	3,05,754	18,912	-	-	-	-	-
9	0	0	0	95,803	8,283	4,420	-	-	-	-	-
10	0	0	0	89,418	5,364	19,520	-	-	-	-	-
11	0	0	0	3,53,640	11,70,218	17,597	-	-	-	-	-
12	1	1	0	35,691	1,54,444	51,671	35,691	1,00,000	-	1,35,691	1,00,000
13	1	0	1	12,223	21,614	1,95,365	12,223	-	1,00,000	1,12,223	1,00,000
14	1	1	1	14,701	43,761	28,700	14,701	43,761	28,700	87,163	87,163
15	0	1	0	64,574	60,580	21,461	-	60,580	-	60,580	60,580
16	0	0	0	1,46,162	3,198	30,833	-	-	-	-	-
17	0	0	0	46,695	1,27,278	6,768	-	-	-	-	-
18	0	1	1	50,984	1,26,492	42,365	-	1,00,000	42,365	1,42,365	1,00,000
.....											
100000	1	0	0	5,966	19,665	28,589	5,966	-	-	5,966	5,966
Mean				55,000	40,009	30,008	2,393	1,542	1,074	**5,009**	**4,959**

Discount = 1- 4,959/5,009 = 1%

Family Floater Discount

Output:

	Family Floater
Sum Insured	Discount
50000	2.1%
100000	0.9%
200000	0.2%
500000	0.0%

- Only Sum Insured Impact considered here
- Other factors can be positive risk selection, saving in expenses, etc.,

Use in Health Insurance

Business Planning

- Loss Ratio Projection
- Correlation between products

Loss Ratio Projection

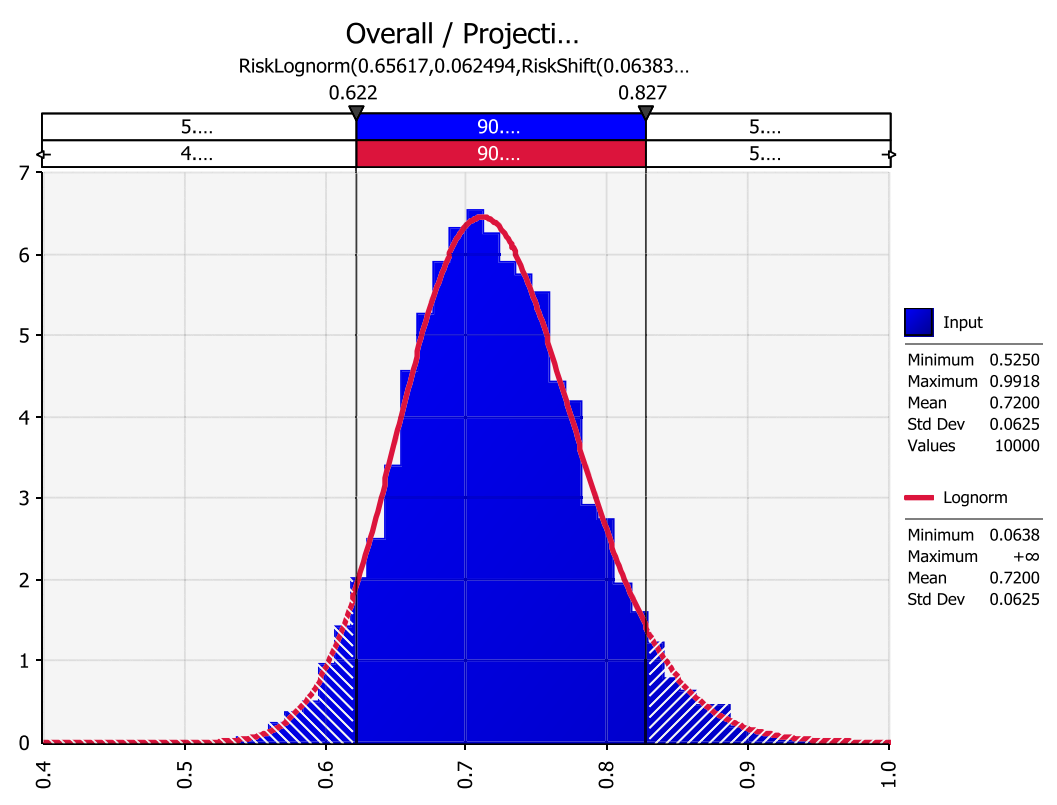
Example:

- A company has only 3 products under Health LOB

Product Line	Mean of Loss Ratio	Std Dev of Loss Ratio	Business Mix
Retail Health	60%	10%	40%
Group Health	90%	10%	45%
Mass Insurance	50%	10%	15%
Overall	72%		100%

- Loss Ratio follows Lognormal distribution
- Loss Ratio projected and simulated

Loss Ratio Projection



We can say that there is only 5% chance that overall loss ratio for the health business will be more than 82.7% if business mix remains same.

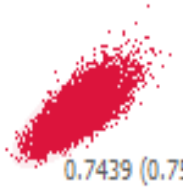
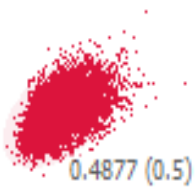
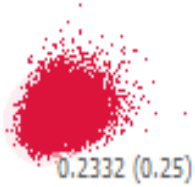
Use in Health Insurance

Business Planning

- Loss Ratio Projection
- Correlation between products

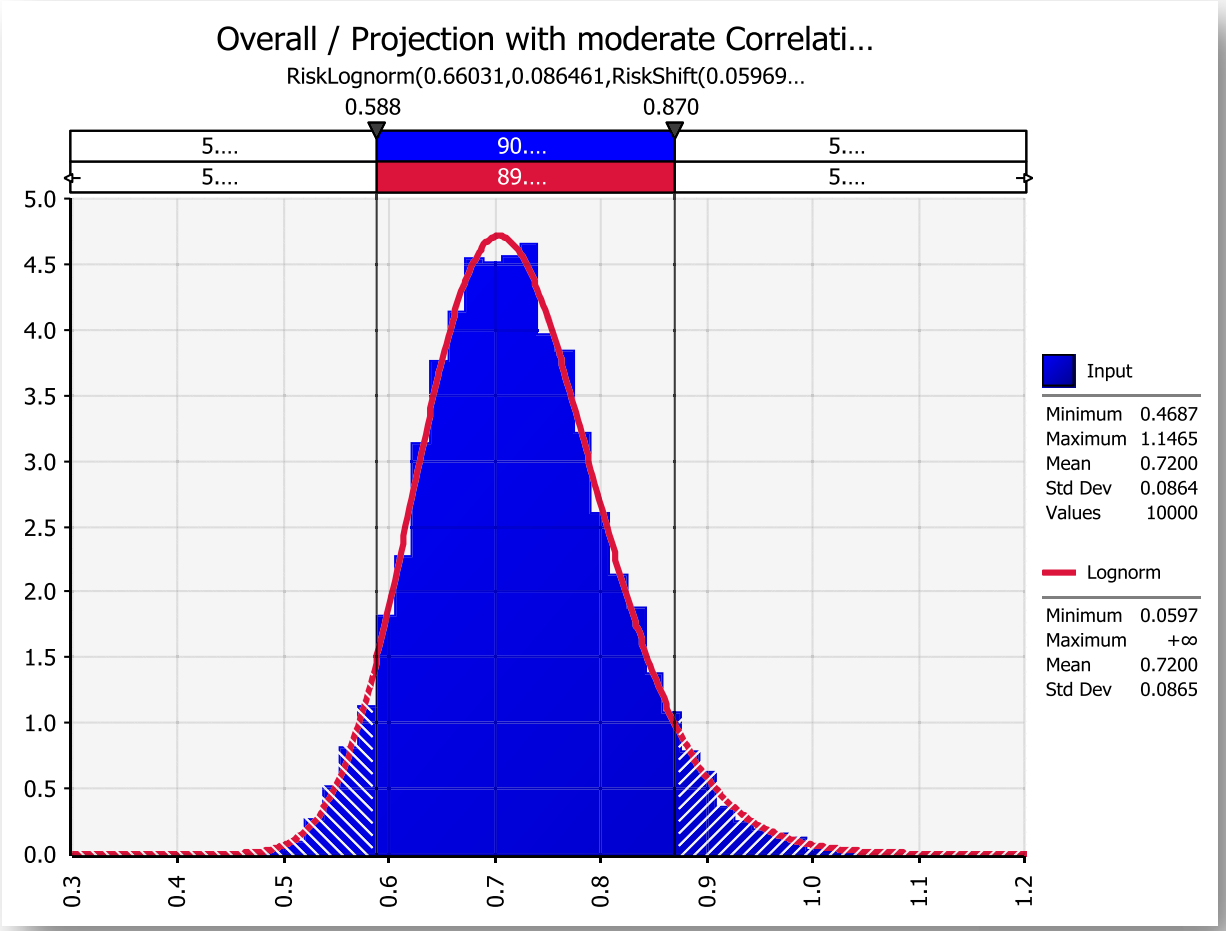
Correlation impact on LR

Correlation Matrix

	Retail Health / Projection Cell F3	Group Health / Projection Cell F4	Mass Insurance / Projection Cell F5
Retail Health / Projection Cell F3	1 (1)	 0.7439 (0.75)	 0.2332 (0.25)
Group Health / Projection Cell F4	 0.7439 (0.75)	1 (1)	 0.4877 (0.5)
Mass Insurance / Projection Cell F5	 0.2332 (0.25)	 0.4877 (0.5)	1 (1)

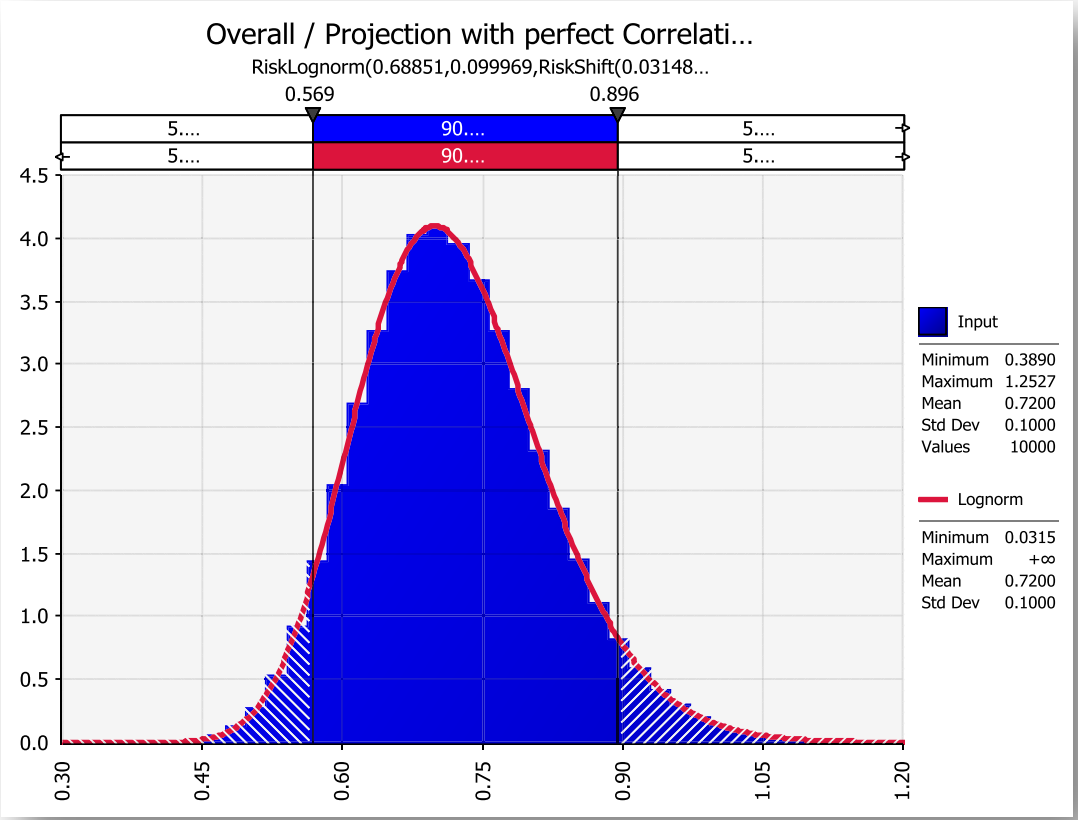
Correlation impact on LR

Moderate Correlation case



Correlation impact on LR

- Perfect correlation in the three Products



The interpercentile range has widened if there is perfect correlation in the three products

Correlation impact on LR

Output:

Correlation	Percentile		Inter-percentile range
	5%	95%	
None	67.2%	82.7%	15.5%
Moderate	58.8%	87.0%	28.2%
Perfect	56.9%	89.6%	32.7%

Correlation increases the inter-percentile range of Loss Ratios

Thank You!!

Any Questions??