INNOVATIVE RESERVING PROCESS IN NON-LIFE INSURANCE: A CHALLENGE FOR RISK MANAGEMENT

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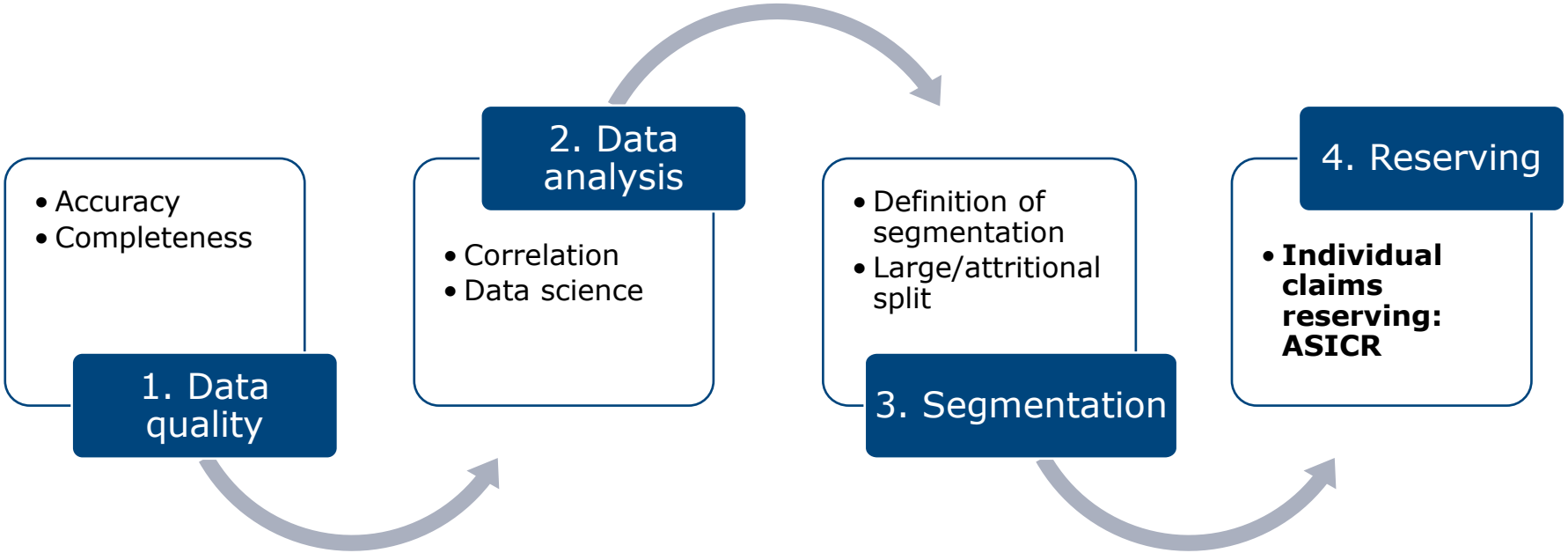
Innovative reserving process



Scope of the study

Scope:

- Reported But Not Settled (RBNS)
- Non-life french insurance company
- Two different lines of business: third party liability/motor and fire/housing
- Attritional/large loss segmentation by extreme value theory

Comparison methodologies:

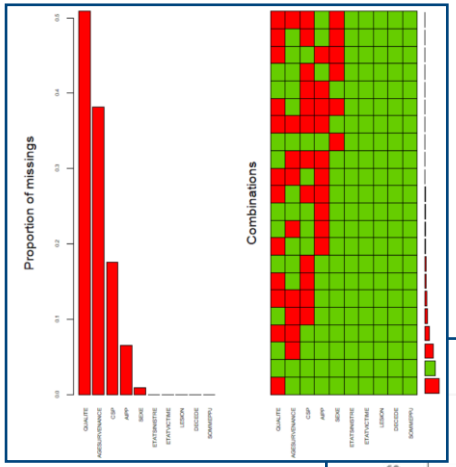
- Aggregated methodology: Chain Ladder with IBNR retreatment
- Individual reserving methodology, based on the article of Antonio and Plat
- Those methods were calibrated by expert

We used a dedicated individual reserving approach, ASICR, to perform the reserving of a non-life entity. Results are skewed, for confidentiality results. Further slides present quickly the process we used on the data before any reserving process.

1. Data quality

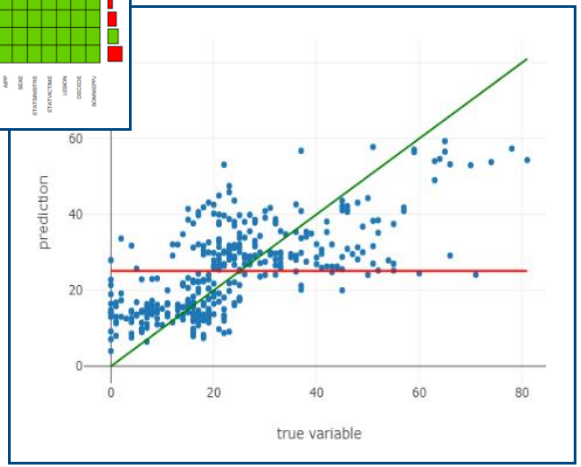
Data:

- Claims information (paid, incurred, delays, information about the cases, etc.)
- Contract's information (warranty, insured amount, description of insured part)
- Data quality has been checked



Completion:

- Completion methodologies have been performed when needed:
  - Deterministic completion (average/quantile)
  - Machine learning completion
- The completion performance are compared on a subset of initial database. It allows to choose the best methodology
- Otherwise, the variable is deleted

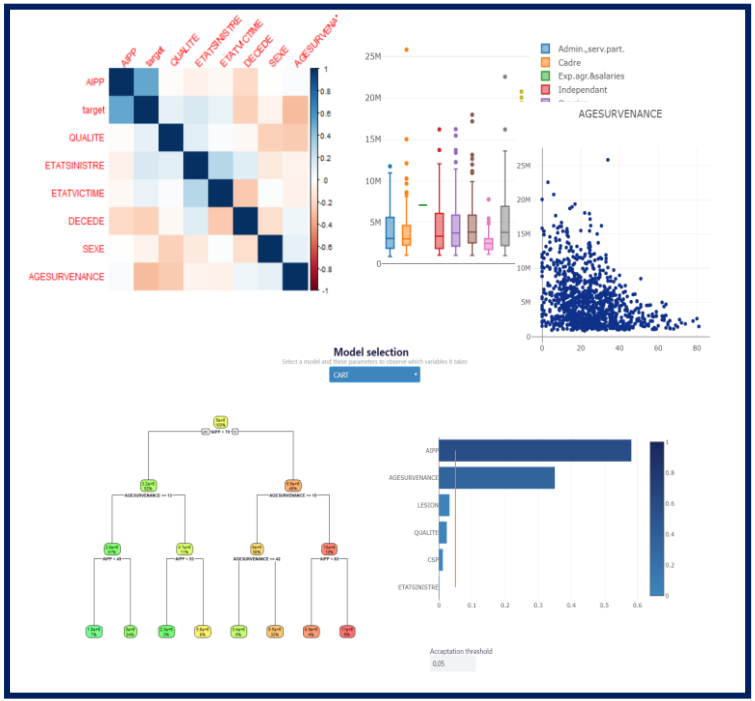


2. Data analysis

Simple to complex analysis on closed claims:

- Correlation study
- Graphics tools
- Data science algorithms: use explainable machine learning tools to find the variable's importance when predicting the ultimate cost:
  - CART
  - Random forest
  - Etc.

Goal: find which variables explain the cost of a case in order to segment properly the data for reserving.



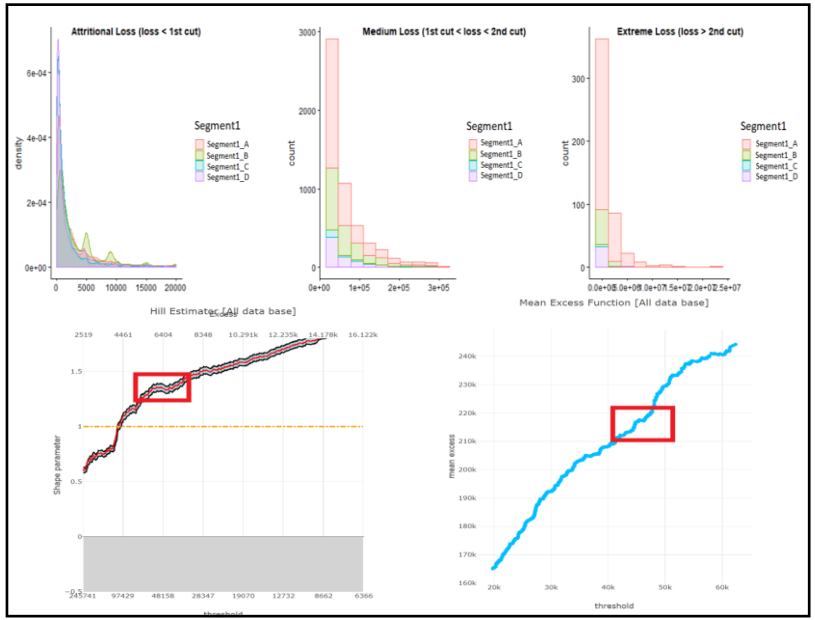
3. Segmentation

Determine an appropriate segmentation thanks to previous analyses:

- Correlation study
- Graphics tools
- Data science algorithms

Use extreme value theory to optimize the large loss threshold:

- QQ-plot exponential and Pickands estimator to check the attraction domain
- Hill estimator and mean-excess function help to find a range of convenient thresholds
- Adequation test to GEV law on bootstrapping subset could determine more precisely the optimal threshold in this range

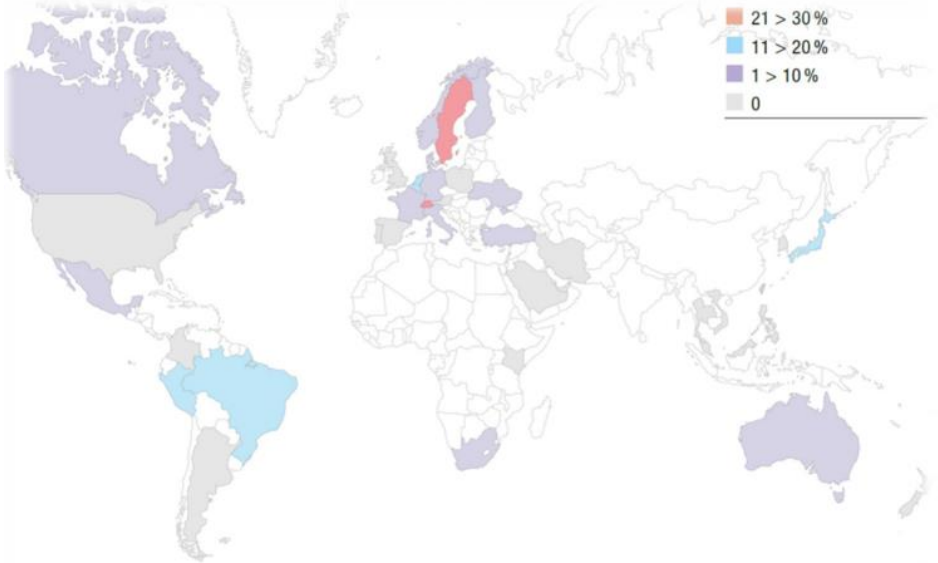


Goal: Determinate the appropriate segmentation to optimize the convergence of reserving model.

4. Individual reserving

A multi-purpose approach

- Assessment of large claims and their reinsurance cessions
- Analysis of areas with systematic over/under reserving estimation
- Optimisation of reserving guidelines



Growing interest in individual reserving methodologies

- ASTIN survey (2016): proportion of companies interested in individual reserving

State of the art of individual reserving methods

Stochastics methods

Article

- ICR : Antonio and Plat (2012).
- Project the life of each file (payment date, closing date, etc.) and the associated costs.
- Quantitative data only.

Master thesis

- [Orozco, 2016] Orozco, S. (2016). Approche de calcul individuel des provisions de la rc - automobile et application à la réassurance. ISFA.
- [Savarre et Payre, 2012] Savarre, S. et Payre, B. (2012). Charge ultime nette de réassurance en rc corporelle : 2 modèles stochastiques pour les flottes automobiles. CEA.

Estimation of an individual ultimate density

Data science methods

Article

- De Felice and Moriconi (2019).
- Use a succession of CART trees to determine the evolution of the claim (cost and condition).
- Qualitative and quantitative data.

Master thesis

- [Barbaste, 2017] Barbaste, M. (2017). Une méthode de provisionnement individuel par apprentissage automatique.
- [Gibaud, 2017] Gibaud, G. (2017). Revues des provisions dossier/dossier avec des méthodes de machine learning. ISFA.

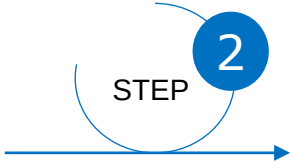
Estimation of an individual ultimate

The three steps of the ASICR methodology

Purpose

Split the claims into homogeneous development cohorts.

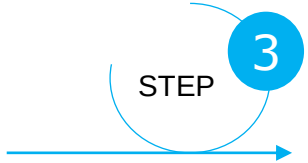
- Ensure a better use of available data to enhance the value of the information contained in the database.
- Use the power of data science for the reserving process.
- Obtain homogeneous and interpretable cohorts.



Purpose

Develop each claim individually.

- Make separate projections for each cohort.
- Calculate a distance between the different claims.
- Use the distance to obtain individual future development.



Purpose

Introduce a measure of model deviation.

- Get multiple estimations for the same claim using a bootstrap approach.

ASICR methodology is calibrated on closed claims to predict the open ones.

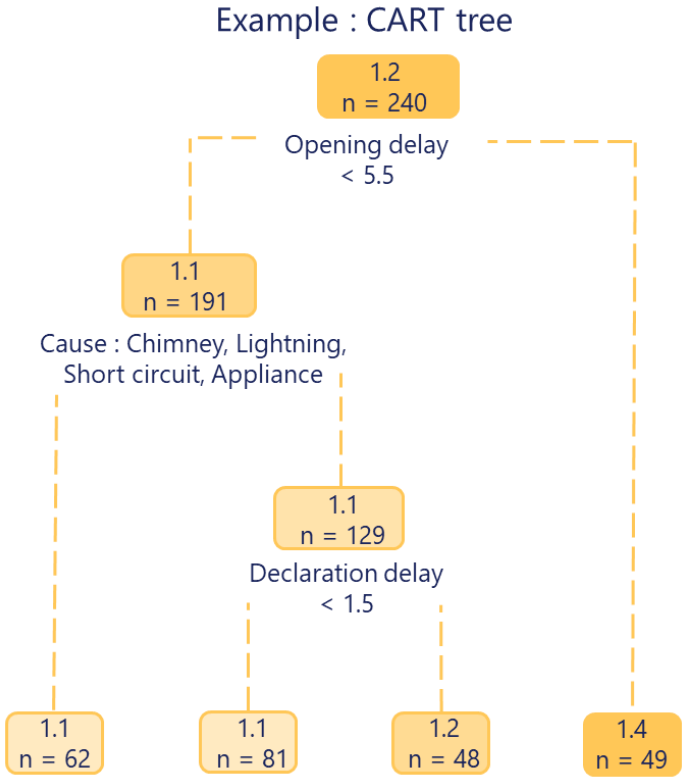
Step 1: Segment the claims into homogeneous cohorts

STEP 1

Purpose of the approach:
- Get an interpretable segmentation.
- Enhance the information contained in the insurance database.
- Adapt the segmentation to the quality and precision of the data.

Description of the step:
- The claims are split in homogeneous cohorts with a CART tree.
- The CART algorithm is used as a segmentation tool, not as its predicted way.
- The target variable is the claim's duration.

Source:
- [Breiman et al., 1999] Breiman, L., Friedman, J., Stone, C. et Olshen, R. (1999). Classification and regression trees. CRC press.



Step 1: Segment the claims into homogeneous cohorts

Focus on the first step

Unsupervised learning algorithms have been tested, but provide poor results:

- K-means clustering
- Hierarchical classification
- PCA

Supervised learning algorithms need a predicted variable, but the actuary doesn't know a priori the best segmentation of the claims. The predicted variable should segment claims into homogeneous development:

- Amounts will not be used, **to avoid overfitting and deal with different history depth.**

- **Duration** could be a good candidate: simple to calculate, known for closed claims and linked to claim's development.

Step 2: Develop each claim individually

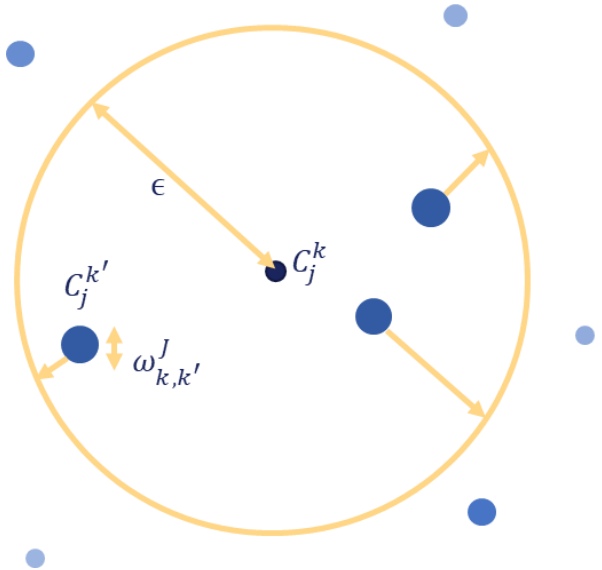
STEP 2

Purpose of the approach:
- Obtain individual future development from historical development.
- Consider the similarity of claims costs between several files.

Description of the step:
- A methodology based on link ratio will be used to get an individual development of the incurred/paid of each claim.
- The future development of a claim is obtained by a weighted average of known development within the same cohort.
- The weights are based on the closeness of the claim's incurred to each other.

Source:
- [Vu, 2015] Vu, D. V. (2015). Modèle de provisionnement des sinistres graves et son allocation économique aux différentes succursales d'axa corporate solutions. ENSAE.

Scheme: link ratio



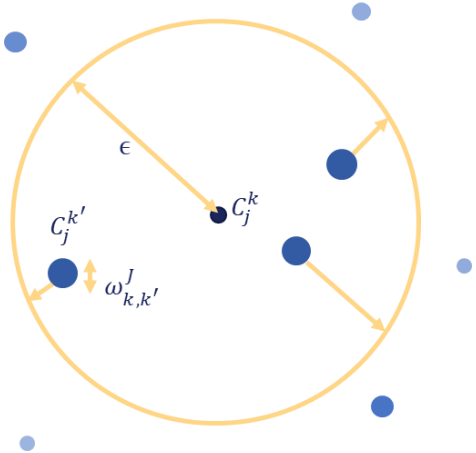
Step 2: Develop each claim individually

Focus on link ratio

The weight is obtained using a quadratic distance between two claim's historical developments:

$$\omega_{k,k'} = \left(\max \left\{ \tilde{\epsilon}, \sqrt{\sum_{j=1}^{n-S(k)+1} (\hat{C}_j^{k'} - C_j^k)^2} \right\} \right)^{-\beta} \quad k' \in \mathcal{K}(k)$$

with $\tilde{\epsilon} = \sqrt{(n - S(k) + 1) * \epsilon^2}, \epsilon > 0.$



These weights are controlled by two parameters:

- β accentuates the proximity of each claim to others.
- ε controls the maximum weight, to prevent overweighting caused by one file and losing the information of the others.

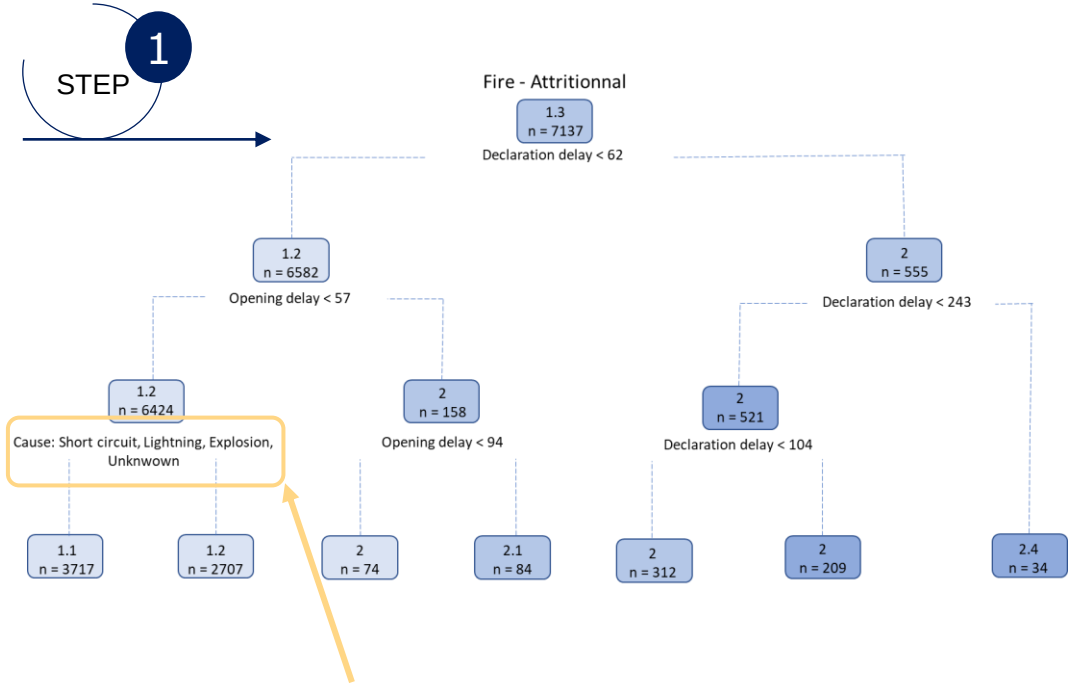
Step 3: Introduce a measure of model deviation

STEP 3

Purpose of the approach:
- Get an empirical distribution of the claim ultimate amount.

Description of the step:
- The volatility of the valuation is estimated using a bootstrap approach.
- The calculation of the link ratio is carried out on a randomly selected sample of the cohort.
- The process is repeated enough time to converge.

Results house/fire: attritional



Variables used by claim's managers play a role in segmentation.

Classification of open cases

	A	B	C	D	E	F	G	TOTAL
2006	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	1	1
2008	0	1	0	0	0	0	0	1
2009	1	6	2	1	0	0	0	10
2010	1	12	0	2	0	0	0	15
2011	1	5	0	1	1	0	1	9
2012	0	5	0	0	0	1	0	6
2013	0	6	0	0	0	0	0	6
2014	2	9	0	0	1	1	0	13
2015	3	12	0	0	0	0	0	15
2016	10	16	0	0	0	0	1	27
2017	23	34	1	3	2	3	1	67
2018	114	166	1	2	10	11	4	308
2019	292	483	1	4	33	17	2	832
TOTAL	447	755	5	13	47	33	10	1310

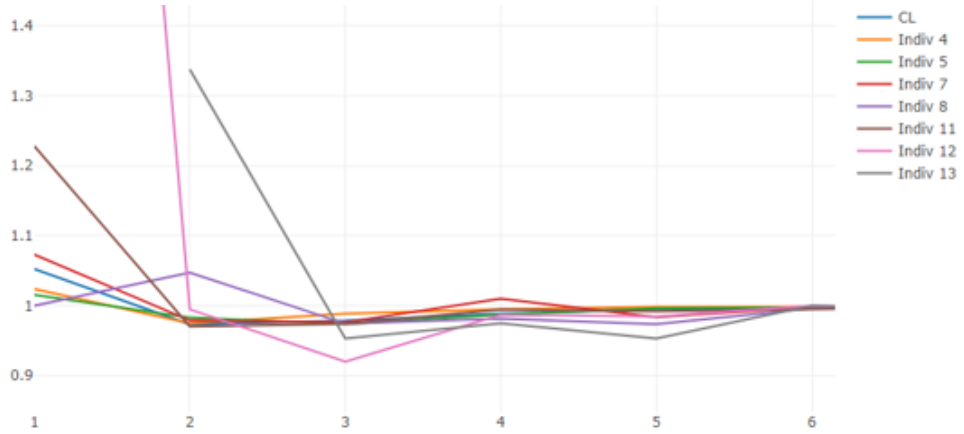
The cases still open are more present (in proportion) than the cases closed in the groups with a higher duration.

Results house/fire: attritional

STEP 2

- Some cohorts present very large initial coefficients.
- Developments stabilize quickly.
- Link ratio parameters are stable, showing homogeneity across cohorts.

Development by group



Link ratio parameters

	A	B	C	D	E	F	G
espilon	199,67	200,00	201,94	200,00	200,01	199,83	200,00
beta	0,96000	1,00000	1,10000	1,00000	0,99900	0,99900	1,00000

Results house/fire: attritional

Accounting overview

	Paid	Outstanding
2006	1 386 935	- 0
2007	1 249 564	191
2008	1 306 095	0
2009	1 218 471	5 957
2010	1 143 233	9 257
2011	1 305 248	1 704
2012	1 231 800	3 243
2013	1 525 575	2 861
2014	1 305 153	8 847
2015	1 516 652	1 060
2016	1 830 590	18 555
2017	1 494 109	55 701
2018	1 744 887	106 017
2019	1 209 514	559 411
TOTAL	19 467 826	772 803

Reserves (without IBNR)

	Chain Ladder	ICR	ASICR
2006	-	- 0	-
2007	191	- 0	191
2008	0	0	0
2009	5 956	- 0	6 728
2010	9 193	0	10 029
2011	1 321	0	3 239
2012	2 433	0	4 014
2013	1 363	3	2 862
2014	4 067	36	9 607
2015	- 14 576	955	1 808
2016	- 153 186	1 868	18 241
2017	- 147 097	4 608	53 323
2018	- 16 714	40 222	93 167
2019	528 594	490 011	562 191
TOTAL	500 972	537 703	765 401

Standard error

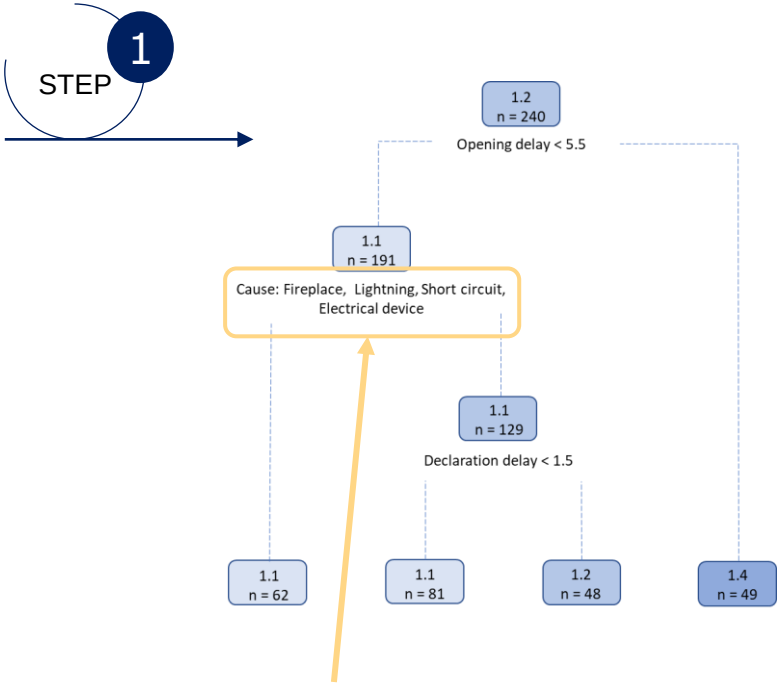
	Chain Ladder	ICR	ASICR
2006	-	0	-
2007	-	0	0
2008	-	0	0
2009	0	0	0
2010	155	0	0
2011	452	0	6
2012	736	0	1
2013	1 262	14	9
2014	3 345	73	69
2015	17 877	2 578	135
2016	24 829	4 614	227
2017	32 753	6 119	6 557
2018	40 998	13 707	8 961
2019	51 531	49 678	153 556
TOTAL	84 130	52 261	182 442

VaR 75%

	Chain Ladder	ICR	ASICR
2006	-	- 0	-
2007	191	- 0	191
2008	0	0	0
2009	5 956	- 0	6 728
2010	9 088	0	10 029
2011	1 016	0	3 239
2012	1 937	0	4 014
2013	512	3	2 862
2014	1 813	36	9 608
2015	- 26 576	955	1 808
2016	- 169 846	1 868	18 242
2017	- 169 005	4 614	53 369
2018	- 44 097	40 403	93 451
2019	495 030	498 457	590 877
TOTAL	444 330	538 541	769 360

- Reserves present disparities in the more recent years.
- The individual methodologies offer a lower standard deviation assessment than the aggregate methodology, except for the ASICR in 2019.
- This significant increase in volatility in 2019 can be explained by highly volatile individual coefficients for the first development, due to the opening case reserves.

Results house/fire: large



Segmentation differs from attritional one.

Classification of open cases

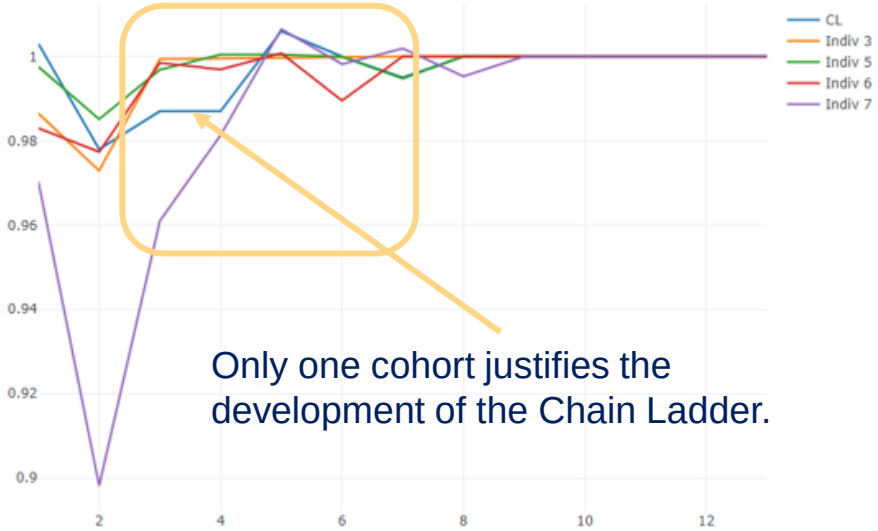
	A	B	C	D	TOTAL
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	0	0	0
2009	0	0	0	1	1
2010	1	1	0	0	2
2011	0	1	1	1	3
2012	0	1	0	0	1
2013	0	4	0	0	4
2014	1	5	2	1	9
2015	1	2	0	0	3
2016	4	4	1	1	10
2017	7	5	4	1	17
2018	10	7	6	1	24
2019	15	24	13	3	55
TOTAL	39	54	27	9	129

Once again, the proportions of open claims are more important in the higher duration cohorts.

Results house/fire: large

STEP 2

Development by group



Only one cohort justifies the development of the Chain Ladder.

Link ratio parameters

	A	B	C	D
espilon	200,00	200,00	1 160,00	200,00
beta	1	1,00000	0,00004	1,00000

This link ratio tends towards an equal weighting of claim.

Results house/fire: large

Accounting overview

	Paid	Outstanding
2006	1 493 269	0
2007	755 917	-
2008	1 594 248	- 0
2009	1 686 031	16 134
2010	2 195 292	42 278
2011	1 828 218	2 825
2012	1 986 233	0
2013	2 653 114	100 308
2014	1 707 523	74 346
2015	2 213 797	93 638
2016	2 593 261	100 518
2017	2 602 936	173 554
2018	1 678 778	362 329
2019	1 153 257	1 780 107
TOTAL	26 141 875	2 746 038

Reserves (without IBNR)

	Chain Ladder	ICR	ASICR
2006	-	0	-
2007	-	0	-
2008	- -	0	-
2009	16 134	0	12 936
2010	42 300	230	30 294
2011	2 323	33 615 -	6 530
2012	- 789	9 847 -	1 322
2013	84 311	30 501	88 507
2014	64 145	62 149	53 641
2015	93 637	23 193	88 480
2016	34 275	66 174	79 534
2017	71 310	105 709	146 534
2018	265 901	246 121	329 543
2019	1 649 799	1 427 154	1 717 663
TOTAL	2 386 921	2 004 693	2 539 280

Standard error

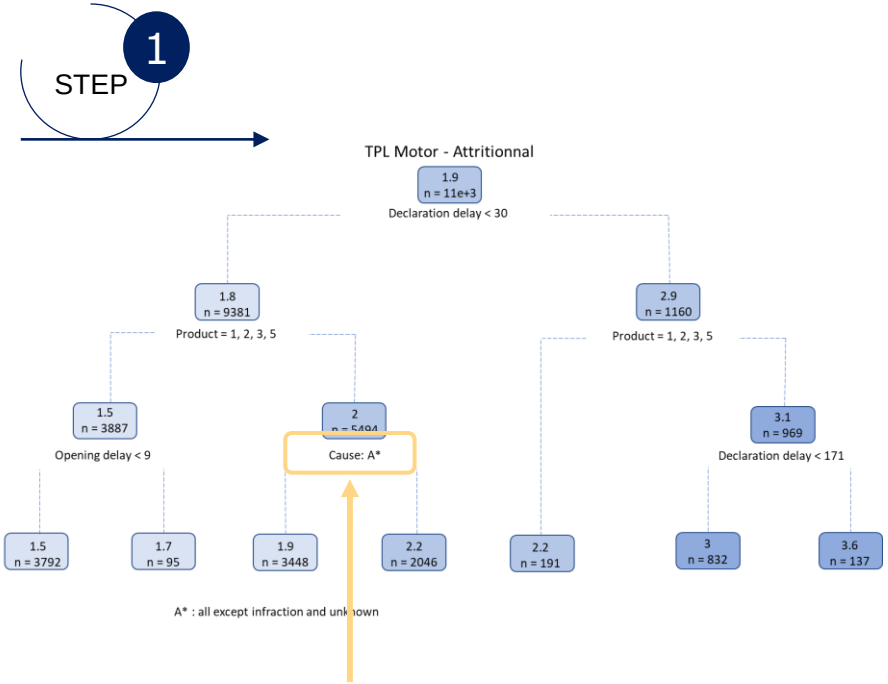
	Chain Ladder	ICR	ASICR
2006	-	0	-
2007	-	0	-
2008	-	0	-
2009	-	0	736
2010	35	161	3 658
2011	2 237	52 868	2 579
2012	1 733	26 633	372
2013	64 300	49 378	1 960
2014	47 682	66 841	6 111
2015	71 756	36 910	863
2016	108 980	59 850	2 753
2017	129 530	71 324	4 848
2018	110 487	88 527	3 700
2019	198 134	205 148	6 987
TOTAL	341 288	264 635	12 668

VaR 75%

	Chain Ladder	ICR	ASICR
2006	-	0	-
2007	-	0	-
2008	- -	0	-
2009	16 134	0	12 934
2010	42 276	230	30 365
2011	815	33 790 -	6 537
2012	- 1 957	9 827 -	1 322
2013	41 398	30 584	88 488
2014	32 379	62 957	53 677
2015	45 937	23 233	88 496
2016	- 37 878	66 717	79 426
2017	- 14 099	107 033	146 610
2018	194 031	252 656	330 212
2019	1 750 937	1 500 281	1 720 285
TOTAL	2 158 094	2 016 753	2 539 913

- Reserves are very close for each methodology.
- ASICR volatility estimators appear much lower. They are controlled by cohort segmentation and equal weighting on the most volatile group.

Results third party liability/motor: attritional



Variables used by claim's managers play a role in segmentation.

Classification of open cases

	A	B	C	D	E	F	G	TOTAL
2006	0	0	0	2	0	0	0	2
2007	0	0	0	1	0	1	0	2
2008	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	2	0	2
2010	0	0	0	0	0	0	1	1
2011	0	0	1	0	0	0	0	1
2012	0	0	1	2	0	0	0	3
2013	2	0	0	1	1	1	0	5
2014	1	0	0	3	0	1	1	6
2015	1	0	0	1	3	0	1	6
2016	4	2	0	1	6	1	0	14
2017	12	1	0	0	10	2	1	26
2018	57	8	2	7	23	2	1	100
2019	218	18	16	18	32	9	0	311
TOTAL	295	29	20	36	75	19	5	479

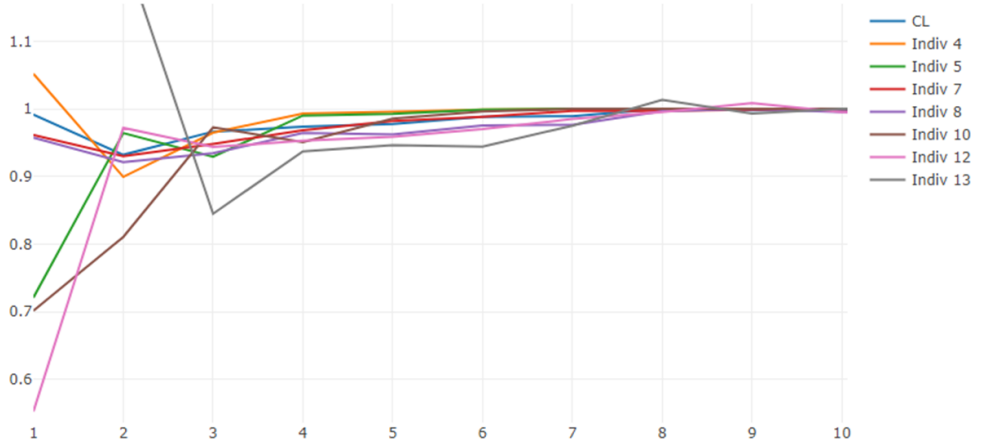
Once again, the proportion of open claims is more important in the higher duration cohorts.

Results third party liability/motor: attritional

STEP 2

- Some cohorts present very large initial coefficients.
- Developments stabilize slower than fire lob.
- Link ratio parameters are stable, showing homogeneity across cohorts.

Development by group



Link ratio parameters

	A	B	C	D	E	F	G
espilon	199,99	200,01	200,00	199,99	201,65	200,00	200,00
beta	1,00002	0,99000	1,00000	0,99000	1,00030	1,00000	1,00000

Results third party liability/motor: attritional

Accounting overview

	Paid	Outstanding
2006	5 690 802	33 087
2007	5 820 943	6 668
2008	5 560 685	2 454
2009	5 671 841	12 195
2010	5 163 551	44 847
2011	4 833 472	45 237
2012	5 133 092	51 527
2013	5 448 251	88 057
2014	5 412 134	137 138
2015	5 476 128	184 703
2016	5 531 220	407 263
2017	5 366 326	1 067 577
2018	4 341 725	2 438 338
2019	2 941 364	5 318 657
TOTAL	72 391 535	9 837 747

Reserves (without IBNR)

	Chain Ladder	ICR	ASICR
2006	33 087	0	33 078
2007	5 448	2 465	6 694
2008	2 458	1 879	2 454
2009	11 415	6 808	14 683
2010	40 134	3 472	30 972
2011	30 522	7 572	46 185
2012	36 251	17 744	75 603
2013	12 316	17 937	86 071
2014	- 4 608	15 136	137 188
2015	- 83 333	13 677	178 703
2016	- 23 949	31 386	396 205
2017	396 886	121 497	1 067 863
2018	1 308 066	698 495	2 407 935
2019	3 640 568	2 302 119	5 862 057
TOTAL	5 405 260	3 240 190	10 345 690

Standard error

	Chain Ladder	ICR	ASICR
2006	-	0	28
2007	212	3 193	58
2008	2 448	3 292	-
2009	74 538	6 491	285
2010	106 100	4 877	63
2011	175 306	7 940	83
2012	159 917	11 880	111
2013	74 481	13 569	196
2014	15 857	11 546	1 149
2015	112 122	10 680	2 049
2016	97 390	17 195	5 033
2017	404 657	31 913	1 723
2018	430 162	68 609	12 608
2019	659 122	111 240	782 995
TOTAL	1 065 007	138 956	829 435

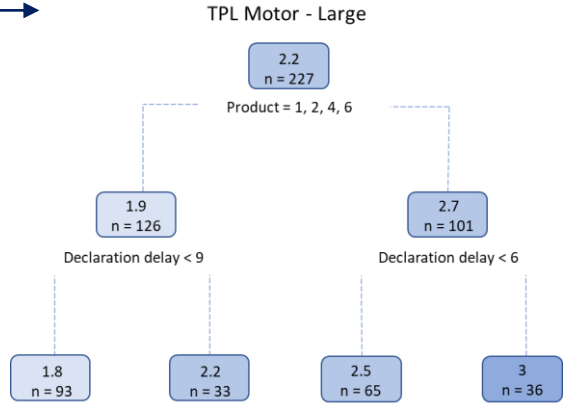
VaR 75%

	Chain Ladder	ICR	ASICR
2006	33 087	0	33 078
2007	5 305	4 618	6 694
2008	808	4 100	2 454
2009	- 38 587	11 186	14 682
2010	- 30 810	6 761	30 973
2011	- 85 872	12 928	46 185
2012	- 70 173	25 757	75 612
2013	- 37 639	27 090	86 072
2014	- 15 291	22 924	137 293
2015	- 158 332	20 881	178 777
2016	- 89 188	42 984	396 891
2017	133 832	143 022	1 066 460
2018	1 036 696	744 772	2 398 472
2019	3 815 163	2 377 149	4 891 294
TOTAL	4 687 689	3 333 914	10 317 830

- Reserves results are unstable, and methodologies do not converge to the same results. Only the ASICR methodology anticipates an increase of reserves.
- The individual methodologies offer a lower standard deviation assessment than the aggregate methodology, except for the ASICR in 2019.
- This significant increase of volatility in 2019 can be explained by highly volatile individual coefficients for the first development, due to the opening case reserves.

Results third party liability/motor: large

STEP 1



Classification of open cases

	A	B	C	D	TOTAL
2006	0	0	4	3	7
2007	0	0	0	2	2
2008	0	0	2	5	7
2009	0	1	7	2	10
2010	1	0	2	5	8
2011	0	1	6	12	19
2012	1	1	6	7	15
2013	8	4	10	4	26
2014	13	6	4	2	25
2015	11	8	7	6	32
2016	20	9	5	6	40
2017	42	9	7	2	60
2018	55	18	4	0	77
2019	51	9	3	1	64
TOTAL	202	66	67	57	392

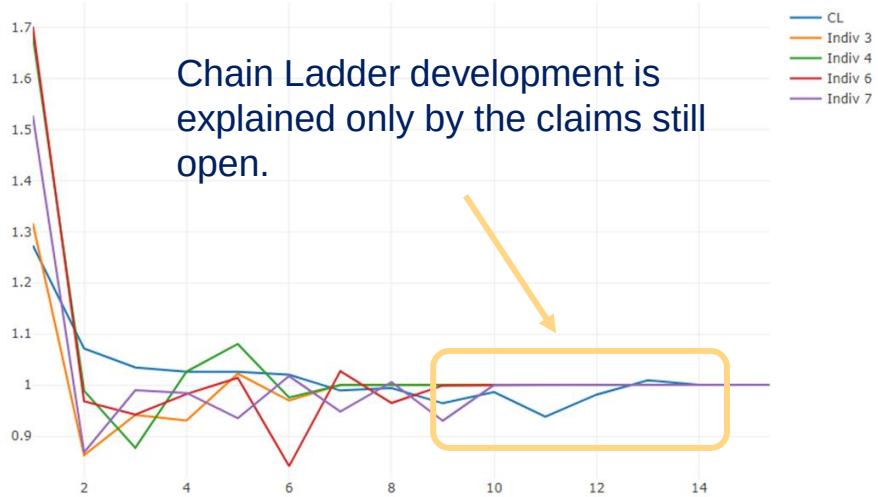
Very few information are available for large claims segmentation, despite the data completion.
For example, all causes are set to “Unknown” in the database.

There is still a lot of open cases after 13 years of development.

Results third party liability/motor: large

STEP 2

Development by group



Chain Ladder development is explained only by the claims still open.

Link ratio parameters

	A	B	C	D
espilon	199,95	200,00	2 600,53	199,97
beta	0,99000	1,00000	2,06000	1,01000

This link ratio tends towards an equal weighting of claim in this group.

Results third party liability/motor: large

Accounting overview

	Paid	Outstanding
2006	2 933 246	914 641
2007	2 373 895	343 613
2008	2 156 347	556 130
2009	4 281 108	6 228 259
2010	3 655 341	1 633 436
2011	3 524 569	2 569 295
2012	2 533 296	2 625 465
2013	3 434 499	2 740 795
2014	2 975 984	3 534 511
2015	2 990 510	7 000 121
2016	3 095 939	6 642 657
2017	2 769 712	4 937 853
2018	1 321 726	6 866 453
2019	357 397	9 632 191
TOTAL	38 403 567	56 225 419

Reserves (without IBNR)

	Chain Ladder	ICR	ASICR
2006	914 641	- 0	920 211
2007	251 408	4 611	343 613
2008	488 683	25 549	556 130
2009	5 772 547	60 331	6 228 259
2010	1 367 870	73 582	1 633 436
2011	2 348 790	238 416	2 569 220
2012	2 343 527	239 936	2 587 033
2013	2 408 062	660 414	2 408 951
2014	3 157 350	654 920	3 536 009
2015	6 610 910	1 032 350	6 878 324
2016	6 350 850	1 491 997	6 724 982
2017	5 038 932	2 519 090	5 106 720
2018	7 540 997	3 486 455	7 281 952
2019	12 805 585	3 509 925	11 359 203
TOTAL	57 400 150	13 997 576	58 134 044

Standard error

	Chain Ladder	ICR	ASICR
2006	-	0	0
2007	35 317	7 065	0
2008	54 139	37 556	0
2009	196 643	150 940	0
2010	409 798	111 720	0
2011	486 064	166 171	35
2012	521 073	191 279	5 316
2013	606 179	283 103	7 701
2014	699 799	273 624	3 678
2015	1 041 940	324 930	36 301
2016	1 087 110	393 601	84 738
2017	1 152 465	483 246	69 775
2018	1 361 134	546 282	177 077
2019	2 067 339	535 179	518 780
TOTAL	4 630 690	1 154 962	556 325

VaR 75%

	Chain Ladder	ICR	ASICR
2006	2 933 246	-	920 211
2007	227 752	9 377	343 613
2008	452 671	50 881	556 130
2009	5 896 652	162 138	6 228 259
2010	1 116 943	148 936	1 633 436
2011	2 104 145	350 496	2 569 205
2012	2 358 917	368 952	2 590 815
2013	2 156 324	851 365	2 404 663
2014	3 115 672	839 476	3 533 191
2015	7 198 833	1 251 512	6 918 586
2016	6 940 393	1 757 477	6 688 805
2017	5 564 626	2 845 034	5 139 151
2018	8 351 490	3 854 916	7 236 152
2019	14 082 500	3 870 898	11 446 534
TOTAL	60 106 503	14 776 586	58 002 716

- Reserves are very close except for the ICR methodology, which is based on paid development and do not consider the case reserves.
- ASICR does not challenge the reserves for the older years.
- The 75% VaR reverses the order observed in average for Chain Ladder and ASICR, because of reduced volatility in the model.

Conclusion

ASICR methodology presents interesting conclusions:

- It presents results in line with other approved methodologies.
- It is adapted for multiple lines of businesses with different risk nature, particularly for large and long-term risk.

This methodology could be improved by:

- Evaluating the volatility introduced by segmentation.
- Using random forest algorithm to perform a lot of possible segmentation (some tests have been performed).
- Estimating the IBNR part of reserves by using the group created.

The methodology could be used for:

- IFRS17: risk adjustment could be defined at a lower granularity.

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Thank you for your attention.

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