Scenario Testing for Flatrated Fleets during the yearly price adjustment process

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Virtual IAA Colloquium (ASTIN), June 22nd, 2022 (Orlando)

About the speaker

ASTIN Non-Life Insurance

Name

- **Michael Klamser (Senior Actuary)**
- **1986-1994:** Studies in Econometrics (TU Karlsruhe)
- **1994:** Entering Allianz Insurance Company (Actuarial Department)
- **1994-2000:** Actuarial Department (Motor business – retail and commercial)
- **2000-today:** Commercial Motor Department
- **Since 1999:** Actuary at the German Association of Actuaries (DAV)

Allianz Group (Non-Life) - 2019

- **Turnover:** 59,2 bln. €,
- **Operating profit:** 5,0 bln €
- **Loss ratio:** 68,0 % (German fleet market/before run-off: 92,0 %)
- **Combined Ratio:** 95,5 % (German fleet market/after run-off: 102,0 %)

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Disclaimer:

All the figures/KPIs in the following slides which are connected with the Allianz fleet portfolio, do not correspond with the figures in reality.

Still, the deductions done in the presentation respectively during the session are the same as the ones based on the real figures.

Glossary:

TP: (actuarially correct) technical premium

CP: commercial premium (before any adjustments)

AP: actual respectively offered premium

LR: loss-ratio (**not** lapse-ratio!!)

MRP: Manual Renewal-Probability

Overview

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1. The flatrate model (cred.) / Bonus-Malus
2. The MRP- / Lapse-Ratio-Model:
   The Build-up of the database
3. Modelling the MRP
4. Modelling the Lapse Ratio
5. The lapse ratio model: 9-field-analysis / scenario-analysis

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1. The flatrate model (cred.) / Bonus-Malus

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Basics:

- Introduced in 2013;
- An essential model to increase the profitability of the overall flatrate portfolio;
- As of end of 2020: approx. 1.000 fleets with an AP of 70 Mio.;
- Includes an **optional** premium adjustment-clause (➔ to compensate for the loss in GWP due to automatic renewal).
- Enables a new calculation of the fleet if certain criteria are met.

1. The flatrate model (cred.) / Bonus-Malus

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<u>Rules for automatic renewal (dependent of 8 LR-classes):</u>

- LR<45 % ➔ -15 % discount,
- LR in (45%,55%) ➔ -10 % discount,
- ….
- LR in (85%,95%) ➔ +15 % loading,
- LR > 95 % ➔ new calculation on the basis of credibility.

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2. The MRP- / Lapse-Ratio-Model: The Build-up of the database

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Whence comes the need to model the probability for manual renewal?

(1) Direct impact on the top- and bottom-line through…

- shunning the premium adjustment and/or
- avoiding the lapse of a customer,
- Portfolio-cleaning.

(2) To answer the question:

- What’s the impact on the lapses?

(3) To estimate separately the rate change because of manual renewal.

2. The MRP- / Lapse-Ratio-Model: The Build-up of the database

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Variables to be examined conc. significance of the risk variables for the …

❖ **MRP-Model**

- fleets flagged for ptf-cleaning,
- LR (grouped) as of end of July,
- individual premium adjustment (dBAK),
- installment,
- distribution channel,
- fleet size….

❖ **Lapse-Ratio-Model**

- customer tenure,
- rate change,
- fleet mix,
- distribution channel,
- fleets flagged for ptf-cleaning,
- **fleets flagged for MR (!)**

Overview

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3. Modelling the MRP

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Selection Procedure (for single and 2x2-effects):

- Model assumptions:

  $alpha$ ➔ maximum significance level (5 %),

  p_i ➔ lapse ratio for fleet i,

  $g(p_i) = \log(p_i / (1-p_i))$ ➔ Link-function, $p = \frac{e^{\mu}}{1+e^{\mu}}$

  distribution: bin(1,p_i) .

- Out of the pool of m possibly significant predictors, the most significant factor is selected.
- 2nd step: the 2nd most significant factor is selected (and so forth)…
- Stop criterion: The sum of all single $alpha^*$ surpasses the maximum significance level $alpha$.

3. Modelling the MRP

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Old result (through Cluster Method by Ward):

Cluster	loss-ratio (as of 31st of July)	MRP
1	from 170 %	93,0%
2	120 % to 170 %	63,0%
3	60 % to 120 %	45,0%
4	up to 60 %	25,0%

Shortcomings:

- Dependency of the MRP merely on one predictor.
- Though organic behaviour was achieved,
  the result is not too helpful (see rules for automatic renewal above).

3. Modelling the MRP

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New Approach through GLM:

Selected Variables:

predictor	1st degree freedom	F-statistics	alpha*
portfolio cleaning (flagged)	1	19,02	<.0001
LR as of 31/7 (grouped)	4	22,38	<.0001
fleet size	2	3,77	0,0233

The shortcomings of Ward were all taken care of.

Parameter Estimator-Statistic:

predictor	level	estimate (lin. pred.)	Standard-error	alpha (Chi-square)
Intercept		3,5133	0,4307	<.0001
ptf cleaning (flagged)	not flagged	-0,9625	0,3231	<.0001
	flagged	0	0	.
LR as of 31/7 (grouped)	<45%	-2,2192	0,3177	<.0001
	45-65%	-1,712	0,31	<.0001
	65-95%	-1,3232	0,3253	<.0001
	95-125%	-0,9518	0,3819	0,0007
	above 125%	0	0	.
fleetsize	30-60	-0,2097	0,2136	0,0088
	60-100	-0,1399	0,2104	0,0199
	above 100	0	0	.

3. Modelling the MRP

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Validation (20% of sample)

Flagged for ptf-cleaning:

ptf cleaning	# fleets (validation sample)	MRP (observed)	MRP (estimated)
not flagged	223	41,1%	41,4%
flagged	26	79,8%	94,1%

LR as of 31st of July:

LR as of 31/7 (grouped)	# fleets (validation sample)	MRP (observed)	MRP (estimated)
<45%	83	21,3%	26,1%
45-65%	79	42,0%	38,9%
65-95%	28	50,6%	57,5%
95-125%	21	63,0%	68,0%
above 125%	38	90,4%	90,0%

Fleetsize:

fleet size	# fleets (validation sample)	MRP (observed)	MRP (estimated)
30-60	89	32,1%	39,5%
60-100	100	47,5%	47,0%
above 100	60	60,8%	57,9%

Overview

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5. The lapse ratio model: 9-field-analysis / scenario-analysis

4. Modelling the Lapse-Ratio

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Challenges

- Challenge 1: fleets **manually** renewed by the Underwriters (see chapter 3).

- Challenge 2: adequate grouping of some variables (e. g. fleet mix, industry).

- Challenge 3: prediction of the finally offered premium for next year (lag of 6 months).

4. Modelling the Lapse-Ratio

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Challenge 2: adequate grouping of fleet mix

Prerequisite:

All flatrated fleets are taken into account.

Step 1: Determination of vehicle groups (cars,trucks,trailers,misc.)

Step 2: Quantile-analysis to form subgroups for each vehicle groups

e. g.

- for cars: share up to 25%/50%/75%/100%,
- for trucks: share up to 20%/40%/100%

- both in relation to the total number of vehicles per fleet-

cars	Max	90%-Q.	75%-Q.	Median	25%-Q.	10%-Q.	Min.
	100,0%	100,0%	87,7%	47,9%	13,3%	3,4%	0,0%

4. Modelling the Lapse-Ratio

<u>Challenge 2:</u> adequate grouping of fleet mix

<u>Step 3:</u> Application of Cluster-Analysis (procedure by **<u>Ward's minimum-variance method</u>**)

- <u>Response variable:</u> lapse-ratio;
- Dividing the original sample in 80/20%-layered samples;
- Defining the stop-criterion.

cluster	parent	_HEIGHT_	_SPRSQ_	_RMSSTD_	_RSQ_	Lapse-Ratio
			....			
CL9	CL6	0,0030	0,0030	0,0161	0,9860	19,3%
OB26	CL6	0,0000	0,0000	0,0000	1,0000	26,7%
CL11	CL5	0,0018	0,0018	0,0034	0,9915	9,7%
CL17	CL5	0,0004	0,0004	0,0023	0,9990	8,3%
CL5	CL4	0,0221	0,0221	0,0085	0,9256	5,4%
CL10	CL4	0,0025	0,0025	0,0075	0,9890	12,7%
CL7	CL3	0,0119	0,0119	0,0124	0,9646	20,8%
CL6	CL3	0,0169	0,0169	0,0334	0,9477	7,9%
CL4	CL2	0,0364	0,0364	0,0126	0,8892	0,8%
CL8	CL2	0,0094	0,0094	0,0118	0,9766	6,9%
CL2	CL1	0,2979	0,2979	0,0279	0,4869	14,0%
CL3	CL1	0,1045	0,1045	0,0343	0,7848	8,3%

- **<u>HEIGHT:</u>** identifies the between-cluster distance measure
- **<u>SPRSQ:</u>** squared semipartial correlation for joining 2 clusters
- **<u>RMSSTD:</u>** Root mean squared standard deviation
- **<u>RSQ:</u>** R-square statistic for a given level of the hierarchy

4. Modelling the Lapse-Ratio

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Challenge 2: adequate grouping of fleet mix - 3

Step 4: Validation of the test sample

Cluster (fleet mix)	# fleets (test)	# fleets (validation)	lapse-ratio (test)	lapse-ratio (validation)
1	201	42	0,8%	1,9%
2	1.208	282	5,9%	5,4%
3	400	117	10,1%	9,2%
4	55	15	18,8%	13,8%
Total	**1.865**	**455**	**6,6%**	**6,1%**

Step 5: Characterization of the Clusters

Cluster (fleet mix)	vehicle group	share with regard to fleet mix	#fleets	lapse-ratio
1	-----------------			
2	cars	75 % and higher	1600	5,9%
	trailers	lowest quantile group		
	Trucks/tractors			
	misc.			
3	-----------------			
4	-----------------			

4. Modelling the Lapse-Ratio

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Challenge 3: prediction of the finally offered premium for next year - 1

Predicament:

An eventual overall premium-adjustment in addition to the automatic renewal has to be decided no later than in August (due to technical restraints).

➔ Prediction of the loss-ratio as of 31st of December on the basis of 31st of July is of paramount importance.

Possible solution (see also **SAS/STAT – PROC GENMOD, examples**) :

Application of the Generalized Linear Model with

- the **multinomial distribution** and ➔ See 2nd presentation „The predictive power of the multinomial distribution – 2 practical examples"
- the **cumulative logit function**.

4. Modelling the Lapse-Ratio

Result (for single effects):

Model analysis:

predictor	1st degree freedom	F-statistics	alpha*
---	---		
fleet mix	2	16,45	<.0001
distribution channel	1	79,51	<.0001
rate change	2	10,47	<.0001
portfolio cleaning (flagged)	1	21,62	<.0001
….	---		

Parameter estimates:

predictor	level	lower conf. Limit	estimate	upper conf. Limit	Standard-error	Chi-square	alpha (Chi-square)
Intercept		-3,45	**-1,67**	-0,04	0,87	3,6	-0,025
---							
fleet mix	1	-2,33	**-1,60**	-1,02	0,33	22,99	<.0001
	3	-1,56	**-0,82**	-0,23	0,34	5,76	0,0157
	4	0,00	**0,00**	0,00	0,00	.	.
distribution channel	tied agent	-2,32	**-1,78**	-1,39	0,24	56,58	<.0001
	broker	0,00	**0,00**	0,00	0,00	.	.
rate change	1	-1,43	**-0,93**	-0,59	0,21	18,72	<.0001
	2	-1,18	**-0,72**	-0,42	0,19	13,51	0,0002
	3	0,00	**0,00**	0,00	0,00	.	.
portfolio cleaning	not flagged	-1,57	**-1,06**	-0,71	0,22	23,05	<.0001
	flagged	0,00	**0,00**	0,00	0,00	.	.

4. Modelling the Lapse-Ratio

Beware! Don`t forget the 2x2-effects!!!

But: Even if several 2x2-effects are identified as significant, heed the alpha (Chi-square)!

The only relevant 2x2-effects to be added to the model was:

„distribution channel" x „ptf cleaning (flagged)".

$$f(x) = \frac{e^x}{1+e^x} (= lapse - ratio)$$

			estimate single effect		sum single effects (distr.channel/ ptf cleaning)	estimate 2x2 effect (distr. channel/ ptf clean.)	sum single + 2x2- effects (distr.channel/ ptf cleaning)	estimate intercept	sum single + 2x2- effects (distr.channel/ ptf cleaning/ intercept
selected effects	**distribution channel**	**ptf cleaning**	**distribution channel**	**ptf cleaning**					
single effects	**tied agent**	**not flagged**	-1,78	-1,06	**-2,84**	0,00	**-2,84**	-1,67	**-4,51**
		flagged	-1,78	0,00	**-1,78**	0,00	**-1,78**	-1,67	**-3,45**
	broker	**not flagged**	0,00	-1,06	**-1,06**	0,00	**-1,06**	-1,67	**-2,73**
		flagged	0,00	0,00	**0,00**	0,00	**0,00**	-1,67	**-1,67**
single / 2x2-effects	**tied agent**	**not flagged**	-0,63	-0,68	**-1,31**	-1,45	**-2,76**	-1,85	**-4,61**
		flagged	-0,63	0,00	**-0,63**	0,00	**-0,63**	-1,85	**-2,48**
	broker	**not flagged**	0,00	-0,68	**-0,68**	0,00	**-0,68**	-1,85	**-2,53**
		flagged	0,00	0,00	**0,00**	0,00	**0,00**	-1,85	**-1,85**

4. Modelling the Lapse-Ratio

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Alpha (Chi-square), considering single and 2x2-effect „distr.channel“ x „ptf cleaning“:

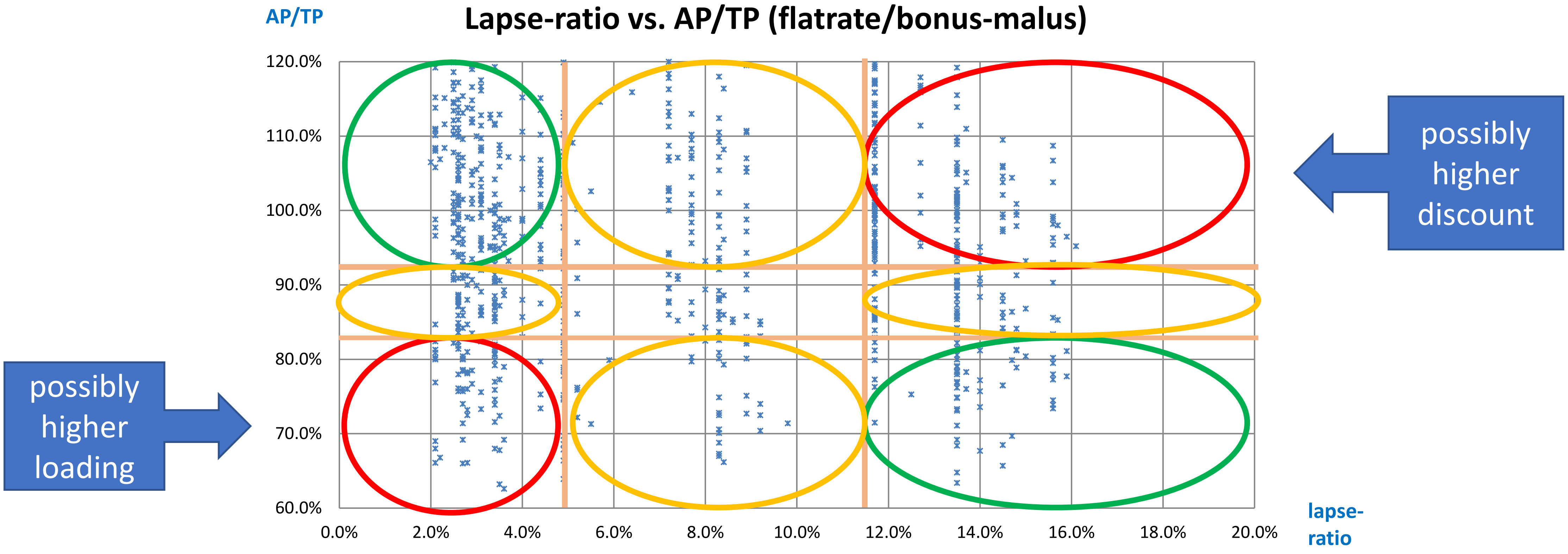
predictor	level1	level2	estimate	Standard-error	Chi-square	alpha (Chi-square)
Intercept			-1,8926	0,88	4,88	0,0272
---						
fleet mix	1		-1,565	0,34	22,58	<.0001
	3		-0,7897	0,34	5,81	0,0159
	4		0	0,00	.	.
distribution channel	tied agent		-0,6695	0,40	3,16	0,0754
	broker		0	0,00	.	.
rate change	1		-0,9087	0,21	19,60	<.0001
	2		-0,7108	0,19	15,13	0,0001
	3		0	0,00	.	.
portfolio cleaning	not flagged		-0,7159	0,25	9,39	0,0022
	flagged		0	0,00	.	.
distribution channel x ptf cleaning	tied agent	not flagged	-1,4937	0,51	9,16	0,0025
	tied agent	flagged	0	0,00	.	.
	broker	not flagged	0	0,00	.	.
	broker	flagged	0	0,00	.	.

Slight deterioration of alpha (Chi-square) at level tied agent – but still acceptable.

Overview

5. The lapse ratio model: 9-field-analysis / scenario-analysis

9-field-analysis: Categorization of the AP/TP-ratio and the Lapse-Ratio - graph:



5. The lapse ratio model: 9-field-analysis / scenario-analysis

scenario-analysis: 20 scenarios (prem. adjustment 0 % to 20 %) - table

prem. adjustm.	# fleets (2021)	# fleets (renewed)	AP (2022) (renewed)	Lapse-Ratio (estimated)	AP/TP-Ratio (2021)	AP/TP-Ratio (2022) (renewed)
0%	1.267	1.157	63,4	11,1%	87,7%	89,6%
1%		1.150	63,1	11,3%		89,9%
2%		1.150	62,9	11,4%		90,4%
3%		1.153	63,7	11,6%		90,9%
4%		1.153	64,1	11,7%		91,5%
5%		1.150	64,9	11,8%		92,1%
6%		1.142	64,6	12,0%		92,4%
7%		1.140	64,7	12,2%		93,0%
8%		1.136	65,2	12,4%		93,6%
9%		1.135	65,5	12,6%		94,2%
10%		1.106	63,9	14,7%		94,8%
11%		1.103	63,8	15,1%		95,3%
12%		1.091	62,9	15,5%		95,5%
13%		1.087	63,6	15,9%		96,0%
14%		1.084	63,1	16,3%		96,4%
15%		1.081	63,0	16,7%		96,9%
16%		1.071	62,4	17,0%		97,6%
17%		1.066	62,4	17,4%		98,0%
18%		1.056	61,8	18,1%		98,8%
19%		1.045	62,4	18,5%		98,9%
20%		1.041	62,0	19,0%		99,1%

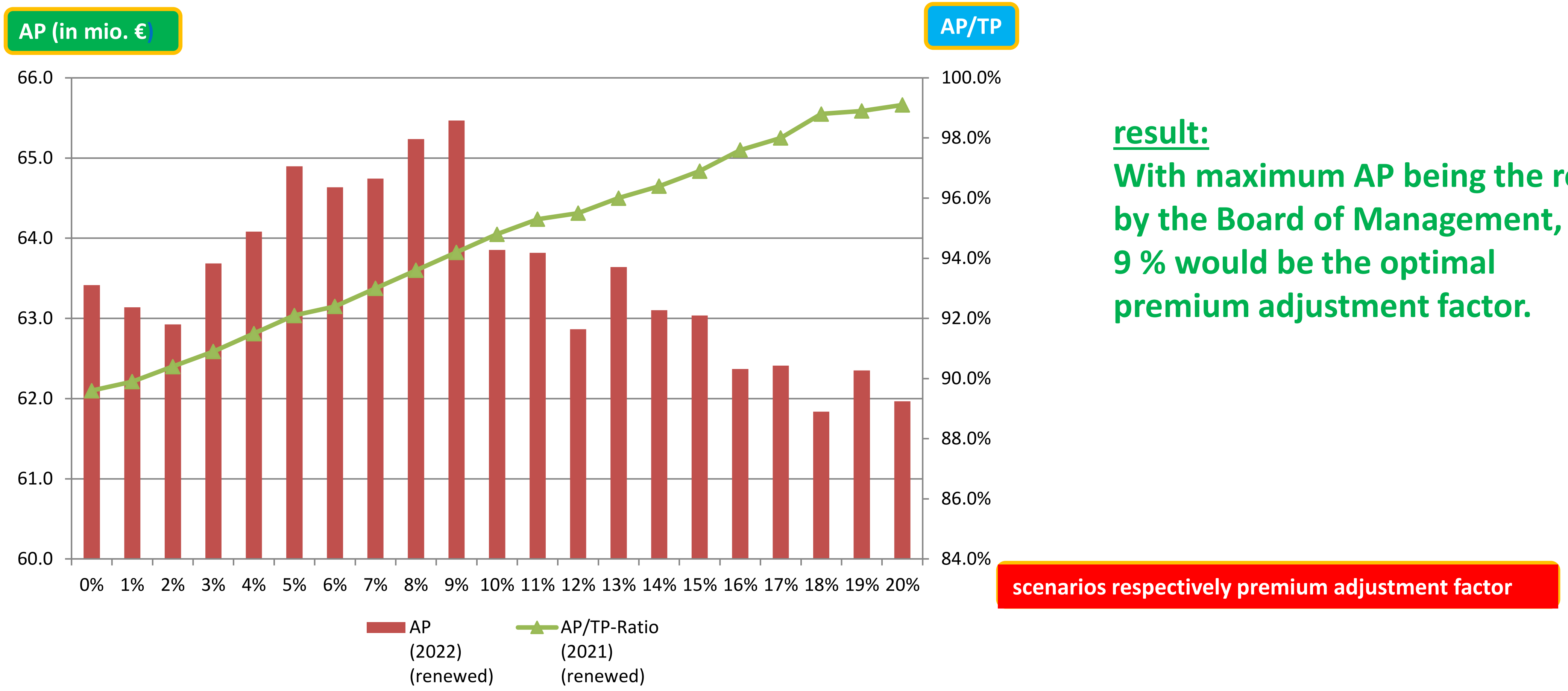
premises:

x up to 9 % increase in premium adjustment
➔ x % increase in overall lapse-ratio.

x from 10 % to 20 % increase
in premium adjustment
➔ 3 times x % increase in overall lapse-ratio.

5. The lapse ratio model: 9-field-analysis / scenario-analysis

<u>scenario-analysis:</u> 21 scenarios (prem. adjustment 0 % to 20 %) - graph



<u>result:</u>
With maximum AP being the requirement by the Board of Management, 9 % would be the optimal premium adjustment factor.

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“The only thing worse than fighting with allies is fighting without them.”

(by Winston Churchill, in the 1940-ies)

Though competition advances us forward,

only by cooperation can we manage to master the real challenges ahead – „dog eats dog“ is doomed to fail.

Backup

The lapse-ratio-model: Build-up of database (creation of fleet mix through clustering)

Cluster method by Ward (source: SAS/STAT guide):

The distance between two clusters is defined by

If $d(\mathbf{x},\mathbf{y}) = \frac{1}{2}\|\mathbf{x}-\mathbf{y}\|^2$ then the combinatorial formula is $D_{KL} = B_{KL} = \frac{\|\bar{\mathbf{x}}_K - \bar{\mathbf{x}}_L\|^2}{\frac{1}{N_K}+\frac{1}{N_L}}$

$$D_{JM} = \frac{(N_J+N_K)D_{JK} + (N_J+N_L)D_{JL} - N_J D_{KL}}{N_J+N_M}$$

In **Ward's minimum-variance method**, the distance between two clusters is the ANOVA sum of squares between the two clusters added up over all the variables. At each generation, the within-cluster sum of squares is minimized over all partitions obtainable by merging two clusters from the previous generation.
The sums of squares are easier to interpret when they are divided by the total sum of squares to give proportions of variance (squared semipartial correlations).

Ward's method joins clusters to maximize the likelihood at each level of the hierarchy under the following assumptions:

- multivariate normal mixture,
- equal spherical covariance matrices,
- equal sampling probabilities.

Peculiarities:

- Ward's method tends to join clusters with a small number of observations;
- It is strongly biased toward producing clusters with roughly the same number of observations;
- It is also very sensitive to outliers.

The calculation of the TP by credibility (here: the risk premium)

$z_i^d = w_i^d / (w_i^d + k)$; **credibiliy factor for claims-layer d and KPI i**

w_i^d : e. g. expected number of claims (for the KPI "overall claims frequency")

$k = \sigma / \tau$, where σ: variability of the fleet over time, τ: variability between the fleets

cf : claims frequency, ca : claims average

Thus, for dimension d and KPI i, we get: $cred\_prem_i^d = z_i^d * \text{experience}_i^d + (1 - z_i^d) * \text{tariff}_i^d$

➔ $risk\_premium = cf_{cred}^{overall} * ca_{cred}^{bas} + cf_{cred}^{exc(>25k)} * ca_{cred}^{exc(25k-80k)} + loading^{exc(>80k)}$

➔ $net\ premium = risk\_premium$ (incl. cost loadings).

Thank you for your attention

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