December 14th, 2020

Actuarial Mathematics in Reinsurance

Ing. Mgr. Tomáš Oravec

VIG Re

About VIG (Re)

Introduction to Reinsurance

Basic Reinsurance Contracts

Basic Pricing Approaches

Capital Modelling

…

About VIG (Re)

VIG **Re**

The Leading Insurance Group in Austria & CEE

Premiums written
EUR 10.4bn
(+7.7%)

Profit before taxes
EUR 521.6mn
(+7.4%)

Combined Ratio
95.4%
(-0.6ppt)

Return on Equity
10.5%

Solvency ratio
210%

S&P Rating
A+
with stable outlook

Market capitalization
~ € 2.2bn
(03/31/2020)

More than
25,000
Employees

VIG Re

Vienna Insurance Group

Highlights H1 2020

Solid 6M 2020 results despite adverse effects of COVID-19

Gross written premium	Profit before taxes	Combined Ratio	Solvency Ratio
€ 5,577.4 mn	**€ 201.2 mn**	**95.5%**	**183%**

GWP up by 2.4% (+€130.7mn)

- Strongest contribution by markets coming from **Austria (+€100mn)** and **Poland (+€46m)**
- Other property business increasing by €180mn (+7.0%)
- **CEE share of 54.6%**

PBT increased by 21.8% (-€55.9mn)

- PBT decrease driven by goodwill impairments and lower financial result due to last year's changed consolidation method of the non-profit housing societies
- Net profit decreased to €126.3 mn (-16.3%)
- Earnings per share of €1.97

Improved by 0.9% due to better claims experience

- Claims ratio down to 63.8%
- Cost ratio stable at 31.7%
- **CoR of <100% and improvements in all segments**
- Stable combined ratio compared to 95.4% at YE 2019

YE 2019: 210%

- Own funds: €7.1 mn
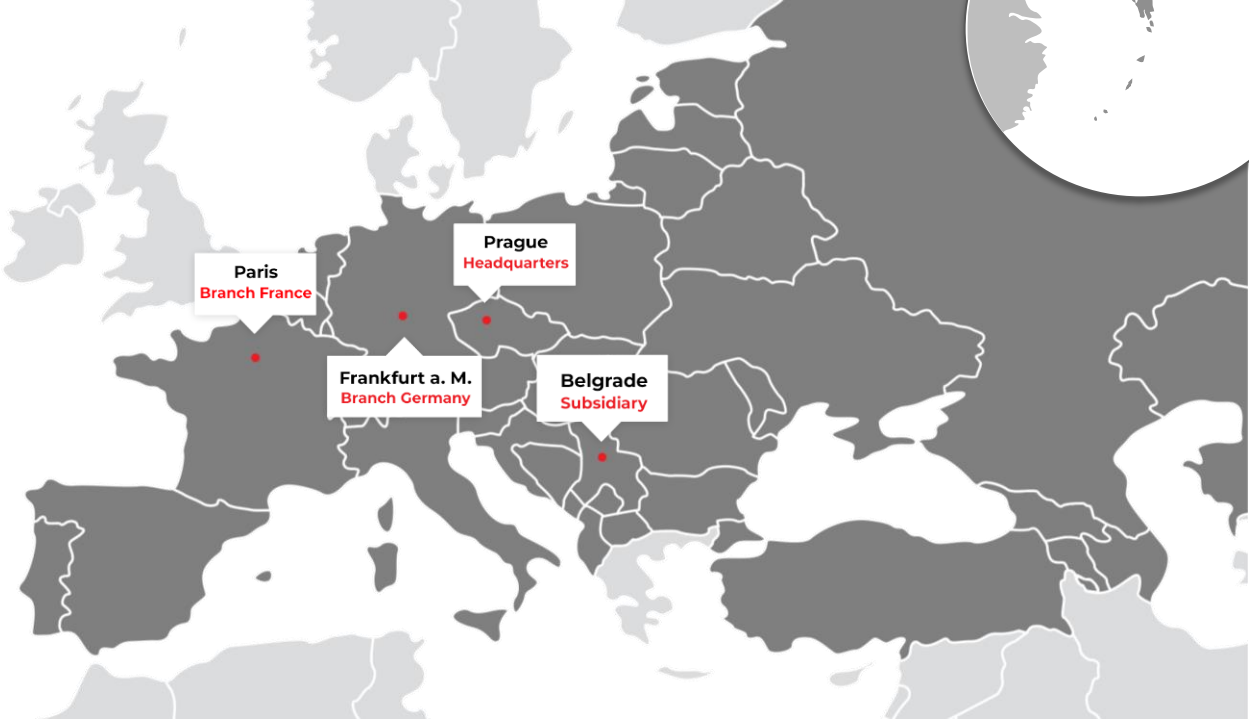- SCR: €3.9 mn

VIG Re

VIG Re Briefly

VIG Re was founded in 2008. Today **leading reinsurer in the CEE**, it is providing risk and capital management solutions to insurance companies of Vienna Insurance Group and outside of VIG.

STANDARD &POOR'S

Rating A+ with stable outlook, unaltered since 2008, confirmed as of 15 October 2020.

Part of **Vienna Insurance Group.**

VIG Re: Offices and Underwriting Territories

Paris
Branch France

Prague
Headquarters

Frankfurt a. M.
Branch Germany

Belgrade
Subsidiary

Today, VIG Re is providing made-to-measure reinsurance to **440+ insurance companies in 39 countries.**

VIG **Re**

Key Figures 2019

| in EUR mn	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Gross written premium	257.2	273.8	274.8	450.3	390.9	405.1	357.7	383.1	423.6	456.9	527.5
Net earned premium	157.9	176.3	170.0	324.7	247.9	233.7	205.9	222.4	256.0	226.0	309.6
Combined ratio*	95.7%	96.1%	95.8%	94.6%	97.6%	97.6%	95.7%	93.2%	94.8%	92.5%	96.0%
Profit before tax	**14.4**	**18.6**	**21.1**	**23.6**	**17.9**	**19.7**	**22.3**	**22.3**	**23.6**	**26.2**	**26.2**

*for Non-Life

ROE 2019 (before tax)
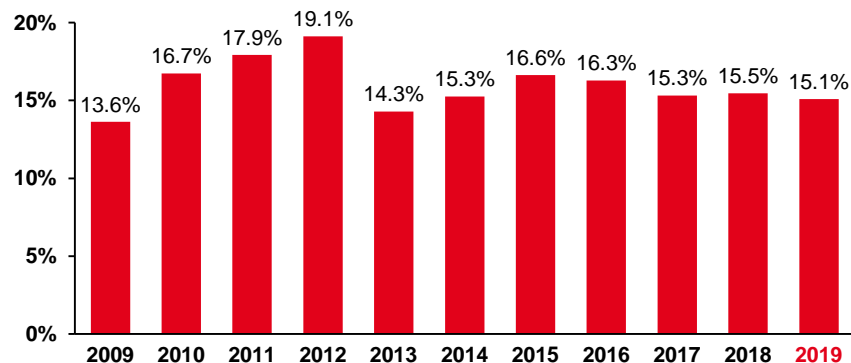
Portfolio Split 2019
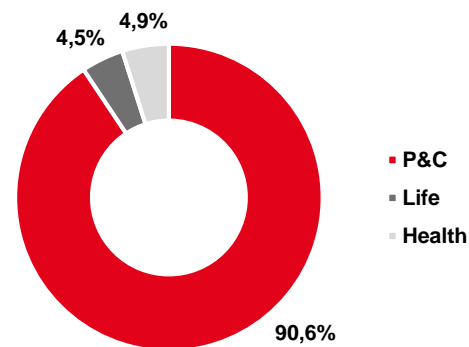
- P&C — 90,6%
- Life — 4,5%
- Health — 4,9%
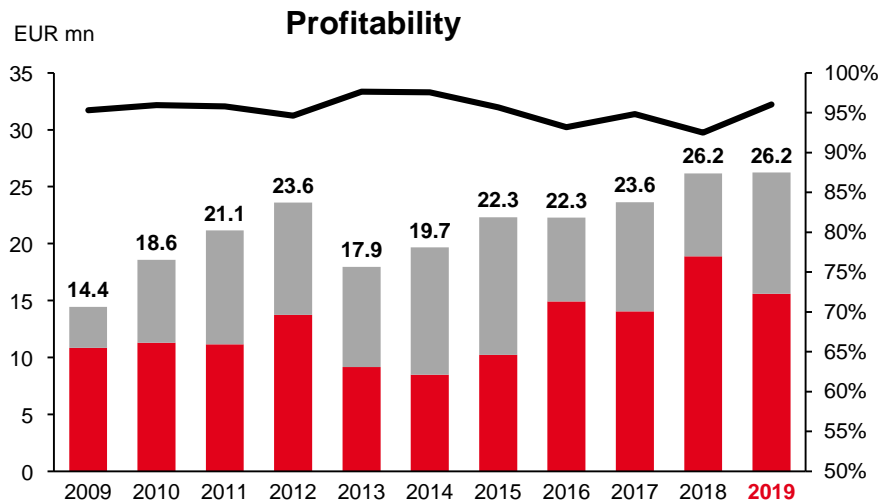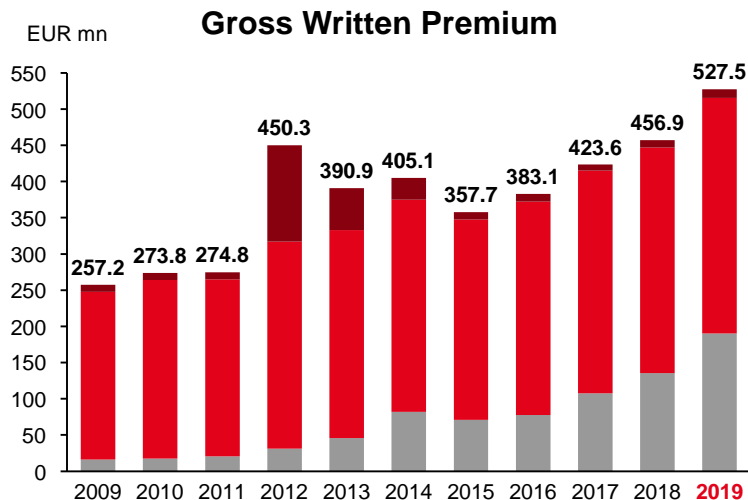
Financial Performance H1 2020

P&L (in EUR mn)	H1 2020 Actual
Gross Written Premium	309.5
Net Earned Premium	184.1
Underwriting Result	7.8
Investment Income*	0.3
Other Expenditures**	2.1
Profit Before Tax	**10.2**
Profit After Tax	7.9

Key Ratios	H1 2020 Actual
Combined Ratio	96.9%
Admin Cost Ratio	2.0%

Investment income impaired due to market volatilities, income impaired by FX effects.

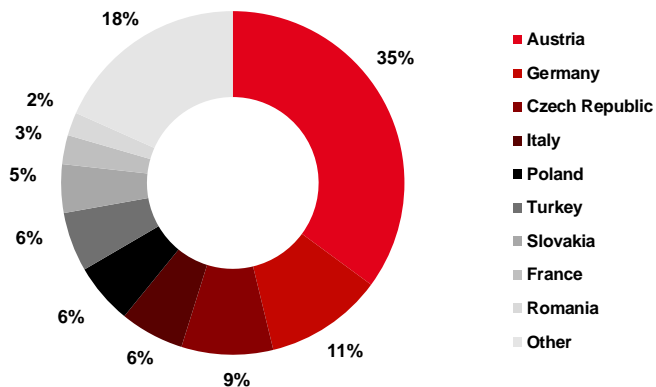Solid UW results, with 2ppt Covid-19 impact on combined ratio.

* Ordinary income 4.2 mn, Extraordinary income EUR -3.1 mn, Interest on Sub. debt EUR -0.7 mn, Expenditures EUR -0.1 mn
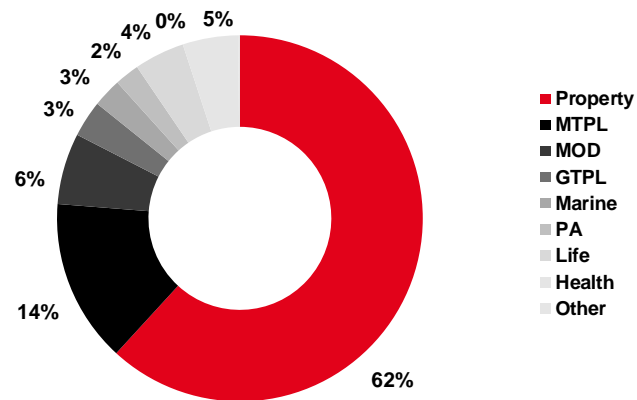
** FX effects

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Portfolio Split 2019

Non-CEE markets: accounting for 40% of GWP, with short-tail lines continuing to dominate the portfolio.

GWP by Underwriting Territory

- ■ Austria
- ■ Germany
- ■ Czech Republic
- ■ Italy
- ■ Poland
- ■ Turkey
- ■ Slovakia
- ■ France
- ■ Romania
- ■ Other

35%
11%
9%
6%
6%
6%
5%
3%
2%
18%

GWP by Line of Business

- ■ Property
- ■ MTPL
- ■ MOD
- ■ GTPL
- ■ Marine
- ■ PA
- ■ Life
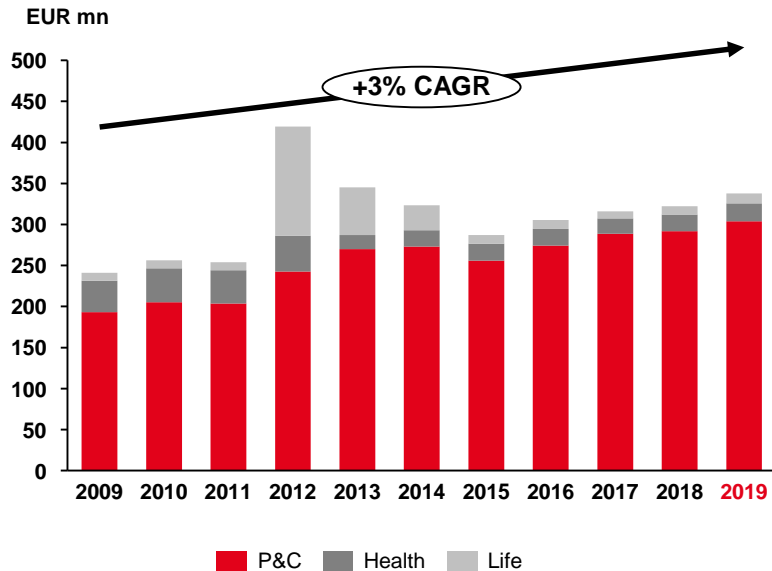- ■ Health
- ■ Other

62%
14%
6%
3%
3%
2%
4%
0%
5%

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VIG Business in 2019

Austria and Czech Republic: most important contributors.

GWP by Business Segments
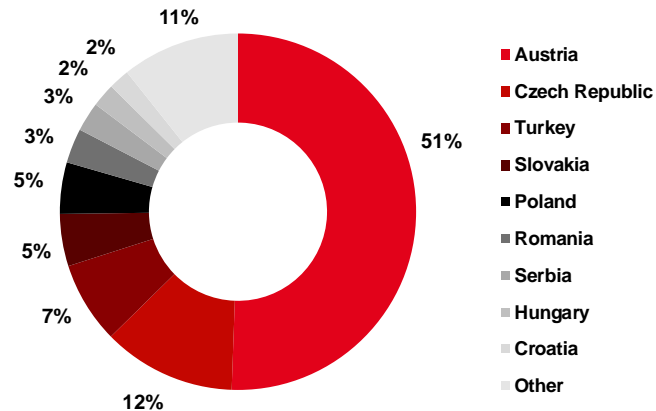
EUR mn

+3% CAGR

Legend: P&C / Health / Life

GWP by Underwriting Territory

51% — Austria
12% — Czech Republic
7% — Turkey
5% — Slovakia
5% — Poland
3% — Romania
3% — Serbia
2% — Hungary
2% — Croatia
11% — Other

- Austria
- Czech Republic
- Turkey
- Slovakia
- Poland
- Romania
- Serbia
- Hungary
- Croatia
- Other
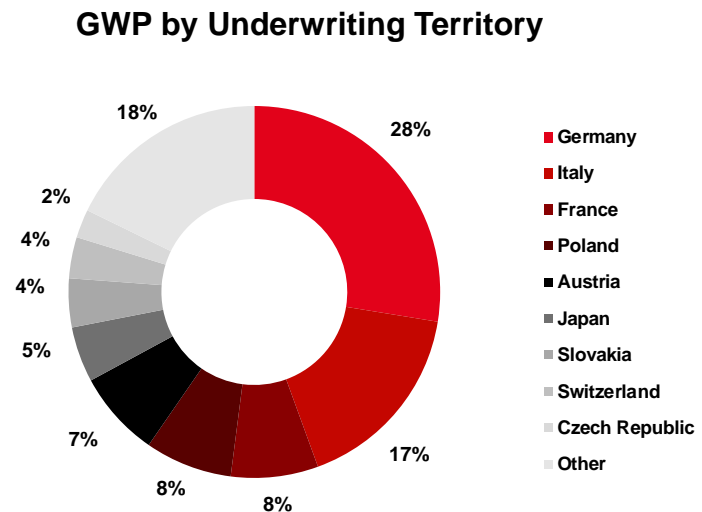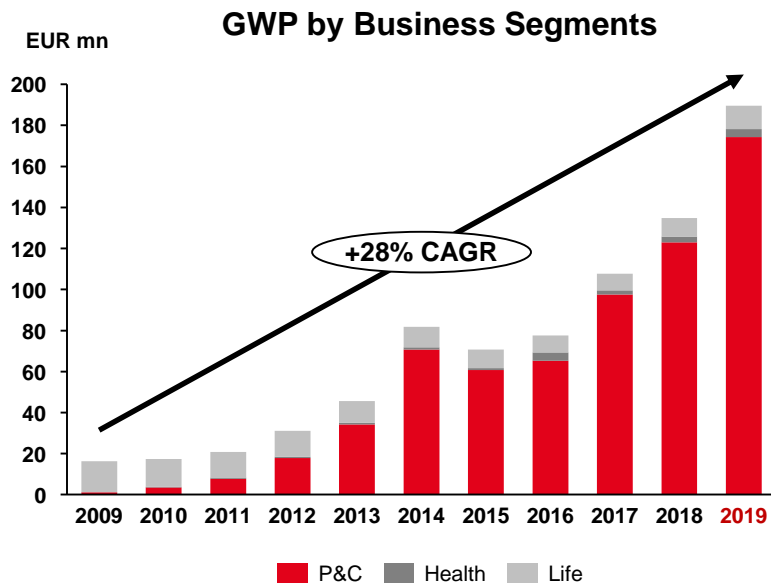
CAGR: Compound annual growth rate

Introduction to Reinsurance

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Definition of Reinsurance

Reinsurance is insurance that is purchased by an insurance company

Reinsurance is the transfer of part of the hazards or risks
that a direct insurer assumes by way of insurance contract
or legal provision on behalf of an insured, to a second
insurance carrier, the reinsurer, who has no direct
contractual relationship with the insured
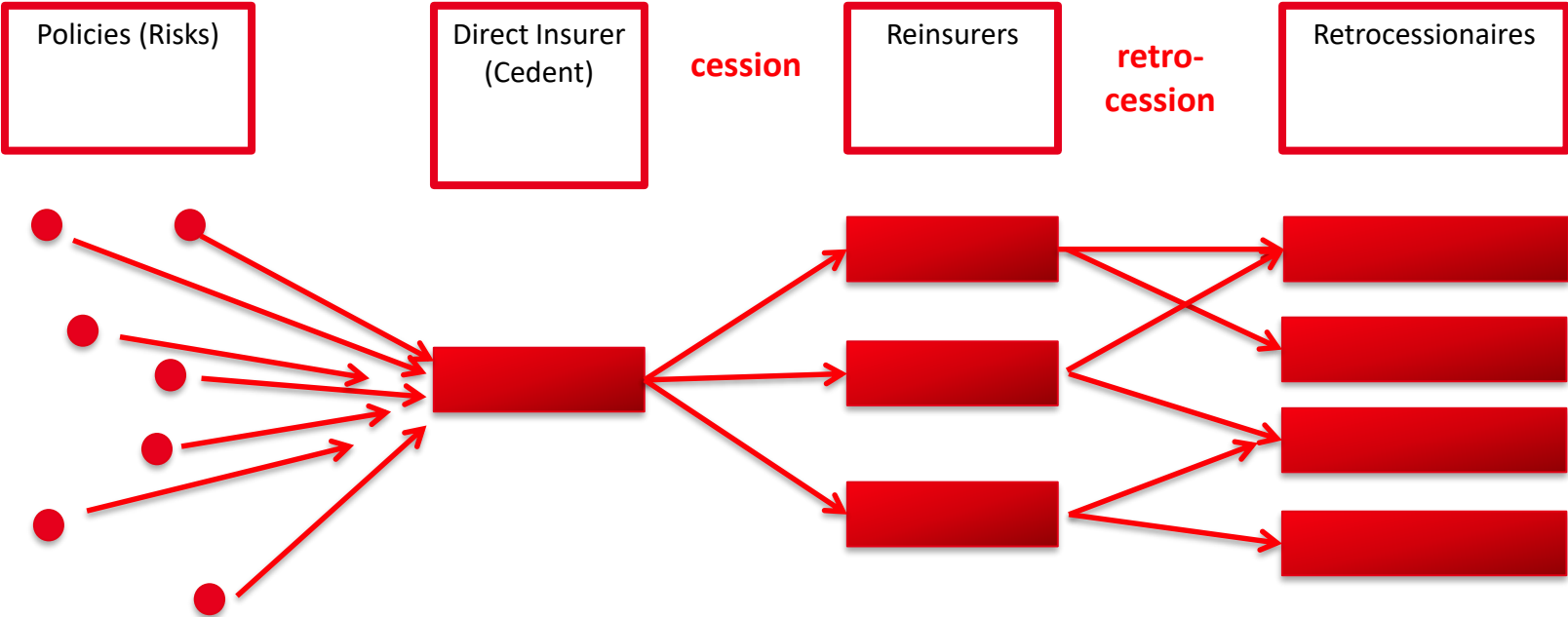
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Origins

First professional company Cologne Re (founded in 1846) as consequence of the catastrophic fire in Hamburg in 1842

- 1846: Cologne Re
- 1853: Aachen Re
- 1857: Frankfurt Re
- **1863: Swiss Re**
- **1880: Munich Re**
- 1886: Frankona Re

Today about 200 professional reinsurers worldwide and large number of direct insurers writing also reinsurance

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Risk Sharing
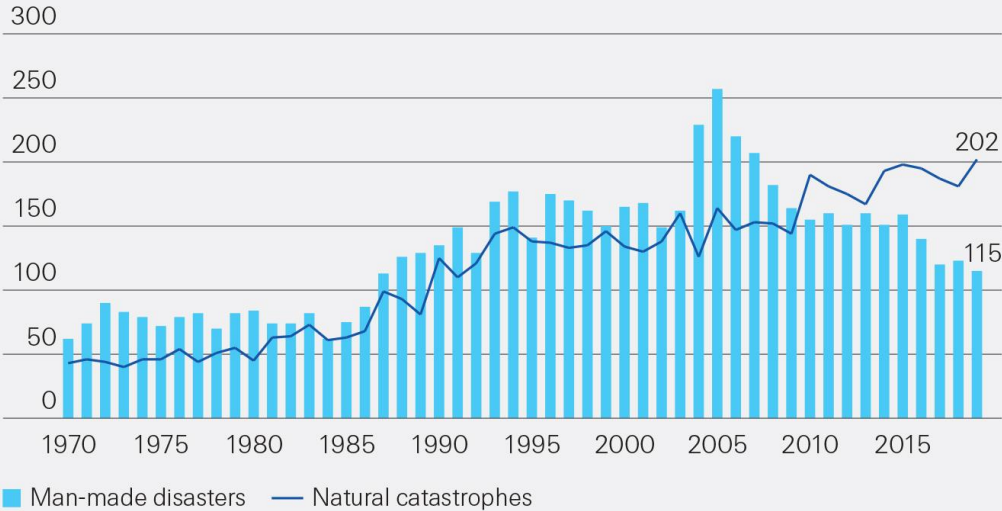
Purpose

- Protection against large single losses and catastrophes

- Reduces volatility of the financial results

- Reduction of solvency capital requirement

- More underwriting capacity for smaller players

- Know-how transfer

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Why Reinsurance? (1/4)

Number of catastrophic events, 1970–2019

Source: Swiss Re Institute

Legend: Man-made disasters, Natural catastrophes

Why Reinsurance? (2/4)

Number of victims, 1970–2019

1. 1970: Bangladesh storm, Peru earthquake
2. 1976: Tangshan earthquake, China
3. 1991: Cyclone Gorky, Bangladesh
4. 2004: Indian Ocean earthquake and tsunami
5. 2008: Cyclone Nargis, Myanmar
6. 2010: Haiti earthquake
7. 2013: Typhoon Haiyan, Philippines
8. 2015: Earthquake in Nepal

■ Man-made disasters — Natural catastrophes

Note: Scale is logarithmic: the number of victims increases tenfold per band.
Source: Swiss Re Institute

Why Reinsurance? (3/4)

Insured catastrophe losses, 1970–2019, in USD billion at 2019 prices

1. Hurricane Andrew
2. Winter Storm Lothar
3. WTC
4. Hurricanes Ivan, Charley, Frances
5. Hurricanes Katrina, Rita, Wilma
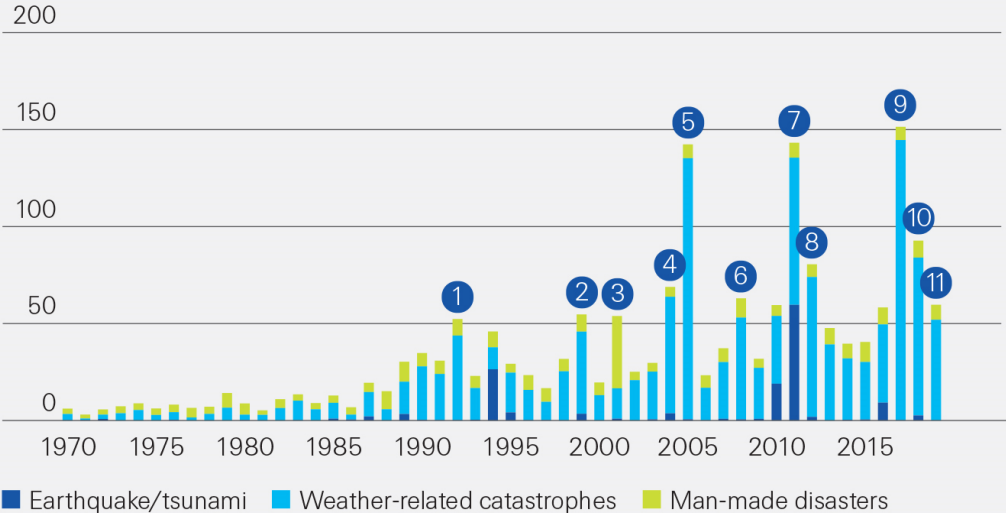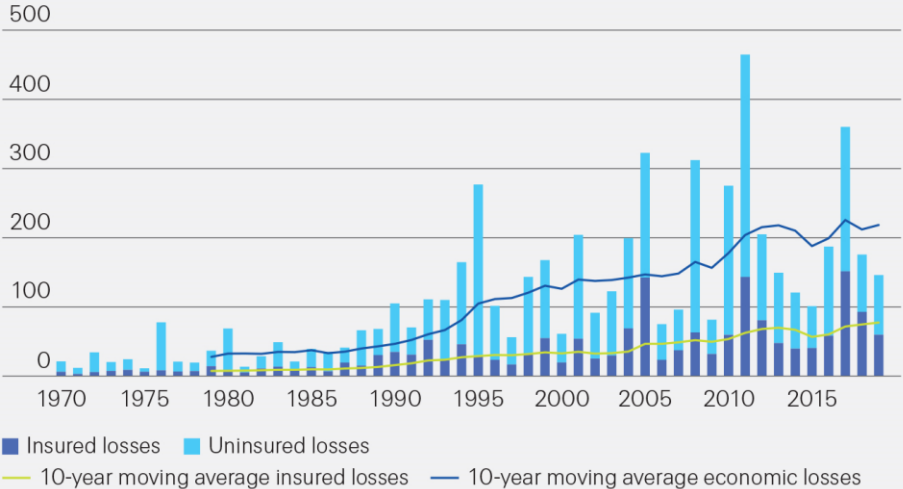6. Hurricanes Ike, Gustav
7. Japan, NZ earthquakes, Thailand flood
8. Hurricane Sandy
9. Hurricanes Harvey, Irma, Maria
10. Camp Fire, Typhoon Jebi
11. Typhoons Hagibis, Faxai

■ Earthquake/tsunami   ■ Weather-related catastrophes   ■ Man-made disasters

Source: Swiss Re Institute

Why Reinsurance? (4/4)

Insured vs uninsured losses, 1970–2019 (USD billion, 2019 prices)

Legend:
- Insured losses
- Uninsured losses
- 10-year moving average insured losses
- 10-year moving average economic losses

Economic losses = insured + uninsured losses;
Source: Swiss Re Institute

Reinsurance Market Subjects

- **Insurance Companies** (reinsurance buyers – risk cedants)

- **Brokers** (intermediaries; main roles: risk modelling, contract structuring, negotiating with reinsured(s) and reinsurer(s), administration of treaties)

- **Reinsurers** (providing capacity)

- **Supervisory Authorities** (EIOPA, Czech National Bank; main roles: enhance reliability, stability and control of the (re)insurance market)

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Top 10 (Re)insurance Brokers

In millions USD

Broker	Country	Turnover		2018-2019 evolution
		2019	2018	
Marsh & Mclennan	United States	16 752	14 942	12.11%
AON	United Kingdom	10 939	10 717	2.07%
Willis Towers Watson	United Kingdom	8 941	8 413	6.28%
Arthur J. Gallagher & co	United States	5 716	5 107	11.94%
Hub International	United States	2 392	2 147	11.42%
Brown & Brown	United States	2 385	2 010	18.65%
Truist Insurance Holdings	United States	2 271	2 016	12.63%
Lockton Cos.	United States	1 868	1 707	9.42%
USI Insurance Services	United States	1 831	1 665	9.96%
Acrisure	United States	1 807	1 378	31.09%
Total		54 901	50 101	9.58%

Source: https://www.atlas-mag.net/en/article/top-10-brokers-in-insurance-and-reinsurance

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Top 10 Reinsurers

In millions USD

Rank	Company	Turnover		SE*	Ratios		
		Life and non-life	Non-life		Loss	Expenses	Combined
1	Swiss Re	42 228	26 095	31 037	79.7	31.7	111.4
2	Munich reinsurance Company	37 864	24 742	34 245	66.7	34.4	101
3	Hannover Rück	25 309	16 555	12 718	69	29.5	98.5
4	SCOR	18 302	8 005	7 139	68.1	30.9	99
5	Berkshire Hathaway	16 089	11 112	428 563	86.6	25.1	111.7
6	Lloyd's	14 978	14 978	39 15	71	34.5	105.5
7	China Re	13 161	5 218	13 881	65	36.4	101.4
8	Reinsurance Group of America	12 15	NA	11 601	NA	NA	NA
9	Great West Lifeco	10 149	NA	19 549	NA	NA	NA
10	PartnerRe	7 285	5 792	7 27	72.4	28	100.4

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Source: https://www.atlas-mag.net/en/article/top-50-global-reinsurers-ranking-of-2019

Basic Reinsurance Contracts

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Types of Reinsurance I

Facultative:

each risk considered individually, obligation neither to cede nor to accept

Obligatory:

group of homogenous risks automatically ceded to the reinsurance treaty

Combination:

either Fac-Obligatory or Obl-Facultative, rare cases

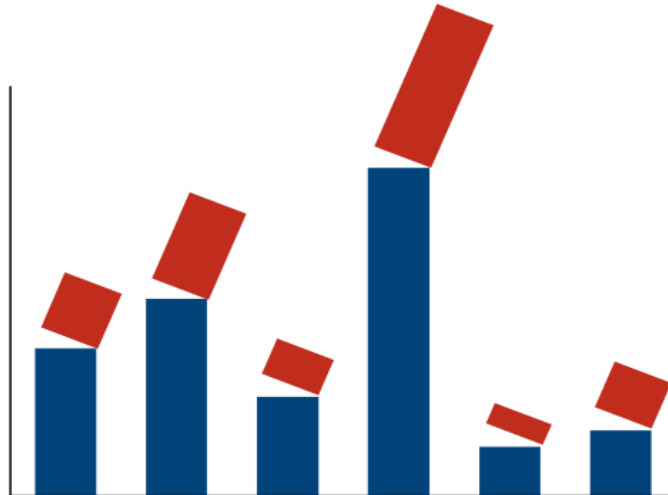**VIG Re**

Types of Reinsurance II

Proportional
- Quota Share
- Surplus

Non-Proportional (Excess of Loss)
- Risk XL
- Cat XL (Event XL)
- Stop Loss
- Aggregate XL

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Proportional: Quota Share

- ceded loss calculated as: $X_z = q \cdot X$
- ratio used also for premium (q)
- commission fixed / sliding scale / profit commission (c)
- loss corridor / loss participation / loss ratio cap

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Proportional: Quota Share (Example)

- Sum Insured SI = 5,000,000
- Treaty Capacity 8,000,000
- Gross Individual Loss X = 1,000,000
- q = 40%
- c = 20%
- Gross Premium P = 2,000
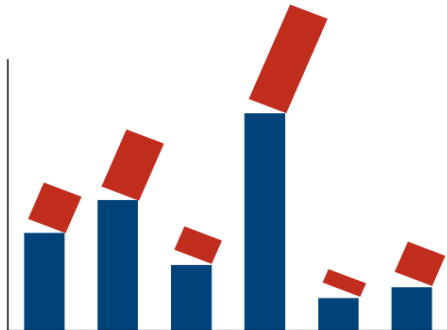
Reinsurer's share:
$X_R = q * X = 400,000$
$P_R = q * P = 800$
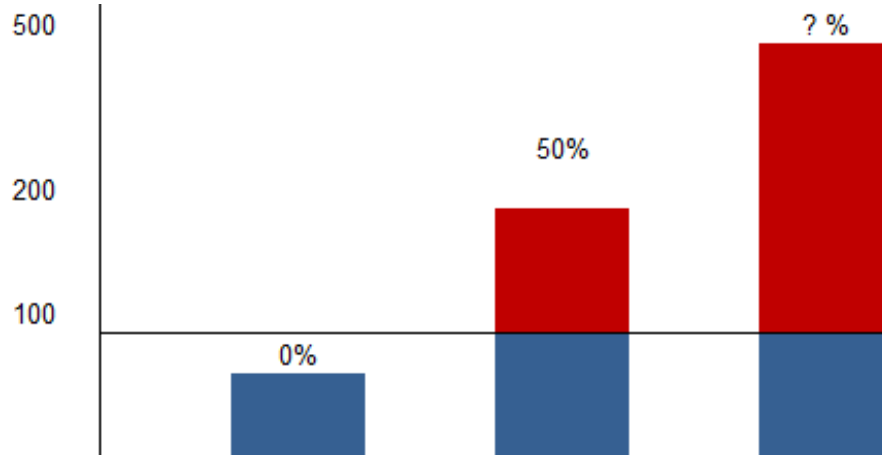
Reinsured's result:
$(P-P_R)-(X-X_R)+c*P_R = -598,640$

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Proportional: Surplus
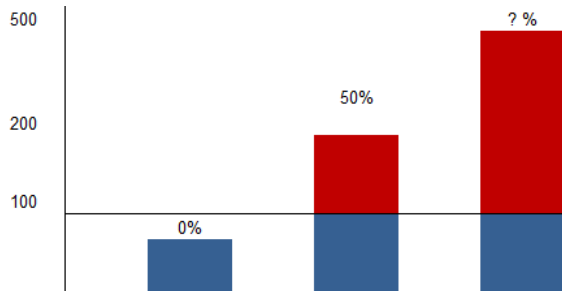
- ceded loss calculated as: $X_z = \left(1 - \dfrac{a}{S}\right) . X$ for $S > a$
- ratio (1 − a/S) used also for premium
- commission mainly fixed

Proportional: Surplus (Example)

- Sum Insured a = 5,000,000
- Treaty Capacity 8,000,000
- Retention S = 2,000,000 and limit 6,000,000 (i.e. 3 lines)
- Ceded percentage = max(1-a/S; 0) = 60%
- c = 20%
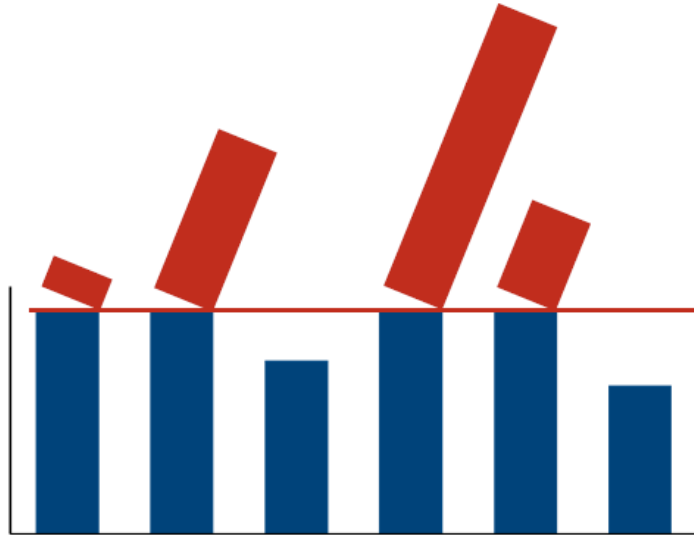- Premium P = 2,000

Reinsurer's share:

$X_R = s * X = 600,000$

$P_R = s * P = 1,200$

Reinsured's result:

$(P-P_R)-(X-X_R)+c* P_R = - 398,960$

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Non-Proportional: Risk XL

- ceded loss calculated as: $X_Z = X - a$ for $X > a$
- premium mostly as % of GNPI (sometimes flat premium)
- reinstatements free / paid / combination

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Non-Proportional: Risk XL (Example)

- Sum Insured = 5,000,000
- Total Capacity = 8,000,000 with Retention 2,000,000 … layer of 6m XS 2m
- Gross Individual Loss X = 3,000,000
- r = 8% (Rate on Premium)
- Gross Premium P = 2,000
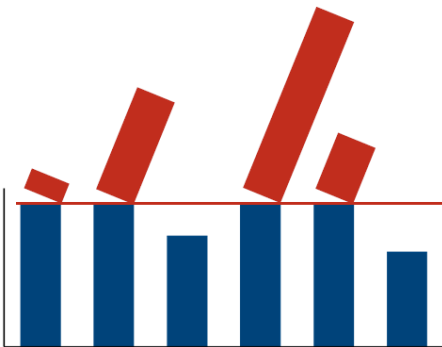
Reinsurer's share:
$X_R = \max(0; X-D) = 1,000,000$
$P_R = r * P = 160$

Reinsured's result:
$(P-P_R)-(X-X_R) = -1,998,160$

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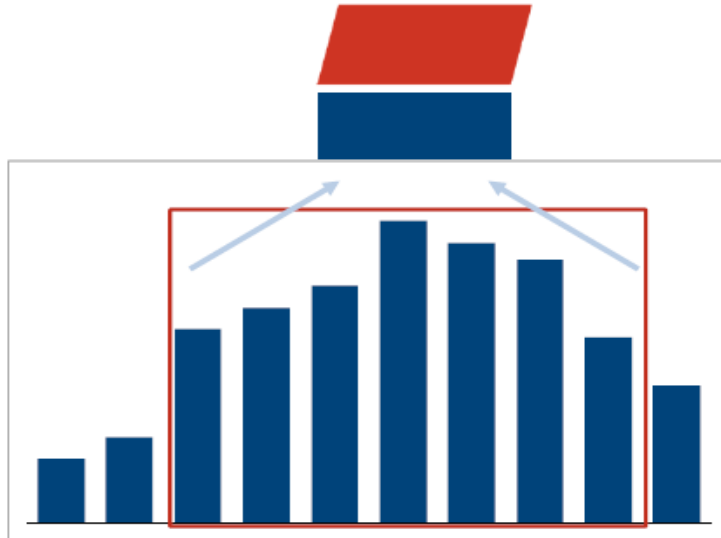# Non-Proportional: Cat XL

- ceded loss calculated as:
- premium as % of GNPI
- reinstatements free / paid / combination
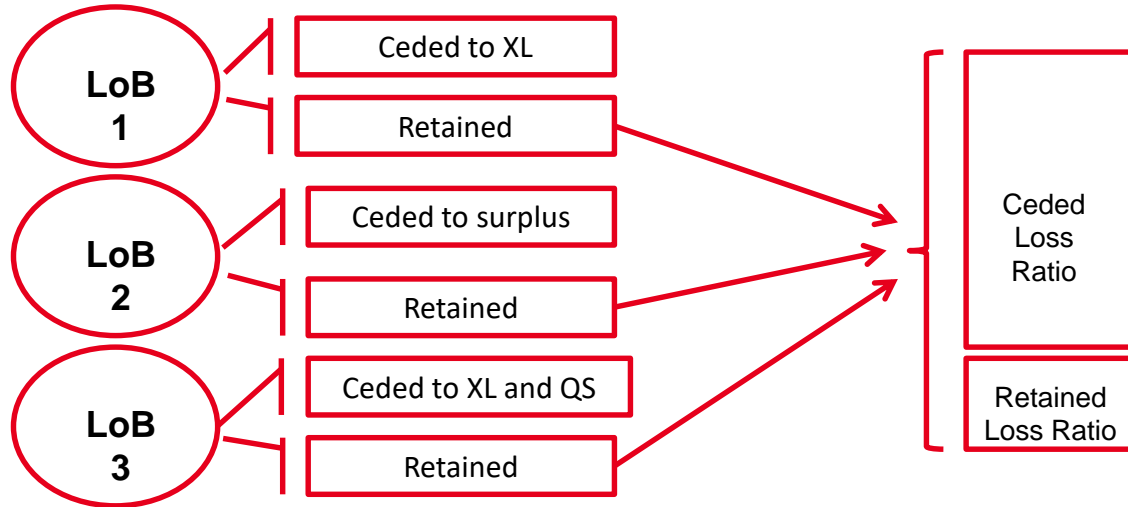
$$X_z = \sum_{i=1}^{n} X_i - a$$

Non-Proportional: Cat XL

Non-Proportional: Stop Loss

Reinsurance Program: Example (in CZK)

Line of Business	Type of reinsurance	Layer	Retention	Limit	Rate	Reinstatements
Personal Accident	XL	1	2 000 000	18 000 000	0,65%	1-3@100%
Personal Accident	XL	2	20 000 000	30 000 000	0,16%	1@100%
Motor Liability	XL	1	30 780 000	23 220 000	2,10%	1-15@free
Motor Liability	XL	2	54 000 000	81 000 000	0,80%	1-15@free
Motor Liability	XL	3	135 000 000	Unlimited	0,21%	unlimited@free
Marine Hull	QS	-	100 000 000	100 000 000	-	-
General Liability	XL	1	10 000 000	10 000 000	6,50%	1-30@free
General Liability	XL	2	20 000 000	30 000 000	3,60%	1-20@free
General Liability	XL	3	50 000 000	50 000 000	1,50%	1-10@free
General Liability	XL	4	100 000 000	200 000 000	0,80%	1-5@free
Fire	Surplus	-	100 000 000	1 500 000 000	-	-
Fire	QS	-	50 000 000	50 000 000	-	-
Fire	XL	-	30 000 000	70 000 000	0,39%	1@free; 2-3@50%
Nat Cat	XL	1	270 000 000	630 000 000	1,20%	2@100%
Nat Cat	XL	2	900 000 000	1 100 000 000	0,90%	1@100%
Nat Cat	XL	3	900 000 000	1 500 000 000	0,30%	1@100%
Nat Cat	RPP	-	fixed price, covering reinstatement premium L1-L2			

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How much Capacity to Buy? (Nat Cat)

Cumulative Probability
Gross Loss OEP for Variation using 'Variation'

Probability	Flood VaR	Flood TVaR	Wind VaR	Wind TVaR
10,00%	0 Kč	92 100 453 Kč	0 Kč	62 888 459 Kč
20,00%	0 Kč	103 613 009 Kč	0 Kč	70 749 516 Kč
25,00%	0 Kč	110 520 543 Kč	0 Kč	75 466 151 Kč
40,00%	0 Kč	138 150 679 Kč	0 Kč	94 332 688 Kč
50,00%	0 Kč	165 780 815 Kč	0 Kč	113 199 226 Kč
60,00%	0 Kč	207 226 019 Kč	0 Kč	141 499 032 Kč
75,00%	0 Kč	331 561 630 Kč	0 Kč	226 398 452 Kč
80,00%	0 Kč	414 452 037 Kč	0 Kč	282 998 064 Kč
90,00%	0 Kč	828 904 075 Kč	0 Kč	565 996 129 Kč
95,00%	326 151 471 Kč	1 450 309 357 Kč	305 676 614 Kč	935 734 592 Kč
98,00%	679 248 645 Kč	2 944 806 306 Kč	581 149 035 Kč	1 725 909 583 Kč
99,00%	1 177 991 695 Kč	5 011 675 072 Kč	937 160 108 Kč	2 727 620 145 Kč
99,50%	2 025 841 749 Kč	8 504 672 338 Kč	1 505 511 096 Kč	4 293 387 584 Kč
99,60%	2 399 453 285 Kč	10 082 181 293 Kč	1 757 598 808 Kč	4 959 981 064 Kč
99,80%	4 098 337 755 Kč	17 097 671 428 Kč	2 727 738 596 Kč	7 767 233 906 Kč
99,90%	6 772 456 926 Kč	28 997 655 663 Kč	4 307 762 232 Kč	12 168 681 280 Kč
99,99%	39 362 649 701 Kč	170 044 702 742 Kč	19 710 762 320 Kč	49 888 271 767 Kč

Solvency 2 (Partial) Internal Model?

X

SII Standard Formula?

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How much Capacity to Buy? (Complex Example)

- Maximise capacity to gain competitive advantage
- Price for „empty capacity"
- Unlimited cover for MTPL

Line of Business	Type of reinsurance	Layer	Retention	Limit	Rate	Reinstatements
Fire	Surplus	-	100 000 000	1 500 000 000	-	-
Fire	QS	-	50 000 000	50 000 000	-	-
Fire	XL	-	30 000 000	70 000 000	0,39%	1@free; 2-3@50%

- **important to know the hierarchy (inurance)**
- **e.g. SI = 400.000.000 CZK, gross loss = 200.000.000**
- **Surplus cover applied as first -> Then QS cover -> Finally XL on net retention**
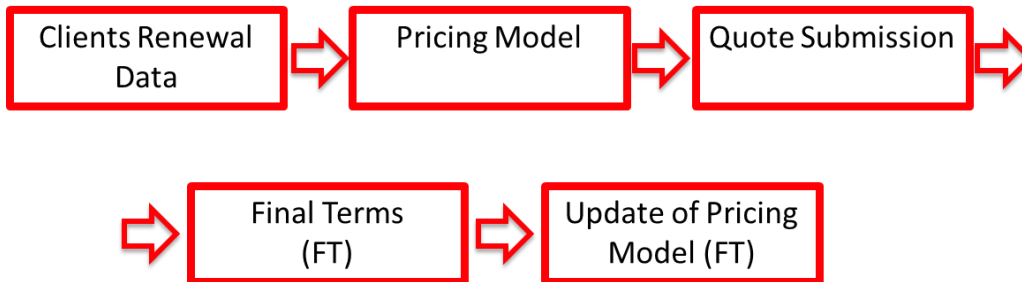
- **-> Ceded losses to the contracts?**
- **loss ceded to surplus (in mio.) = ((400-100)/400) * 200 = 150**
- **loss ceded to QS (in mio.) = (200 – 150) * 0,5 = 25**
- **loss ceded to XL (in mio.) = Max (0; (200 – 150 – 25) – 30) = 0**
- **net loss (in mio.) = 25**

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How to Structure Reinsurance Program?

• Define capacity

• What is maximum retention (e.g. group rules)

• Targets of the company might be:
  ➢ Minimise price
  ➢ Maximise mean net underwriting result
  ➢ Minimise volatility of net underwriting result
  ➢ Maximise return on capital
  ➢ Other (financial, cash-flow, etc.)

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Timeline of Renewal 1.1. xxxx

- **May – September**: data preparation by insurance companies and submissions to brokers, suitability assessed by brokers / internally

- **September – December**: data sent to reinsurers who provide their quotes > decision about final terms (FOT) and wordings > placement

- **December 31st** – all treaties need to be placed (rare exceptions possible)

Clients Renewal Data → Pricing Model → Quote Submission →

→ Final Terms (FT) → Update of Pricing Model (FT)

VIG Re

Decisions about Final Terms

Layer	Limit	Retention	Quoted Rate (as % of GNPI)							Final?
			Swiss Re	R+V	Markel	Amlin	Novae	Scor	Aspen	
1	23 220 000	30 780 000	1,30%	1,10%	0,89%	1,30%	2,00%	1,70%	1,10%	1,1% - 1,3%
2	81 000 000	54 000 000	0,65%	0,72%	0,59%	0,85%	0,79%	0,60%	0,99%	0,65% - 0,72%
3	Unlimited	135 000 000	0,26%	0,19%	0,15%	0,21%	0,10%	0,30%	0,26%	0,21% - 0,26%

Layer	Limit	Retention	Written line (indication)							Total
			Swiss Re	R+V	Markel	Amlin	Novae	Scor	Aspen	
1	23 220 000	30 780 000	30%	25%	10%	15%	20%	30%	25%	105%
2	81 000 000	54 000 000	30%	25%	10%	15%	20%	30%	25%	95%
3	Unlimited	135 000 000	30%	25%	5%	15%	5%	30%	35%	115%

Final terms are subject to further negotiations:

- Not all requested reinsurers (wanted to) quote
- Offer of whole package VS "cherry-picking"
- Leader(s) and followers, differential terms

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Reinsurance Market Cycles

Regional Property Catastrophe Rate–On–Line Index
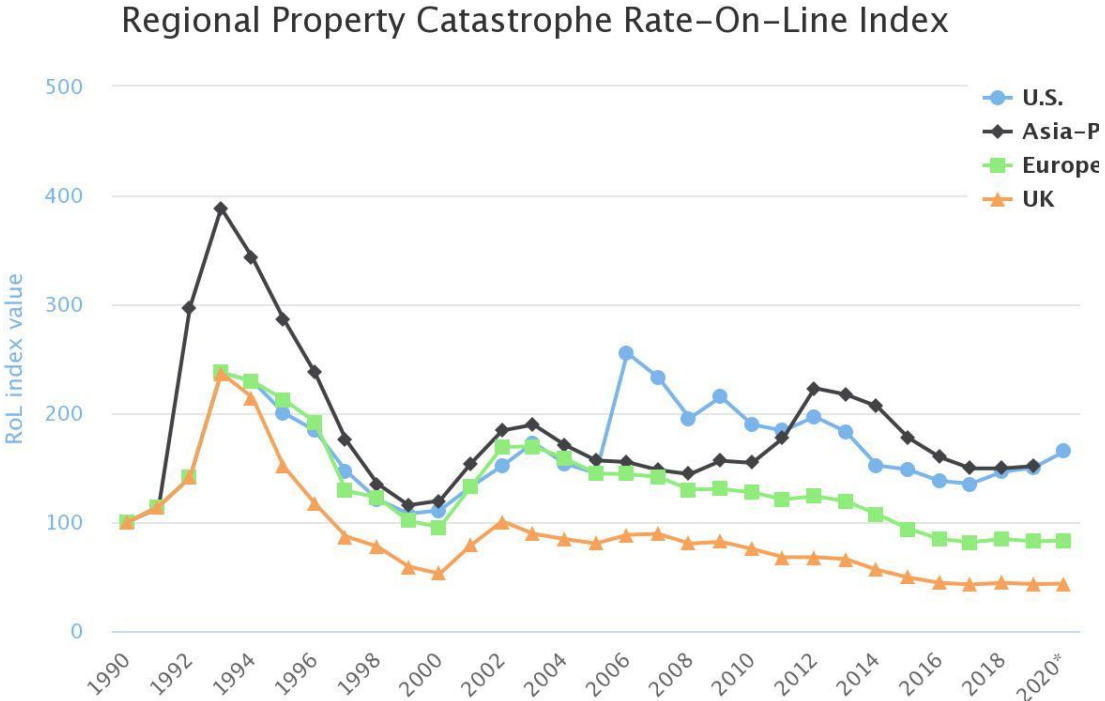
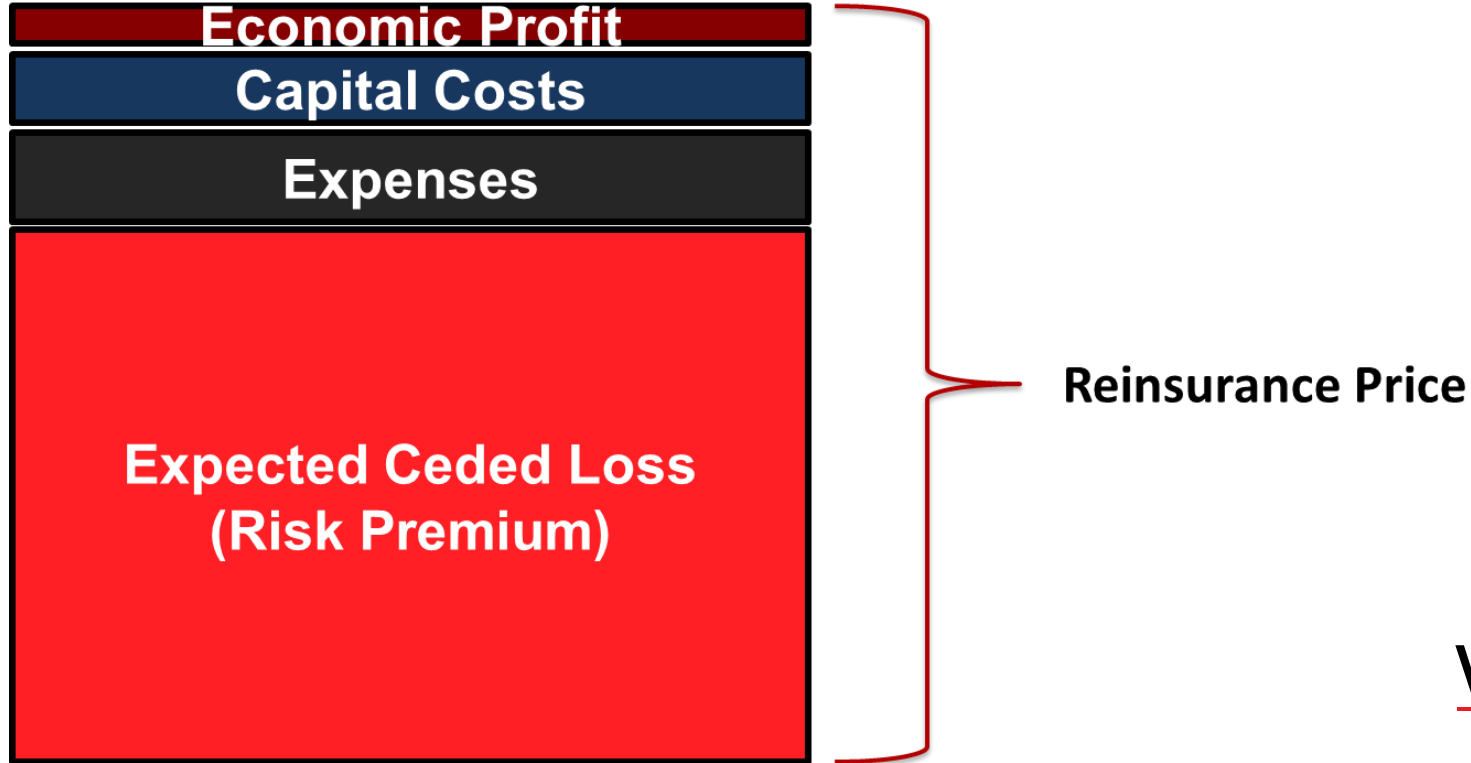Source: Data from Guy Carpenter, presented by Artemis.bm

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Actuarial Mathematics in Reinsurance

Basic Pricing Approaches

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Components of Reinsurance Price

Pricing Techniques

EXPERIENCE RATING

- enough loss data
- extrapolates historical experience
- does not reflect changes in portfolio and its structure
- works with either individual company or market-based parameters

EXPOSURE RATING

- claims experience is limited
- significant changes in portfolio
- works with market based parameters (increased limits factors or property exposure curves)

Burning Cost

Probabilistic Approach

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Pricing Techniques

| **Excess of Loss Contracts**	**Proportional Contracts**	**Aggregate Contracts**
• Generally 3 types: Per Risk XL, Per Event XL, Combined XL (Per Risk & Per Event XL) • Interested in modelling large losses (above certain threshold) • Split for Per Risk (NonCat) Losses and Per Event (Cat) Losses	• Concerns Quota Share and Surplus • First Dollar Coverage • Surplus is modelled as 100% QS with ceded figures • Split for Large Losses and Attritional Losses	• Concerns Aggregate Excess of Loss and Stop Loss • Aggregated Losses modelled (split for Large losses and Attritional Losses if provided or needed)

Technical Premium = Mean Ceded Loss (discounted) + Brokerage + Taxes + Admin Costs + Profit Loading (Premium Risk Loading + Reserve Risk Loading) + Other Expenses

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Pricing Techniques – Split of Claims
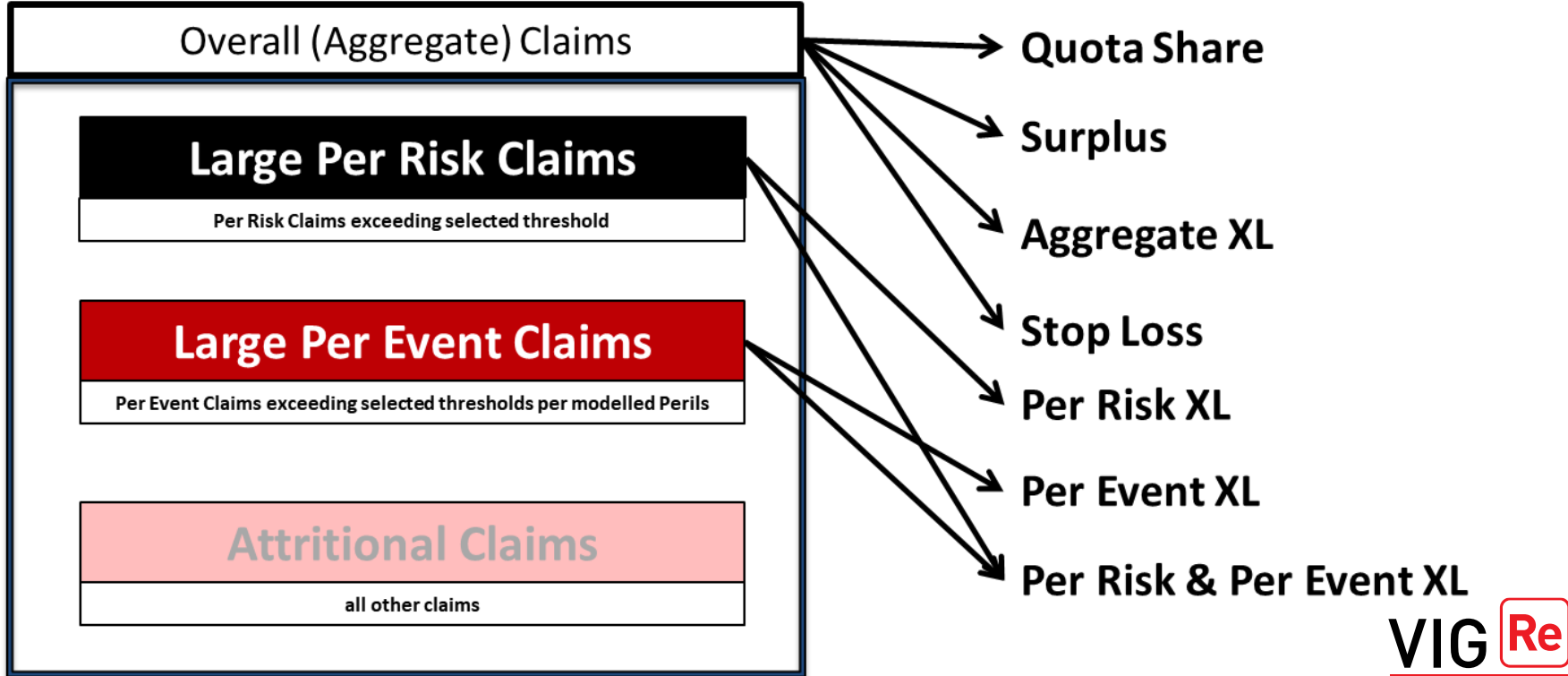
Profit Loading (Premium Risk and Reserve Risk Loading)

O   **Premium Risk** (including Nat Cat)

= risk that we do not collect enough premium to cover losses: 1 in 200 years scenario (0,5% probability)

O   **Reserve Risk**

= risk that reserves are not sufficient for the next accounting year (again 1 in 200 years, i.e. 0,5% probability)

Premium Risk   **Reserve Risk**

Year 1   Year 2   Year 3   Year N

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Pricing Techniques – Experience Rating

EXPERIENCE RATING	EXPOSURE RATING

- enough loss data
- extrapolates historical experience
- does not reflect changes in portfolio and its structure
- works with either individual company or market-based parameters

- claims experience is limited
- significant changes in portfolio
- works with market based parameters (increased limits factors or property exposure curves)

Burning Cost

Probabilistic Approach

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Burning Cost – Data

Loss ID	OY	Original Loss Amount
1	2009	1 123 082
2	2009	556 707
3	2012	403 008
4	2012	360 652
5	2013	331 734
6	2014	451 033
7	2015	472 194
8	2015	475 532
9	2015	331 284
10	2015	550 227
11	2016	326 479
12	2016	365 737
13	2017	581 045
14	2017	320 788
15	2017	1 526 408
16	2017	491 553
17	2018	677 467
18	2018	313 451
19	2018	861 805
20	2018	373 716

Layer	1	2
Limit	1 200 000	1 500 000
Retention	300 000	1 500 000

Year	Premium
2009	15 000 000
2010	20 000 000
2011	25 000 000
2012	30 000 000
2013	35 000 000
2014	40 000 000
2015	45 000 000
2016	50 000 000
2017	55 000 000
2018	60 000 000
2019	65 000 000

Assumption:
We have 20 historical claims and we quote a treaty for 2020 (i.e. treaty period is 1.1.2020 - 31.12.2020).

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Burning Cost – Example

Loss ID	OY	Original Loss Amount	Inflated Loss Amount
1	2009	1 123 082	1 554 608
2	2009	556 707	770 613
3	2012	403 008	510 519
4	2012	360 652	456 863
5	2013	331 734	407 991
6	2014	451 033	538 557
7	2015	472 194	547 403
8	2015	475 532	551 272
9	2015	331 284	384 049
10	2015	550 227	637 864
11	2016	326 479	367 455
12	2016	365 737	411 641
13	2017	581 045	634 923
14	2017	320 788	350 534
15	2017	1 526 408	1 667 947
16	2017	491 553	537 133
17	2018	677 467	718 725
18	2018	313 451	332 540
19	2018	861 805	914 289
20	2018	373 716	396 475

Adjust individual claims by <u>appropriate</u> inflation index (CPI, construction costs, etc.)

<u>Reason</u>: By this you get claim amounts valued in the form as if the losses occured in 2020)

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Burning Cost – Example
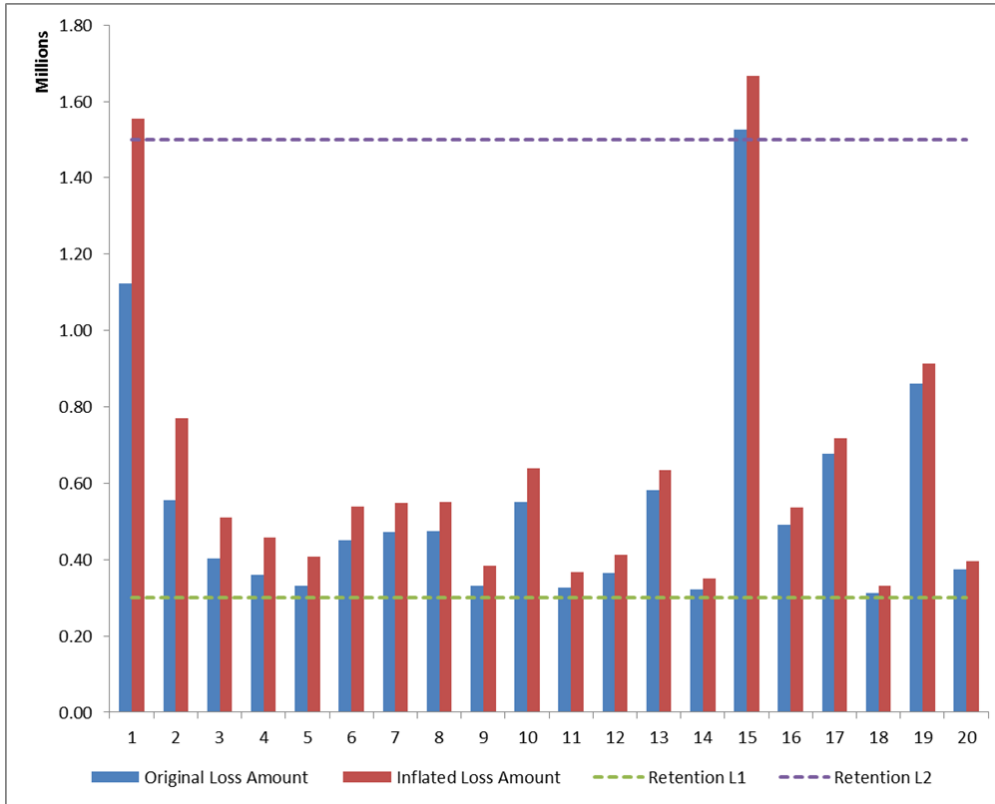
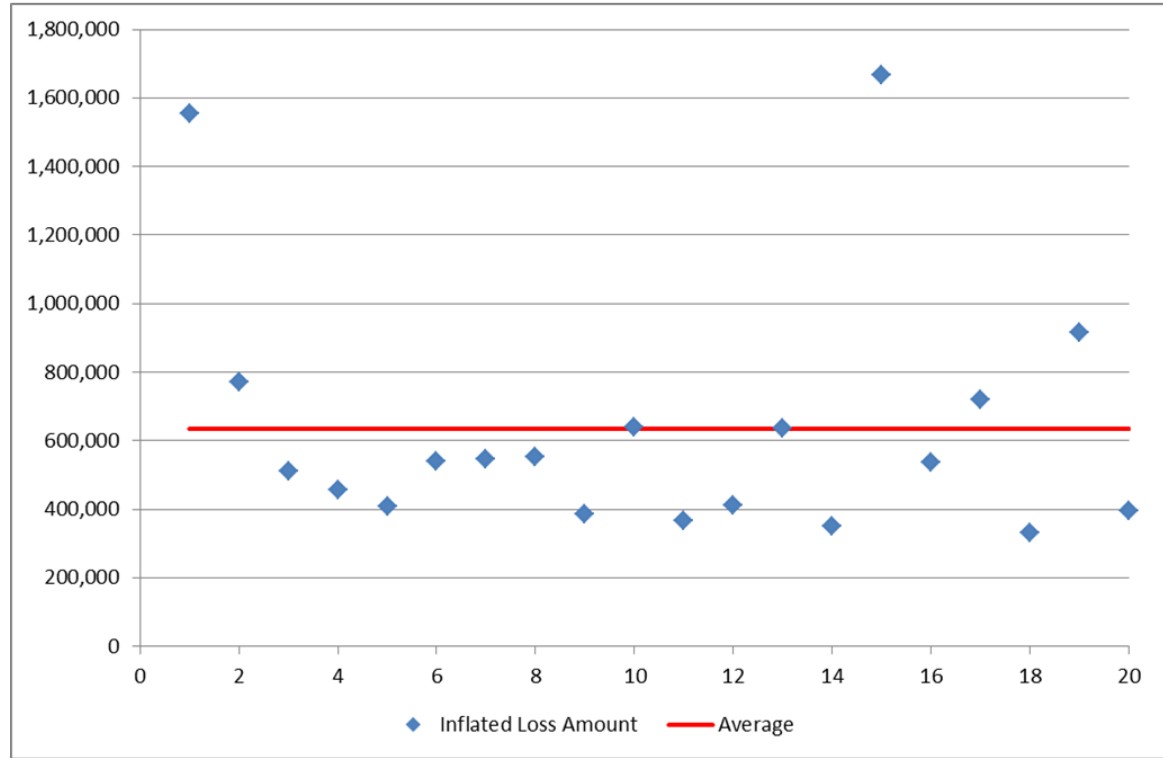# Burning Cost – Example

Average claim

Mean	634,570
STD	367,218
CoV	57.87%

Standard Deviation (shows volatility around the average)

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2}.$$

Coefficient of variation = STD / Mean

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Burning Cost – Example

$$\min(\max(OriginalLoss - Retention; 0); Limit)$$

Layer	1	2
Limit	1,200,000	1,500,000
Retention	300,000	1,500,000

Loss ID	OY	Original Loss Amount	Inflated Loss Amount	L1		L2	
				Ceded Original	Ceded Inflated	Ceded Original	Ceded Inflated
1	2009	1 123 082	1 554 608	823 082	1 200 000	0	54 608
2	2009	556 707	770 613	256 707	470 613	0	0
3	2012	403 008	510 519	103 008	210 519	0	0
4	2012	360 652	456 863	60 652	156 863	0	0
5	2013	331 734	407 991	31 734	107 991	0	0
6	2014	451 033	538 557	151 033	238 557	0	0
7	2015	472 194	547 403	172 194	247 403	0	0
8	2015	475 532	551 272	175 532	251 272	0	0
9	2015	331 284	384 049	31 284	84 049	0	0
10	2015	550 227	637 864	250 227	337 864	0	0
11	2016	326 479	367 455	26 479	67 455	0	0
12	2016	365 737	411 641	65 737	111 641	0	0
13	2017	581 045	634 923	281 045	334 923	0	0
14	2017	320 788	350 534	20 788	50 534	0	0
15	2017	1 526 408	1 667 947	1 200 000	1 200 000	26 408	167 947
16	2017	491 553	537 133	191 553	237 133	0	0
17	2018	677 467	718 725	377 467	418 725	0	0
18	2018	313 451	332 540	13 451	32 540	0	0
19	2018	861 805	914 289	561 805	614 289	0	0
20	2018	373 716	396 475	73 716	96 475	0	0

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Burning Cost – Example

Premium shall be inflated to current level (as-if 2020) and then put into relation with as-if losses (however not inflated in this example)

Sum of all ceded claims into Layer 1 in accident year 2009

=1,079,789 / 15,000,000

| Year	Premium	Non-Inflated				Inflated			
		Ceded L1	Ceded L2	Non-Inflated BC L1	Non-Inflated BC L2	Ceded L1	Ceded L2	Inflated BC L1	Inflated BC L2
2009	15 000 000	1 079 789	0	7,20%	0,00%	1 670 613	54 608	11,14%	0,36%
2010	20 000 000	0	0	0,00%	0,00%	0	0	0,00%	0,00%
2011	25 000 000	0	0	0,00%	0,00%	0	0	0,00%	0,00%
2012	30 000 000	163 660	0	0,55%	0,00%	367 382	0	1,22%	0,00%
2013	35 000 000	31 734	0	0,09%	0,00%	107 991	0	0,31%	0,00%
2014	40 000 000	151 033	0	0,38%	0,00%	238 557	0	0,60%	0,00%
2015	45 000 000	629 237	0	1,40%	0,00%	920 587	0	2,05%	0,00%
2016	50 000 000	92 217	0	0,18%	0,00%	179 096	0	0,36%	0,00%
2017	55 000 000	1 693 386	26 408	3,08%	0,05%	1 822 590	167 947	3,31%	0,31%
2018	60 000 000	1 026 439	0	1,71%	0,00%	1 162 029	0	1,94%	0,00%
2019	65 000 000	0	0	0,00%	0,00%	0	0	0,00%	0,00%
		Average (of BC)		1,326%	0,004%			1,902%	0,061%
		Total Ceded/Total Premium:		1,106%	0,006%			1,470%	0,051%
		Diff %		-16,565%	37,500%			-22,701%	-16,884%

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Burning Cost L1 – Drawbacks
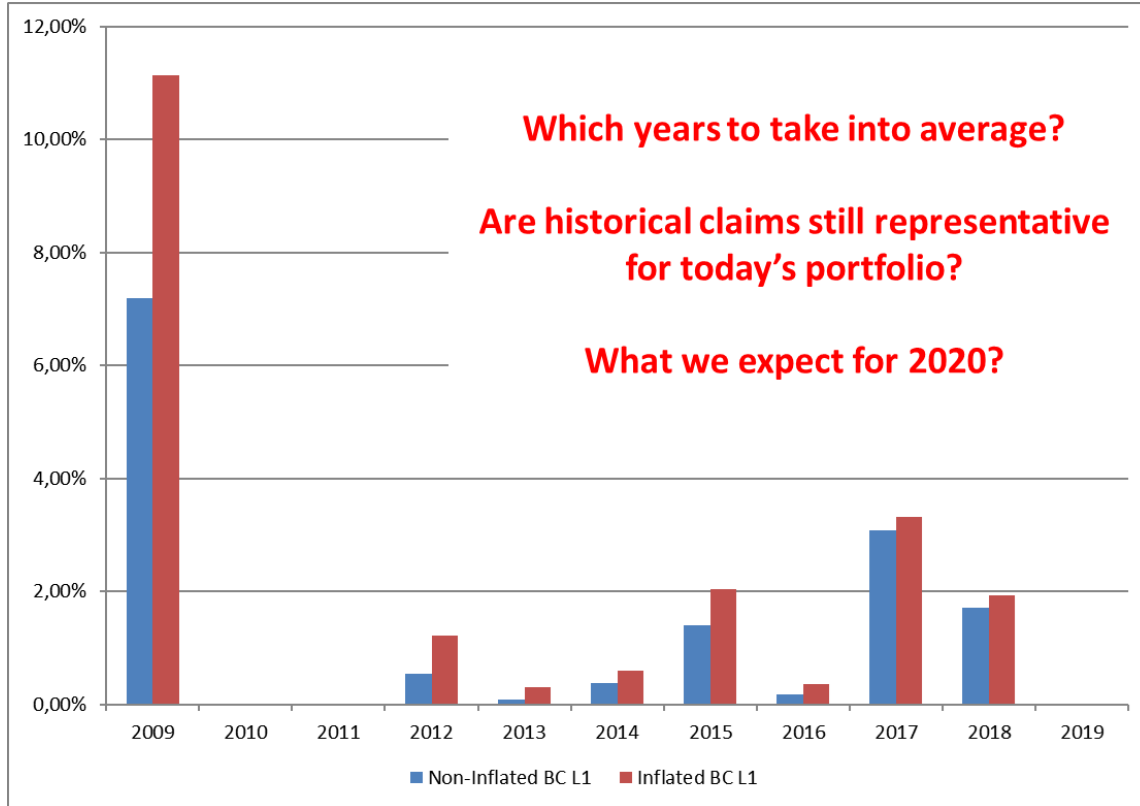
Burning Cost L2 – Drawbacks
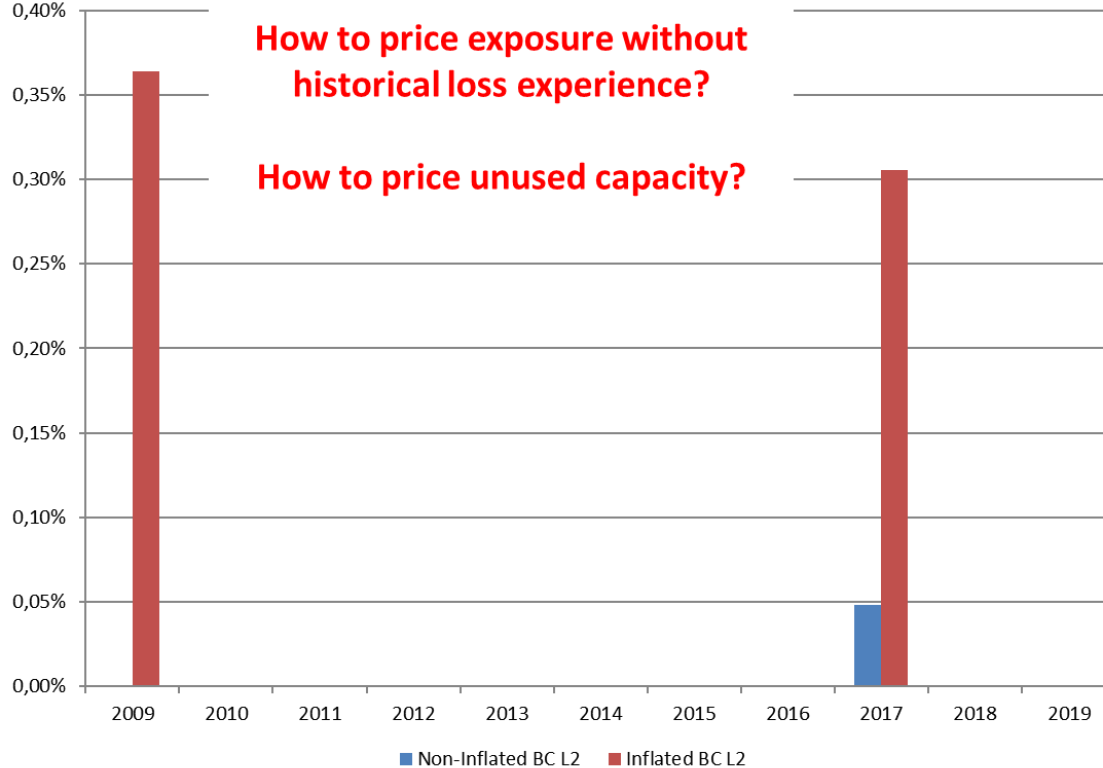
Burning Cost – Real Example

Large Claims Burning Costs Analysis

	Option 1	Option 1				Burning Costs			
Option:						Option 1	Option 1		
Limit in Contract Currency:	2 300 000	999 999 999			Include	2 300 000	999 999 999		
Retention in Contract Currency:	700 000	3 000 000			Year in the	700 000	3 000 000		
Limit in Claims Currency:	2 300 000	999 999 999			BC analysis?	2 300 000	999 999 999		
Retention in Claims Currency:	700 000	3 000 000				700 000	3 000 000		
	Ceded Inflated Ultimate Loss					Inflated Ultimate BC (incl. IBNER, but excl. IBNR, w/o index clause)			
1993	0	0			0	NA	NA		
1994	0	0			0	NA	NA		
1995	0	0			0	NA	NA		
1996	0	0			0	NA	NA		
1997	0	0			0	0,00%	0,00%		
1998	0	0			0	0,00%	0,00%		
1999	717 305	0			0	4,72%	0,00%		
2000	2 785 305	1 480 853			0	17,29%	9,19%		
2001	390 352	0			0	1,90%	0,00%		
2002	3 317 127	476 936			0	17,15%	2,47%		
2003	0	0			0	0,00%	0,00%		
2004	484 057	0			1	2,48%	0,00%		
2005	0	0			1	0,00%	0,00%		
2006	0	0			1	0,00%	0,00%		
2007	4 600 000	2 486 174			1	19,94%	10,78%		
2008	662 557	0			1	2,80%	0,00%		
2009	0	0			1	0,00%	0,00%		
2010	139 779	0			1	0,56%	0,00%		
2011	67 660	0			1	0,27%	0,00%		
2012	682 047	0			1	2,62%	0,00%		
2013	0	0			1	0,00%	0,00%		
2014	0	0			1	0,00%	0,00%		
2015	0	0			1	0,00%	0,00%		
2016	0	0			1	0,00%	0,00%		
2017	0	0			1	0,00%	0,00%		
2018	0	0			1	0,00%	0,00%		
2019	0	0			0	0,00%	0,00%		
Selected Average BC						1,912%	0,719%		

L1: 0,7M XS 2,3M

L2: 3M XS 999,999999M

Inflated Ultimate BC
Selected Average BC

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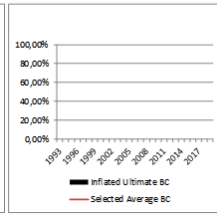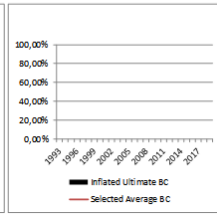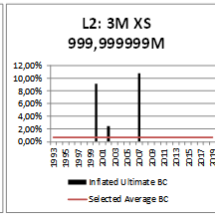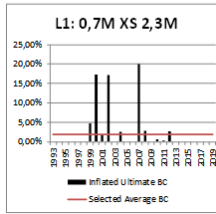
Probabilistic Approach – Possible Remedy for BC Drawbacks

- Individual claims are mutually independent identically distributed random variables
- Number of claims is independent from claims amounts

Collective Risk Model (if assumptions are fulfilled):

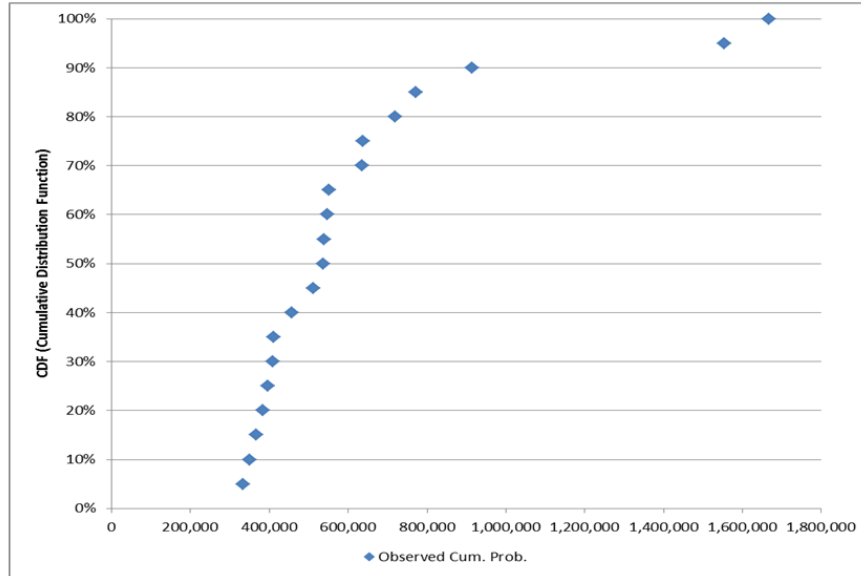Total Expected Loss Amount = Expected Number of Claims * Expected Claim Size
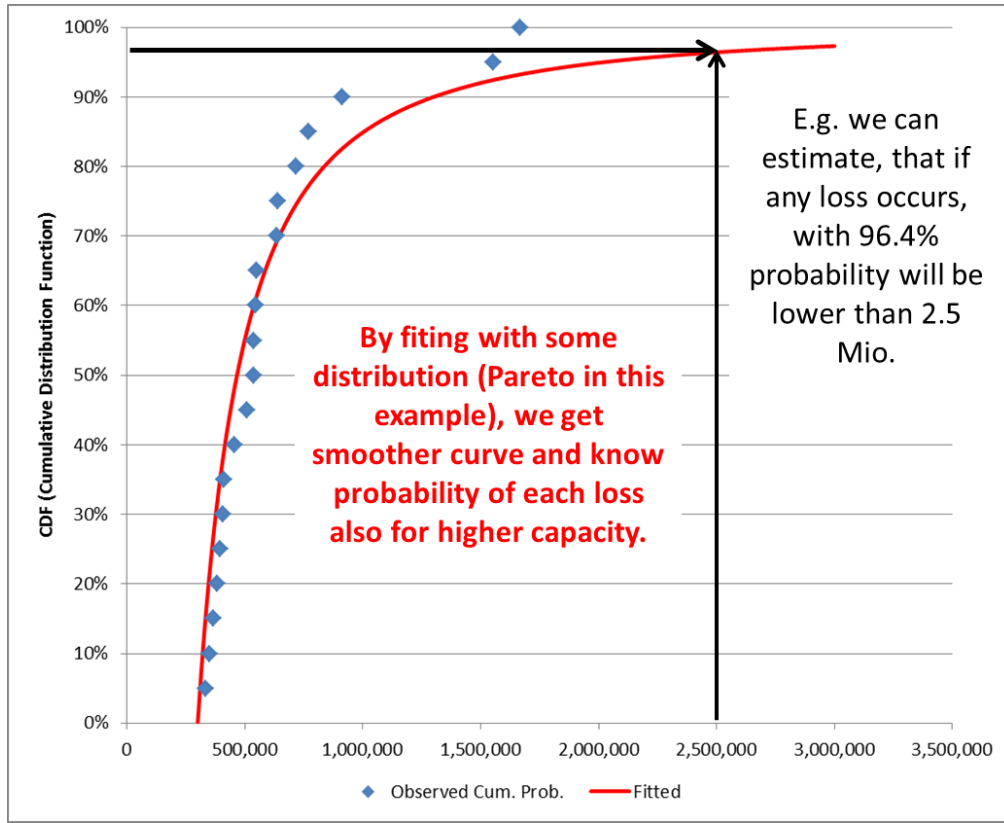
Frequency Model

Severity Model

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Probabilistic Approach – Severity Model

Rank	Sorted Claims	Observed Cum. Prob.
1	332,540	5%
2	350,534	10%
3	367,455	15%
4	384,049	20%
5	396,475	25%
6	407,991	30%
7	411,641	35%
8	456,863	40%
9	510,519	45%
10	537,133	50%
11	538,557	55%
12	547,403	60%
13	551,272	65%
14	634,923	70%
15	637,864	75%
16	718,725	80%
17	770,613	85%
18	914,289	90%
19	1,554,608	95%
20	1,667,947	100%

- Empirical distribution function – claims are sorted
- Each claim has equal probability of 1/20=5%
- Interpretation: probability, that any claim will be equal to or lower than 8th claim is 8*5% = 40%

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Probabilistic Approach – Severity Model

E.g. we can estimate, that if any loss occurs, with 96.4% probability will be lower than 2.5 Mio.

By fiting with some distribution (Pareto in this example), we get smoother curve and know probability of each loss also for higher capacity.

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Probabilistic Approach – Frequency Model

	Number of Claims xs Threshold	Number of Claims xs Threshold / 1M EUR Premium
2009	2	13,333%
2010	0	0,000%
2011	0	0,000%
2012	2	6,667%
2013	1	2,857%
2014	1	2,500%
2015	4	8,889%
2016	2	4,000%
2017	4	7,273%
2018	4	6,667%
2019	0	0,000%

Average (2012-2018):	2,57	5,550%
GNPI 2015:	70 000 000	3,89

Estimated number of large claims in 2020 (Exposure adjusted)

Relative frequency calculated per 1M EUR (exposure weighted)

Probabilistic Approach – Frequency Model

	Number of Claims xs Threshold	Number of Claims xs Threshold / 1M EUR Premium
2009	2	13,333%
2010	0	0,000%
2011	0	0,000%
2012	2	6,667%
2013	1	2,857%
2014	1	2,500%
2015	4	8,889%
2016	2	4,000%
2017	4	7,273%
2018	4	6,667%
2019	0	0,000%

Average (2007-2013):	2,57	5,550%
GNPI 2015:	70 000 000	3,89

Possible frequency distributions
Negative Binomial: Variance > Mean
Poisson: Variance = Mean
Binomial: Variance < Mean

This the value for mean value of frequency in case of Poisson distribution

Pure average of number of claims underestimates the frequency, therefore exposure weighting is applied.

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Simulations – Methodology

1) <u>Select number of simulations</u>: Each simulation represents 1 treaty year, i.e. by 500 simulations we simulate 500 years (500 different outcomes of 2020 treaty year)
2) <u>Generate number of claims based on the frequency model</u>: in each year (simulation) different numbers of claims are generated
3) <u>Generate severity of each claim based on the severity model</u>: for each simulated claim in previous step a different claim size is generated
4) <u>Apply reinsurance structure</u>: within each of 500 years as-if reinsurance structure is applied and we can see the expected average ceded loss (reinsurer´s result), their volatility and many other statistics

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Simulations – Example

- **Number of years** (simulations): 100
- **Frequency**: Poisson distribution with expected 3.89 claims per year
- **Severity**: Pareto distribution with threshold of 300k EUR and alpha parameter of 1.57

Threshold used for per risk XL programs which are assumed further, typically around 80% of priority, but depends on many other factors. Specialised tests and more rigorous approaches for its selection can be applied.

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Simulations – Number of Generated Claims per Year
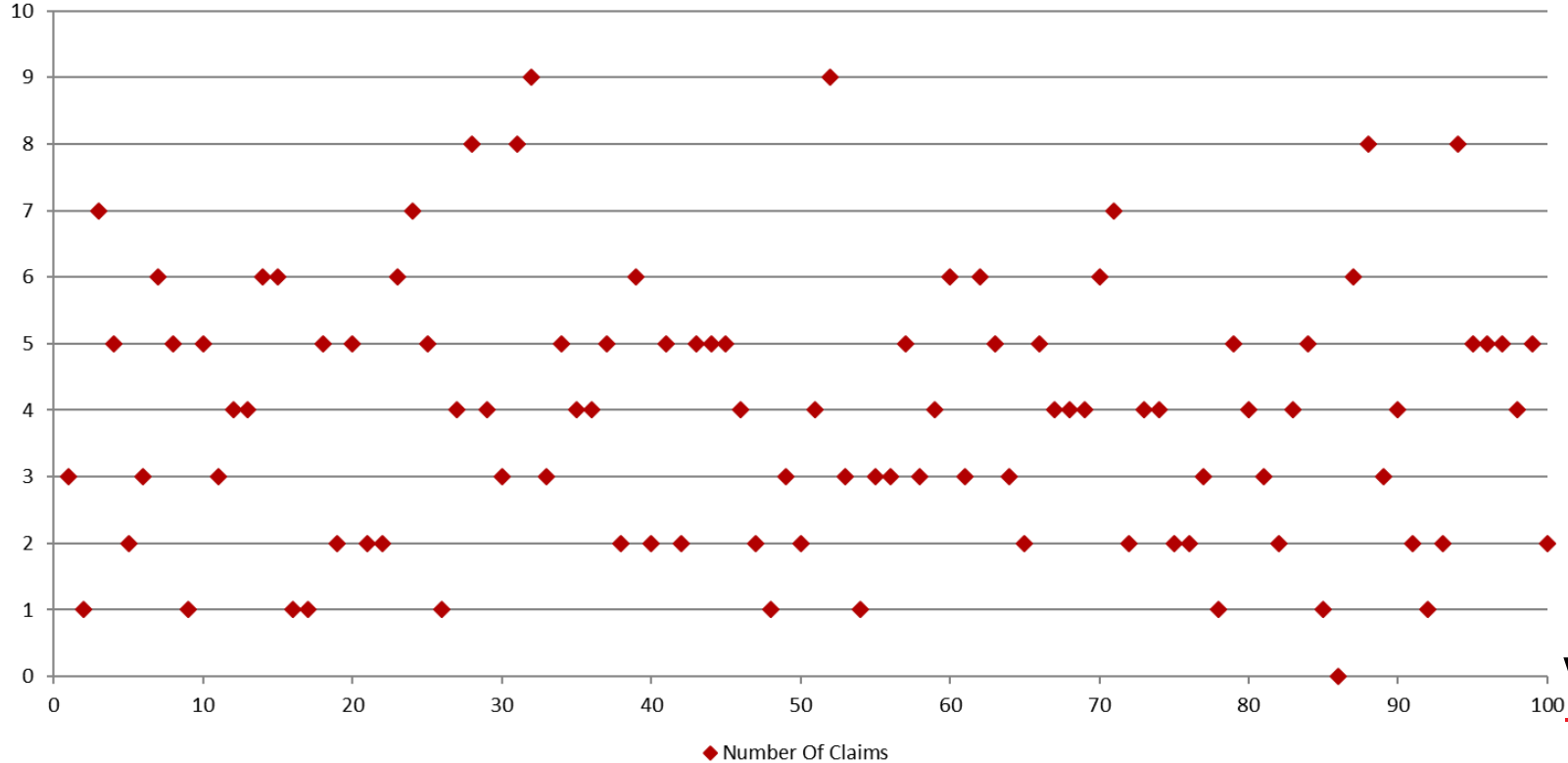
Simulations – Generated Severity and Applied Reinsurance

For each claim its size is generated and reinsurance structure is applied.

Layer	1	2
Limit	1,200,000	1,500,000
Retention	300,000	1,500,000

Thanks to simulations we know much more than average and also large claims are generated which help with pricing of higher layers.

	L1	L2
Mean	1 180 247	224 395
STD	887 138	495 991
CoV	75,2%	221,0%

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Simulations – CDFs for Ceded Losses to L1 and L2
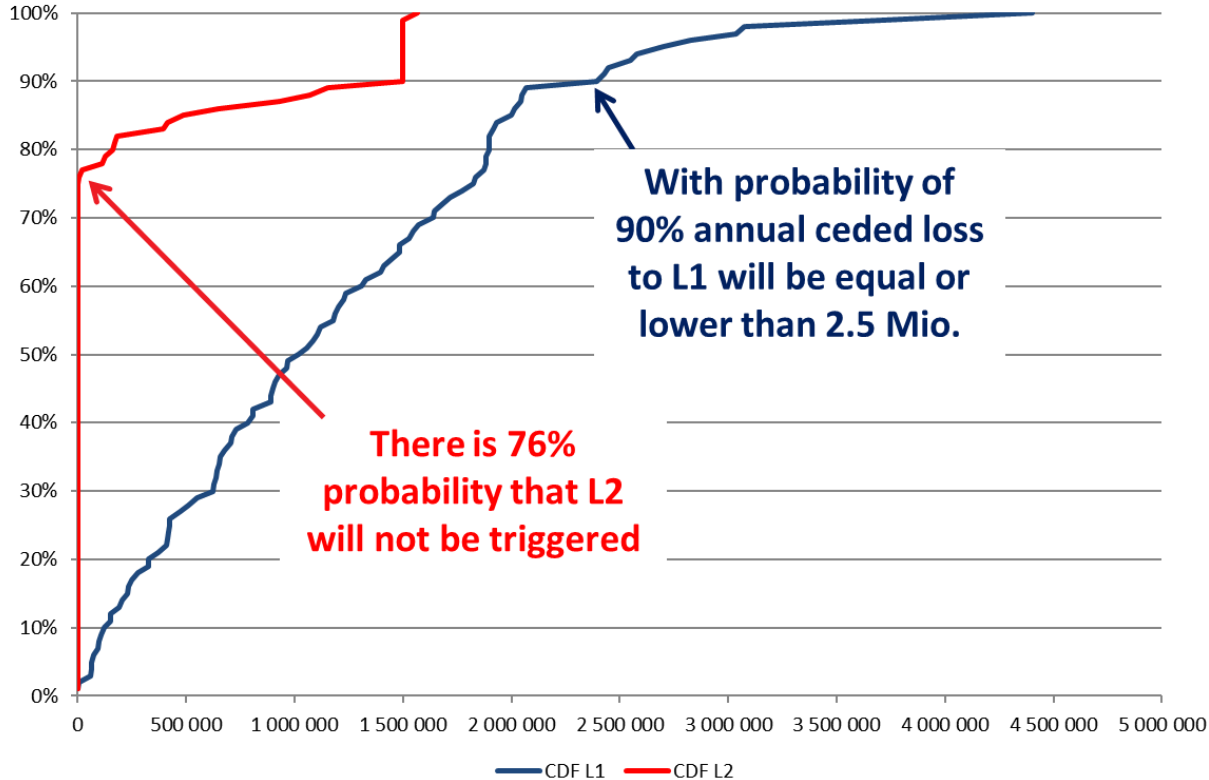
Simulations – Ceded Losses to L1 and L2

	L1	L2
Mean	1 180 247	224 395
Variance	787 013 582 465	246 007 544 336
STD	887 138	495 991
CoV	75,2%	221,0%
VaR(50%)	1 016 756	0
VaR(98%)	3 073 696	1 500 000
VaR(99%)	3 702 626	1 500 000
TVaR(98%)	4 051 728	1 534 033

VaR(p) is p-th quantile of simulated distribution
TVaR(p) = E(CededLoss | CededLoss > VaR(p))

$$RP = 1/(1 – p) \qquad p = 1 – 1/RP$$

RP 1 in 250, i.e. VaR(99.6%) … usually purchased capacity
RP 1 in 200, i.e. VaR(99.5%) … Solvency 2 capital requirement

Median. Half of simulation results is lower or equal.

Value at Risk. First 98% of simulation results are lower or equal, i.e. with 98% probability the ceded loss will be equal or lower to this value. Another interpretation: the worst result assumed to happen once in 50 years (i.e. The return period (RP) for the loss of 1,5M EUR to L2 has return period of 50 years).

Tail Value at Risk. Expected value of loss given that the loss is greater than corresponding VaR quantity (i.e. average of 2% greatest losses).

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Simulations – Real Example from Broker

	Property Internal	GTPL Internal	Casco Internal	Marine Internal	PA Internal	Other LOB Internal	TOTAL Internal
Expected Values							
Net Premium	53,203,375	5,038,841	5,394,995	3,242,504	416,903	14,093,243	67,296,617
Premium	83,489,354	7,207,998	7,486,264	4,235,292	416,903	19,346,457	102,835,812
Commission	26,179,347	2,169,157	2,091,269	992,788	0	5,253,215	31,432,561
RI costs	4,106,633	0	0	0	0	0	4,106,633
Base RI Premium	4,026,760	0	0	0	0	0	4,026,760
Reinstatement RI Premium	79,873	0	0	0	0	0	79,873
Net losses	50,344,987	3,672,667	5,182,396	2,046,187	298,526	11,199,777	61,544,764
Losses	53,584,398	3,672,983	5,182,396	2,046,187	1,385,577	12,287,143	65,871,542
Recoveries from Retro Cover	3,239,411	316	0	0	1,087,050	1,087,366	4,326,777
CoV	10.52%	24.46%	10.11%	26.47%	41.41%	10.54%	8.81%
Return period							
2	50,086,244	3,541,643	5,152,701	1,964,846	281,108	11,090,299	61,292,725
5	54,718,137	4,301,006	5,612,077	2,458,614	388,549	12,104,991	66,027,591
10	57,268,903	4,790,506	5,870,611	2,769,244	453,656	12,711,492	68,617,410
20	59,440,798	5,266,199	6,099,510	3,054,651	512,966	13,246,450	70,831,936
50	61,992,531	5,922,311	6,364,153	3,402,182	583,860	13,937,167	73,400,563
100	63,840,335	6,422,016	6,533,065	3,650,447	636,363	14,472,847	75,338,421
200	65,522,691	7,047,684	6,677,326	3,902,412	679,172	15,043,793	76,891,929
250	65,969,583	7,279,023	6,717,123	3,982,964	689,726	15,251,646	77,486,285
500	67,533,481	8,013,528	6,823,006	4,231,802	717,488	15,962,482	79,057,505
1000	68,951,078	8,804,987	6,938,570	4,451,092	738,242	16,708,786	80,539,644
Max	79,818,130	22,168,601	7,593,657	5,901,909	5,342,337	30,640,029	91,495,279

Mean → (Net Premium, Premium, Commission, RI costs)

CoV → (CoV)

RP Report → (Return period rows)

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Expected Reinsurer Deficit (ERD) Test

Logic: ERD test defines whether a reinsurance contract can be identified as a risk transfer between Reinsured and Reinsurer. It compares expected negative result for reinsurer to premium, i.e. it takes simulations with negative results, calculates average negative results to reinsurer, multiplies by its probability and compares to premium (to fulfill the risk transfer requirement of a reinsurance contract, calculated ratio must be greater than 1%).

Average result from all simulations where ceded loss > premium, i.e. reinsurer's negative result

Relative number of simulations where ceded loss > premium, i.e. probability of reinsurer's negative result

$$\frac{AVG(\text{Premium} - \text{Loss} \mid \text{Ceded Loss} > \text{Premium}) * \dfrac{\text{count (simulations with negative results)}}{\text{count (all simulations)}}}{\text{Premium}}$$

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Property FLS Exposure Rating – Limited Data Availability

- **Risk profiles** (number of risks, PML/SI, premium per band)
- **Exposure** (historical and estimated GNPI)
- **Per Risk Large Claims** (gross or ceded basis depending on treaty type)
- **Per Event Large Claims** (if covered and experienced, gross or ceded basis depending on treaty type)
- **Aggregate claims** (required for proportional and aggregate contracts)
- **The largest risks**

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Property FLS Exposure Rating – Exposure Curve Parameters Selection
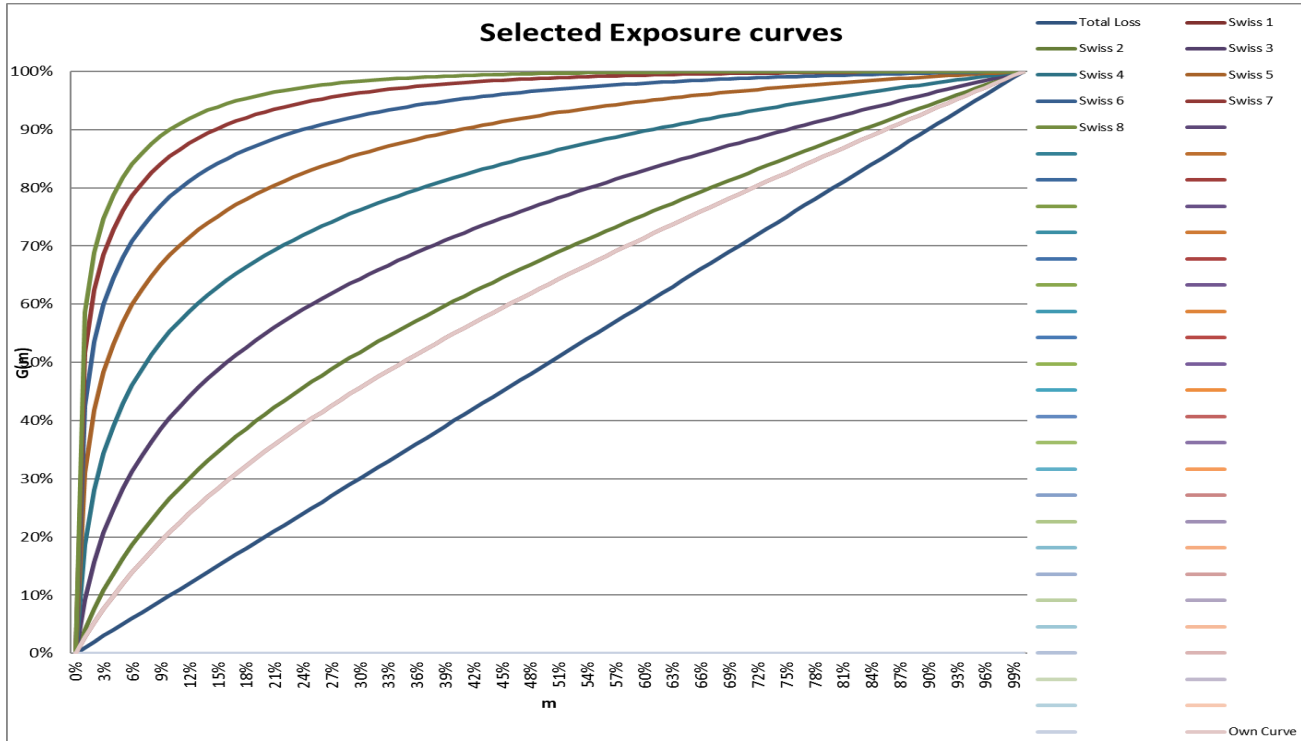
Property Exposure Rating – Freq/Severity Model

Large Claims Exposure Rating MetaRisk Inputs : Severity Input CDF & Frequency for Standard Loss Cause

MetaRisk Large Claims Inputs	
Large Claims Severity	Large Claims Frequency

Threshold:	750 000
Max SI:	488 750 000
Iterations:	300
Step Length:	1 632 107

MR Input CDF

Loss Value	Cumulative Probability
750 000	0,0000000000000
2 376 562	0,7273868164545
4 003 125	0,8454789491178
5 629 687	0,8990065962295
7 256 250	0,9297910980176
8 882 812	0,9445226024795
10 509 374	0,9564728882640
12 135 937	0,9649957092031
13 762 499	0,9696338461839
15 389 061	0,9741036462487
17 015 624	0,9774284677359
18 642 186	0,9801592623535
20 268 748	0,9821381500554
21 895 310	0,9838099094428
23 521 874	0,9852384965998
25 148 436	0,9872321497395
26 774 998	0,9883481244660
28 401 560	0,9891912540312
30 028 122	0,9899384464917
31 654 686	0,9906434235669
33 281 248	0,9912342107005
34 907 808	0,9918063007134
36 534 372	0,9922826272433
38 160 936	0,9927159785690
39 787 496	0,9931116675647
41 414 060	0,9934741770558
43 040 620	0,9938073122227
44 667 184	0,9941143333642
46 293 748	0,9943980356941
47 920 308	0,9946608335787
49 546 872	0,9949048422075
51 173 432	0,9951318843033
52 799 996	0,9953435789911
54 426 560	0,9955413389585
56 053 120	0,9957264186473
57 679 684	0,9958999257840
59 306 244	0,9960628531196

Expected No. of Claims in 2016:

0,5193138

Frequency from Exposure Rating: use for Poisson Pure distribution in case there are no historical claims

Frequency

0,519313831
0,141571797
0,080244919
0,051979889
0,036460454
0,02881018
0,022604231
0,018437869
0,015769564
0,013448335
0,011721709
0,010303569
0,009275906
0,008407738
0,007665853
0,006630521
0,00605098
0,005613131
0,005225104
0,004859
0,004552196
0,004255101
0,004007738
0,003782693
0,003577206
0,00338895
0,003215948
0,003056508
0,002909178
0,002772703
0,002645986
0,00252808
0,002418144
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0,00221933
0,002129225
0,002044615
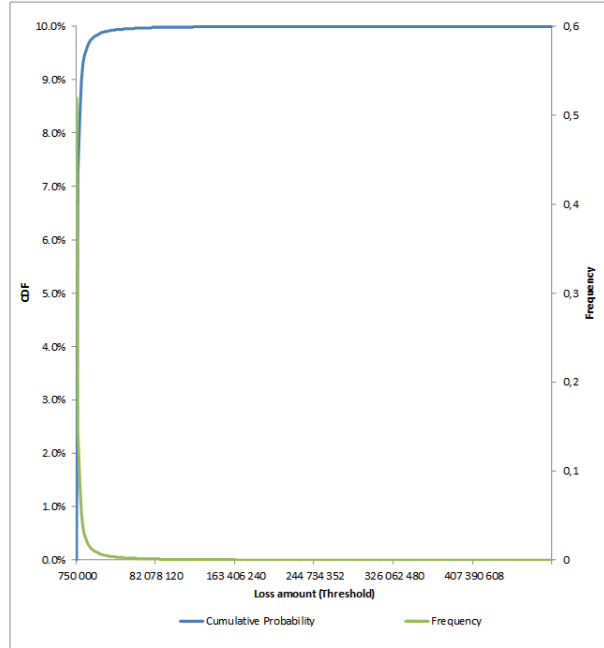
Actuarial Mathematics in Reinsurance

Capital Modelling

VIG Re

Partial Internal Model under Solvency II

- After the renewal we merge all models and create one huge stochastic model (incl. natural catastrophes on cross-country level)

- This serves for calculation of SCR (expected from 2020)

- Retrocession optimization

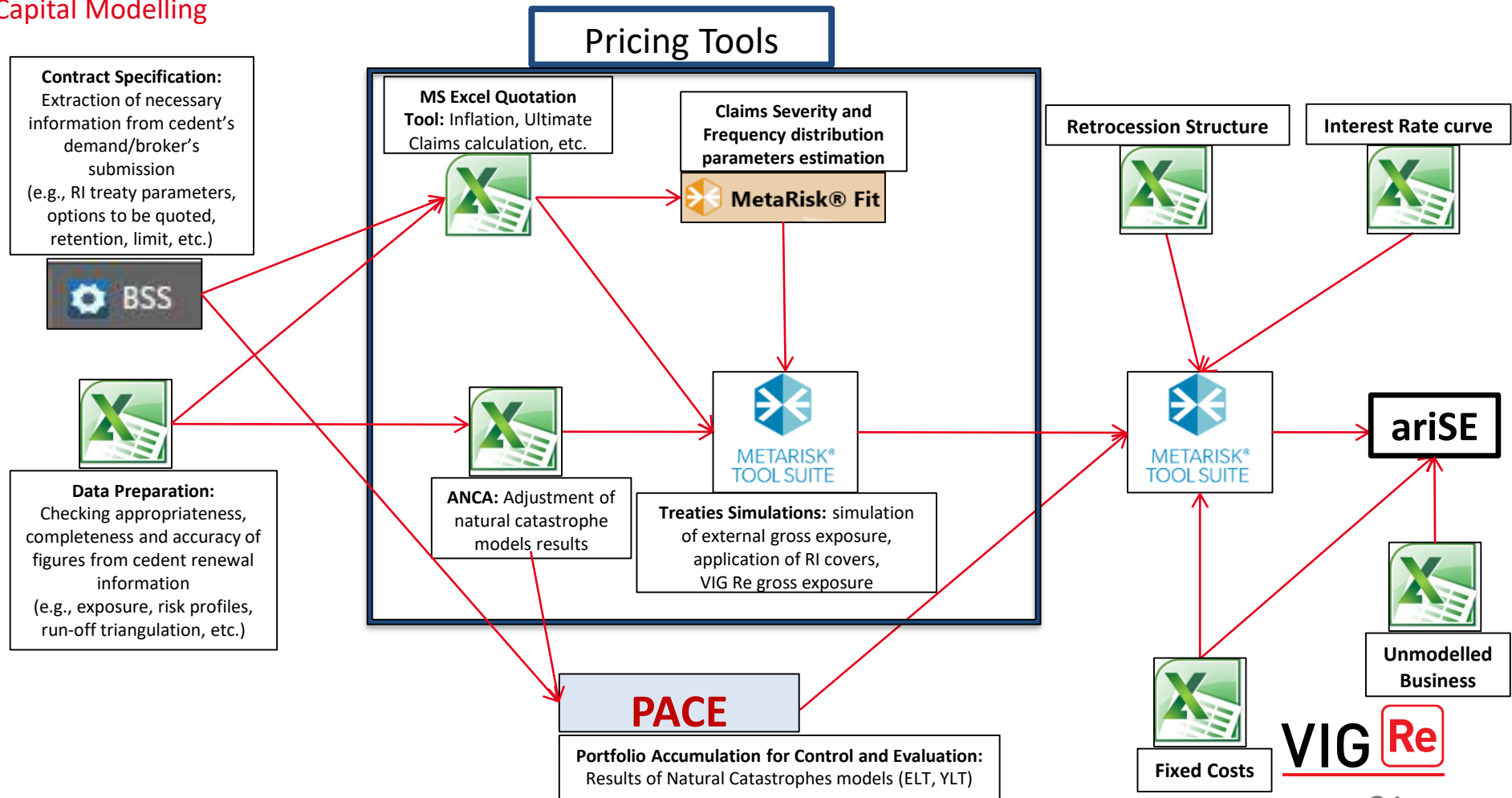- Assessment of business profitability

- Creation of business plan

Scope of Partial Internal Model in VIG Re
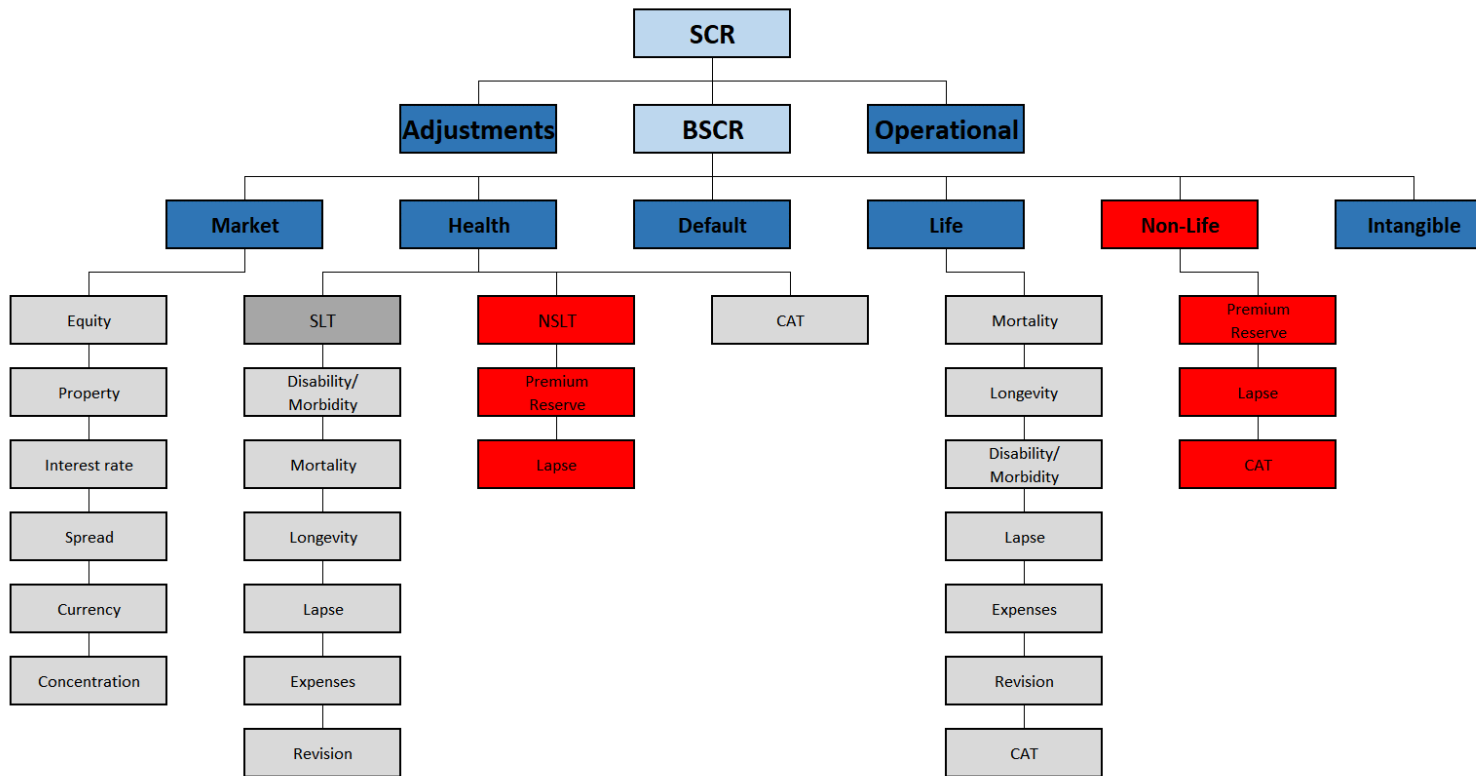
Reserve Risk Process

○ RI contracts segmentation into homogenous risk groups (SII LoBs, accounting basis, country of cedant, etc.)

○ Best Estimates (claims TP) and one-year standard deviations

○ Simulation of ultimate claims

VIG **Re**

Capital Modelling

Pricing Tools

Contract Specification: Extraction of necessary information from cedent's demand/broker's submission (e.g., RI treaty parameters, options to be quoted, retention, limit, etc.)

BSS

Data Preparation: Checking appropriateness, completeness and accuracy of figures from cedent renewal information (e.g., exposure, risk profiles, run-off triangulation, etc.)

MS Excel Quotation Tool: Inflation, Ultimate Claims calculation, etc.

Claims Severity and Frequency distribution parameters estimation

MetaRisk® Fit

ANCA: Adjustment of natural catastrophe models results

Treaties Simulations: simulation of external gross exposure, application of RI covers, VIG Re gross exposure

METARISK® TOOL SUITE

Retrocession Structure

Interest Rate curve

METARISK® TOOL SUITE

ariSE

Unmodelled Business

Fixed Costs

VIG Re

PACE

Portfolio Accumulation for Control and Evaluation: Results of Natural Catastrophes models (ELT, YLT)

81

Capital Modelling

Pricing of NL & NSLT Health Reinsurance

Capital Modelling
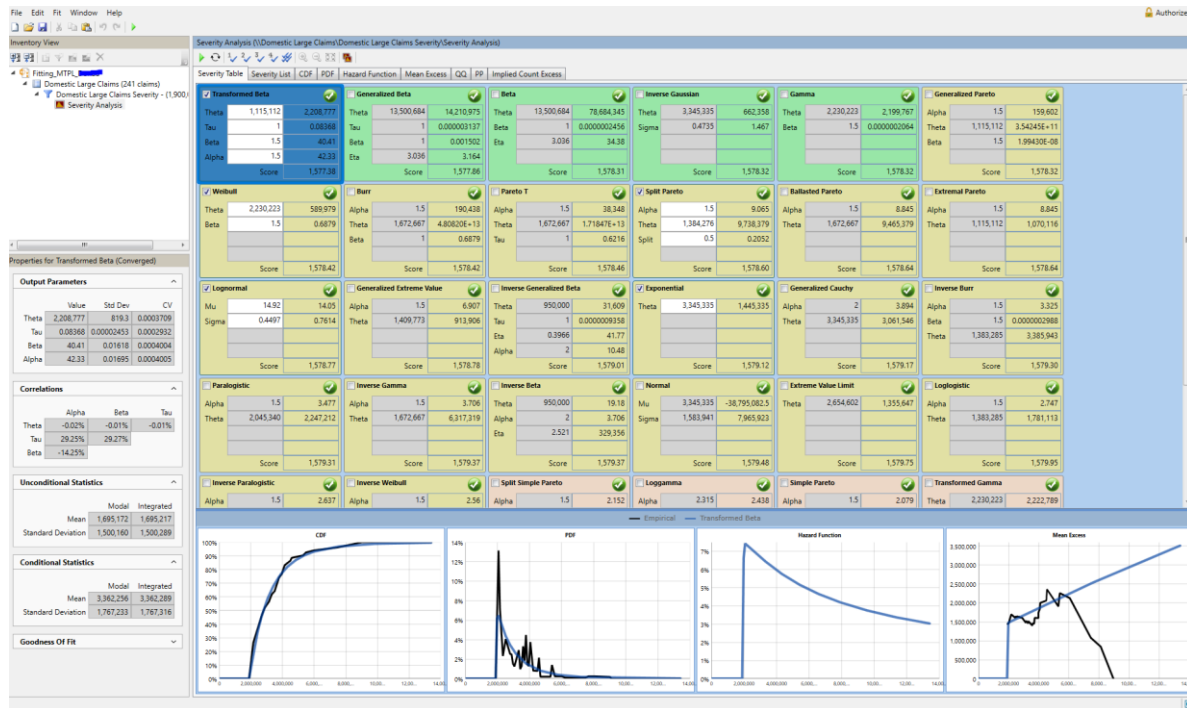
Pricing of NL Reinsurance: Simple Example

Pricing of NL Reinsurance: Complex Example
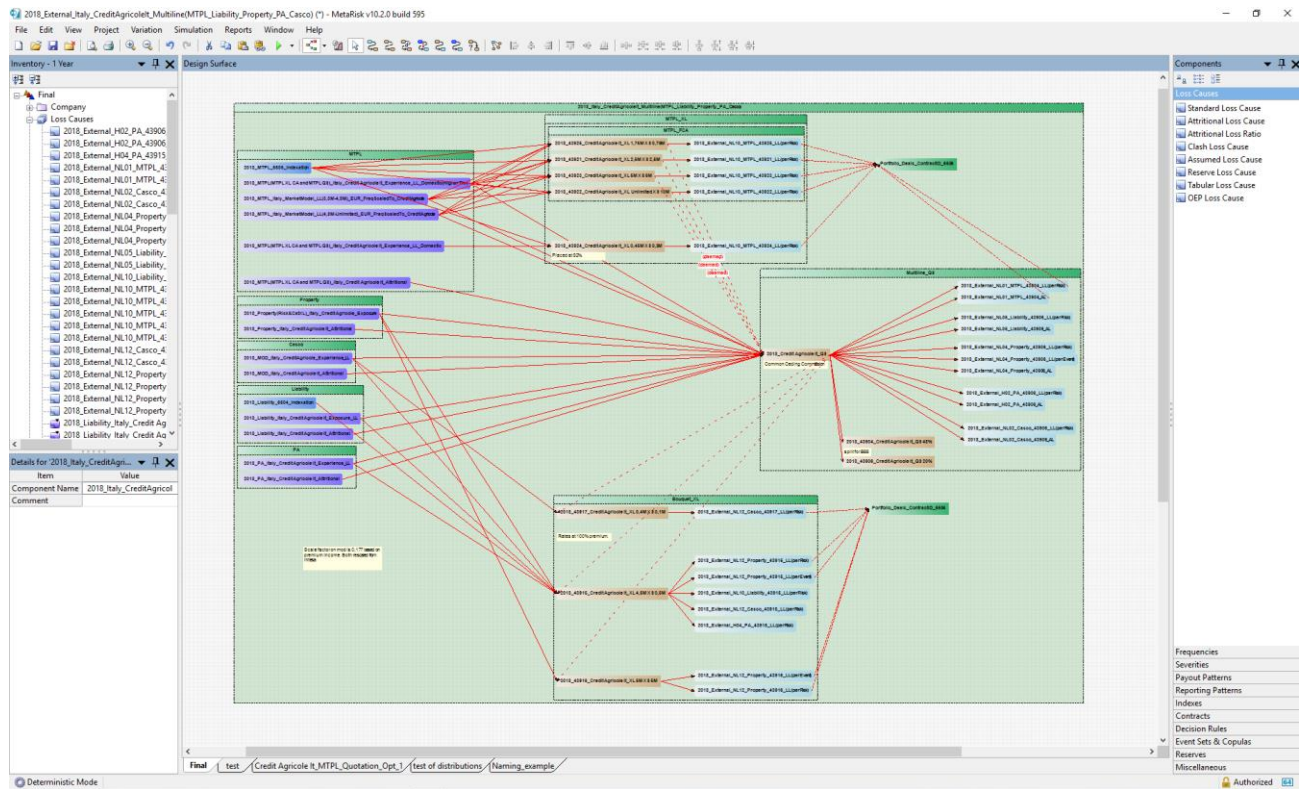
Capital Modelling

Aggregated MetaRisk Model

Active Reinsurance Contracts
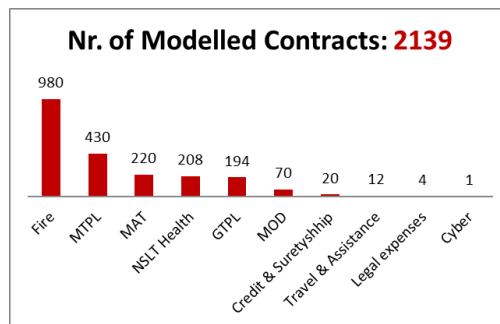
VIG Re Retrocession
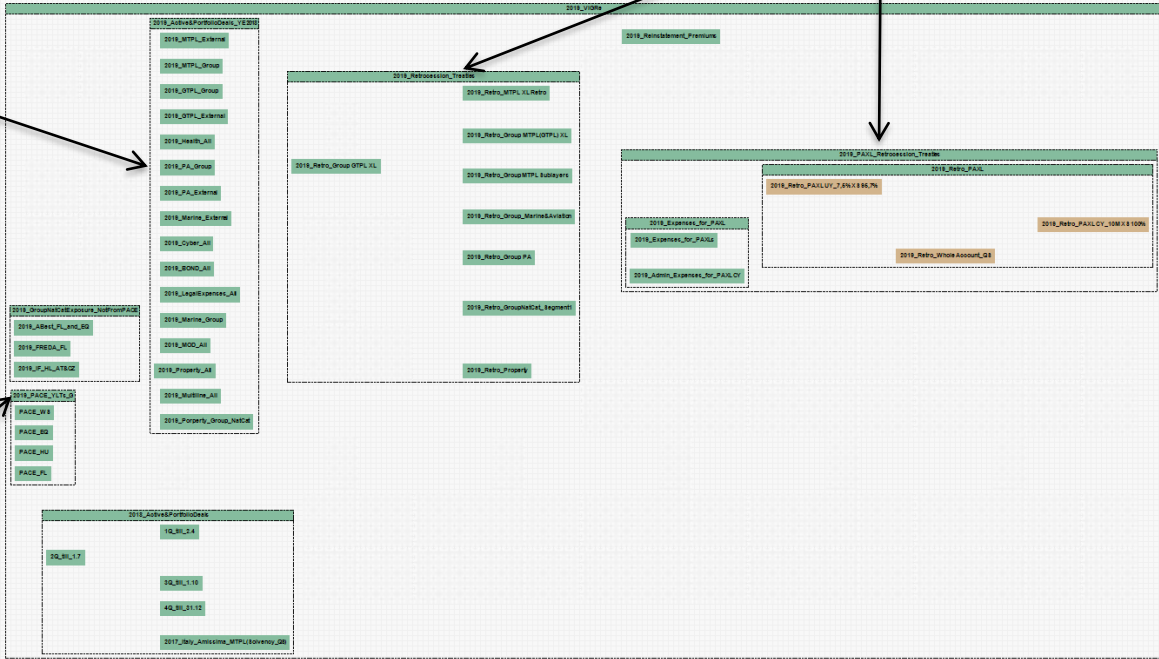
Correlated YLT

YE 2019 Model: Reinsurance Programs & Contracts

○ **P&C and NSLT Health RI Programs**

Number of RI programs	2017	2018	2019	2020
Non-Proportional Facultative:	24	53	163	206
Proportional Facultative:	12	57	108	114
Non-Proportional Obligatory:	435	511	650	778
Proportional Obligatory:	135	154	205	221
Total	606	775	1 126	1 319

○ Facultative – **capital add-on**

○ Obligatory - **modelled**

Nr. of Modelled Contracts: **2139**

Fire	980
MTPL	430
MAT	220
NSLT Health	208
GTPL	194
MOD	70
Credit & Suretyshhip	20
Travel & Assistance	12
Legal expenses	4
Cyber	1

Portfolio

Program

Contract

VIG Re
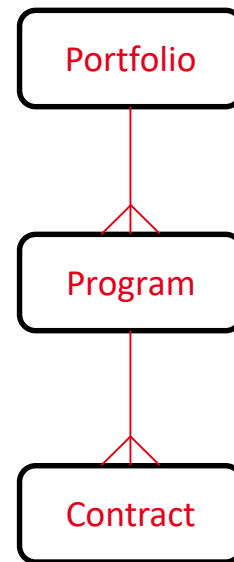
Parameterisation of MetaRisk Model

O each contract model consists of one, but usually more loss causes

O each loss cause needs to be parameterised (frequency, severity, payout patterns)

O for Nat Cat treaties we need external modelling

Number of Loss Causes	2017	2018	2019	2020
Large Loss Causes	551	1 105	1 567	1 885
Attritional/Aggregate Loss Causes	368	323	323	502
Nat Cat Loss Causes	85	472	472	728
Total Number of Loss Causes	1 004	1 900	2 362	3 115

O complex retrocession

VIG Re

YE19 Composition of SCR

🔴	Non-life underwriting risk	45%
🔴	Operational risk	13%
🔴	Market risk	14%
⚫	Counterparty default risk	17%
⚫	Life underwriting risk	5%
⚫	Health underwriting risk	6%

VIG Re

YE19 Standard vs. Partial Internal Model SCR

Underwriting Risk Gross SCR

- Standard Model
- Partial Internal Model

NSLT Health Premium and Reserve Risk   Non-Life Premium & Cat and Reserve Risk

Underwriting Risk Net SCR

- Standard Model
- Partial Internal Model

NSLT Health Premium and Reserve Risk   Non-Life Premium & Cat and Reserve Risk
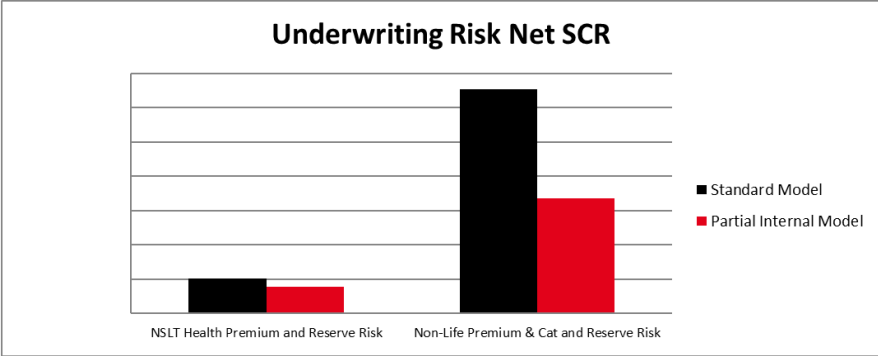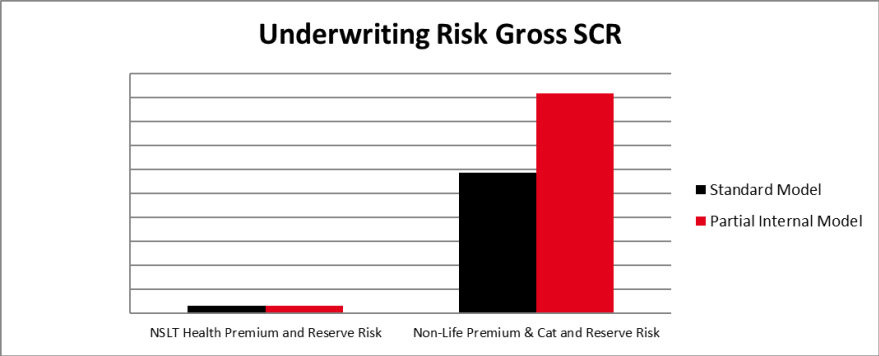
PIM Gross SCR/SF Gross SCR	156,3%
PIM Net SCR/SF Net SCR	52,0%

VIG Re

YE19 Underwriting Risks Composition
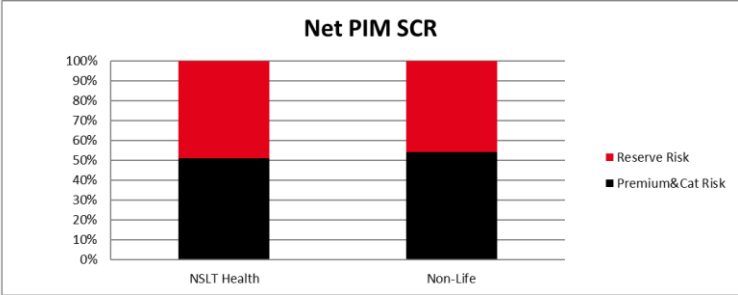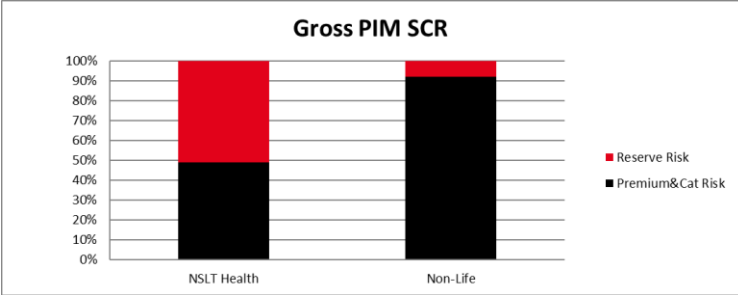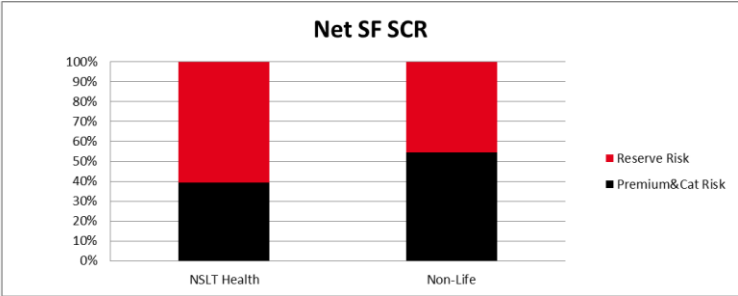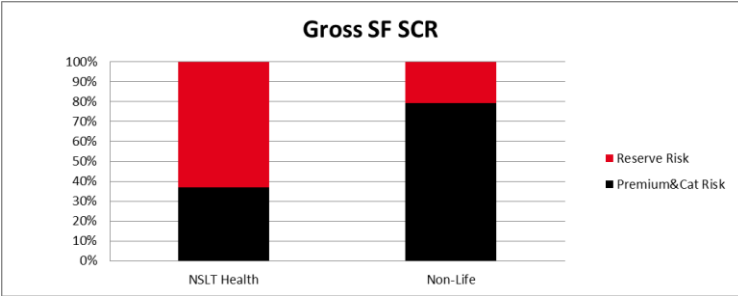
Thank You!

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