Premium Capping Schemes in German Health Insurance

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Type of presentation:
- important practical application
- straightforward problem, ideal for APL
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- big chunks of surplus
- one of only a few steering mechanisms in German health insurance
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Outline

1. Introduction to the (re)calculation of premiums in German health insurance
2. Some remarks on the business model and the surplus (usage)
3. An overview of the implemented process for pricing and checking capping schemes
4. Creating and pricing capping schemes
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- **Premium calculation**: how actuarial assumptions are used for calculating premiums
- **Premium recalculation**: how (individual) premiums are adjusted to new actuarial assumptions
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**Objective**: show how tightly regulated German health insurance is. **All processes presented** after agreement and/or supervised by independent trustee / BAFin / auditors!
Calculation of premiums in German health insurance based on:

- mortality rate $q_x$
- lapse rate $w_x$

Both probabilities depend on gender, but get "unisex-ified" for newer tariffs. They depend on age (but not birth year) and are annually revised and contain securities.
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That fore use the so called “equivalence principle”. Calculate premiums so that the (accumulated, discounted, expected) income from a lifelong constant premium equals the (accumulated, discounted, expected) claims.
Gross premium calculation

Based on net premiums:

- add security margin $\sigma_x \geq 5\%$
- add costs (claim regulation costs $\rho_x, \ldots$)
- subtract discount on costs if objective reasons
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Build up und usage of benefit reserves

Due to German laws and calculation principles:

- young people pay more than necessary
  - "flat" $P_x$ example
  - "steep" $P_x$ example

- benefit reserve $V_x$ accumulated in young years and used up in high age
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- total reserve encompasses many kinds besides the benefit reserve

- reserve is a calculated quantity

- reserve is only meaningful applied to a collective and does belong to the latter (not the insurer or individual insureds)
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Rules for adjustment of actuarial assumptions

Are premiums forever?

- each year compulsory check of $K_x$ versus real claims (not identical to calculation...)
- if results are within $\pm 5\%$ of each other no recalculation, outside $\pm 10\%$ compulsory recalculation
- another (more recent) check on mortality rates $q_x$, outside $\pm 5\%$ compulsory recalculation
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The recalculation of premiums is done the same way as the original calculation. New premiums are to be used for all subsequently signed contracts.
Recalculation of individual premiums

What do new premiums mean for business in force?

- principle is that (benefit) reserve $V$ defines everything
- calculate $m V_x$ accumulated in the $m$ years passed since contract time
- fix sum, it encapsulates the “rights” of the insured person
- use new annuities to define an individual, permanent discount $h$ financed by reserve
- define new individual premium as $b = b_{x+m} - h$
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That process is a so called “technical start”. Afterwards the insured person is not distinct from one with contract age $x + m$ and an (individual) discount on the premium.
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- Business model where the surplus comes from in German health insurance
- Premium capping schemes how surplus is used for premium capping schemes
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Outline of section on business model

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**Objective**: show that capping schemes are one of a few steering opportunities.
Concerning premiums we have seen:

- arbitrary (re)calculation not possible
- explicit profit margins not allowed
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- security margins in tables
- explicit security margin in net premiums
- reserve, interest above technical rate
- additionally not-regulated add-on tariffs, occasionally costs
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Importand surplus source: (benefit) reserve

Reserve:

- is part of liabilities and (in older companies) completely dominates assets and liabilities in the balance sheet
  - liabilities (older)
  - liabilities
- can run into the tens of thousands for single contracts
  - "flat" \( V_x \) examples
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- No, because:
  - at least 90% of extra interest
  - at least 80% of surplus regardless of origin

must be returned to policy holders within 3 years

- funds cumulated in “war chest” (called “RfB”)
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The idea of capping premium increases

We know that premium increases $\Delta b$ during (individual) recalculation:

- depend on plan, gender, age, but also accumulated reserve
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- cannot be directly correlated with increases in premiums at contract time $b_x$
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> illustration
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The idea is to avoid financial hardship by capping increases.
Premium discounts are equivalent to reserve, so

- fix a desired (new) discount $\Delta h$
- price it to $\Delta V$ (using standard actuarial formula)
- inject $\Delta V$ into the reserve
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We want to use surplus, more specifically RfB, for capping. We must

- create some objective capping rules (depending on tariff, gender, age, ...)
- persuade the independent trustee that the resulting benefits are fairly distributed
- price the costs
- reach agreement with the trustee and implement the rules

Such a set of rules is called capping scheme or model.

The problem (but not for APL!): the costs are part of the agreement and must be based on (afore hand) simulation.
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Such a set of rules is called capping scheme or model.

The problem (but not for APL!): the costs are part of the agreement and must be based on (aforehand) simulation.
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Outline of workspace overview section

In this section we give an overview of the implemented process:

- the used workspace
- what the workspace used for capping contains and what dependencies there are
- data basis
- how an appropriate data basis is provided
- premium recalculation
- how the premium recalculation is simulated
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**Objective**: separate technically necessary preparations from capping proper.
Overview of the overall capping process

The overall capping process consists of

1. design and pricing of a capping scheme as well as further usage of the results
2. check of capping effects using comparisons on productive databases
3. import of the official results of capping and quality control
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Overview of the capping process proper

The capping process proper encompasses

- extracting a suitable data basis from DB2
- simulating the premium recalculation
- and then
  - pricing of a capping model or
  - agglomerating data in a special way and estimating the cost of a model
- as well as
  - presenting capping results graphically
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Workspace structure

On the technical side:

- workspace is simply structured and not very deep, measured in calls nesting
- each main step a go-through-once-and-you-are-done process
- very low degree of interactivity (except estimation of costs)
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1. starting the main tasks
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- optimized basic algorithms for hardcore data processing
- basic functions which implement (grouped) application of operators on equivalence classes of rows of multicolumn arrays (primitive in Dyalog 14.0?)
- auxiliary functions for using component files
- auxiliary functions for presenting results in Excel (Synfusion libraries?)
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- response times of the DB2 vary wildly (DB2 main purpose: IMS transactions)
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The necessary data extracted:

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Processing the data basis

In the function acquiring the data basis:

- import of data per ado, provider MSDASQL
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Mitsos
Premium Capping Schemes in German Health Insurance
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The overall layout of the premium recalculation simulation is the following:

- Import actuarial tables (annuities, tariff premiums) and other necessary information once
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The costs of the simulation are CPU and I/O (including problems with network).
Recalcualtion proper

In the main loop the recalculation is simulated:

- new values of individual reserves calculated (using actuarial tables)
- new values of individual discounts derived (using actuarial tables — some work to be done, presently process “old style”)
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**Objective:** finally do some capping!
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The capping simulation is build for two main purposes:

1. enable a decision of the board of executives
2. achieve the consent of the independent trustee
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The following results are (usually) needed for each tariff system:

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GUI

The capping simulation is build for two main purposes:

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2. achieve the consent of the independent trustee

The following results are (usually) needed for each tariff system:

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Mitsos  Premium Capping Schemes in German Health Insurance
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That’s much more data and data processing needed...
The workspace is however not only used for the regular recalculation process:

- prepare for new processes (capping individual risk loadings)
- test new ideas (finance capping to maximum premium regardless of increase?)
- answer questions of supervising authority (capping of 10 year average premium increases)
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The result is high data volume and complexity, many parameters (to be used occasionally).
The function implementing the capping process itself is simple:

- **Initialization**
  - get previous statistics and model(s)
  - bind excel book(s)

- **Main loop**
  - price one million tariffs
  - save (part of) data
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- **Finish**
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Pricing the model on a part of business in force

Kernel function takes a part of business in force as argument and prices model on it:

- takes certain individual kinds of reserve into account (§12a(2), §12a(3))
- calls a kernel-kernel-capping-function several times
  - many kinds of capping (tariff, combination, ...)
  - special capping rules for special plans (conflict with another kind of capping!)
  - different interpretation of rules
- takes the rest of individual kinds of reserve into account (§12a(4))
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- technical statistics for internal checks (including runtime and parameters)
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- a matter of minutes rather than hours — but how to go down to seconds?
- good information on one model — but comparison of similar models cumbersome
- create appropriate agglomeration and price it:
  - similar premium and premium increase lead to similar behavior under capping scheme
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Creating a “capping agglomeration”

- GUI

Separate function implements the agglomeration:

- Group premium (increase) in 1€-intervals and compress to midpoint
- Use annuities as individual “weight”
- Sum matrix up after keys and grouped premium (increases), get agglomerated weight and error margin
- For error on absolute limits compare compressed value with original ones
- Error on relative limits similar but more complicated

[Illustration]
Creating a “capping agglomeration”

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Creating capping schemes and estimating their cost

Capping models:
- technically simple numeric matrices
- GUI (needed and) used (by non-APL-ers) to create them

The same GUI is used to estimate their costs:
- load desired capping agglomeration
- load / create / modify / save model
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Conclusion

Pricing of premium capping schemes:
- moderately demanding software architecture
- many details
- much serious work to ensure performance and reliability
- extremely important for German health insurers
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Overview of examples and illustrations

- $q_x$ and $w_x$
- $K_x$
- Net premiums
- Consequences
- Gross premiums
- "Flat" $P_x$
- "Steep" $P_x$
- "Flat" $V_x$
- "Steep" $V_x$
- Recalculation
- Liabilities (older)
- Liabilities
- "Flat" $V_x$
- "Steep" $V_x$
- Surplus (older)
- Surplus
- Increase
- Price
- Surplus (older)
- Surplus
- Main
- After-capping
- Parameter
- Estimator
- Data
- Runtime data
- Recalculation
- Runtime recalculation
- Pricing
- Results
- Scheme
- With decrease
- Without decrease
- Runtime pricing
- Price
- Estimation
- Estimating
- Agglomeration
- Error
- Estimator
Typical examples of $q_x$ and $w_x$. 

$q_x$ or $w_x$ [%] $x_0$

$0$ $10$ $20$ $30$ $40$ $50$ $60$ $70$ $80$ $90$ $100$ $110$ $120$

Typical examples of mortality rates $q_x$ and lapse rates $w_x$. 

[Graph showing typical mortality rates $q_x$ and lapse rates $w_x$.]
Typical examples of $K_x$

Typical examples of claims per capita and year $K_x$ for substitutive health coverage.
Net premium calculation in formulas

Annuities calculated after

\[ \ddot{a}_x = \frac{N_x}{D_x} = \frac{\sum_{m=x}^{\omega} D_m}{D_x} = \sum_{m=0}^{\omega-x} \left( \prod_{n=0}^{m-1} (1 - q_{x+n} - w_{x+n}) \right) \cdot (1 + i)^{-m} \]

Present value of claims calculated after

\[ A_x = \frac{U_x}{O_x} = \frac{\sum_{m=x}^{\omega} O_m}{O_x} = \sum_{m=0}^{\omega-x} \left( \prod_{n=0}^{m-1} (1 - q_{x+n} - w_{x+n}) \right) \cdot K_m \cdot (1 + i)^{-m} \]

Defining equation for net premiums \( \ddot{a}_x \cdot P_x = A_x \).
A different formulation of the equivalence principle

Equivalence principle is transitive and defines reserve

\[ m \, V_x = A_{x+m} - \dot{a}_x \cdot P_x \]

It is the same as demanding that retrospectively accumulated premiums surpassing claims (the reserve) will equal prospectively accumulated claims surpassing premiums

\[
m \, V_x = \sum_{n=0}^{m} \frac{(P_x - K_{x+n}) \cdot (1 + i)^{m-n}}{\prod_{k=n}^{m-1} (1 - q_{x+k} - w_{x+k})} \]

\[
= \sum_{n=m+1}^{\omega-x} (K_{x+n} - P_x) \cdot \left( \prod_{k=m}^{n-1} (1 - q_{x+k} - w_{x+k}) \right) \cdot (1 + i)^{m-n}
\]
Most of gross premiums calculated after

\[ b_x = \frac{P_x + \gamma_x}{12 \cdot (1 - (\Delta_x + \frac{\alpha_x}{12 \cdot \bar{a}_x}))} \]

where \( \gamma_x \) contains most of the costs, \( \Delta_x \) the security margin and \( \alpha_x \) defers direct acquisition costs (provisions) to a negative reserve.
Typical example of $P_x$ (flat $K_x$)

Typical example of (annual) net premiums $P_x$ in high end tariff compared with claims $K_x$.

"steep" $P_x$
Typical example of $P_x$ (flat $K_x$)

Typical example of (annual) net premiums $P_x$ in high end tariff compared with claims $K_x$.

$K_x$ or $P_x$ [K€]

$\Delta P \approx +1.500$€

$x = 35$

$x + m \approx 57$

$\Delta P \approx -9.600$€
Typical example of $P_x$ (steep $K_x$)

Typical example of (annual) net premiums $P_x$ in high end tariff compared with claims $K_x$.
Typical example of $P_x$ (steep $K_x$)

Typical example of (annual) net premiums $P_x$ in high end tariff compared with claims $K_x$.

$$\Delta P \approx +2,400\,\text{€}$$

$$\Delta P \approx -11,900\,\text{€}$$

$x = 35$

$x + m \approx 55.5$

[Diagram showing the relationship between $P_x$ and $K_x$]
Typical examples of the (huge!) $m \cdot V_x$

$P_x$ or $m \cdot V_x$ [K€]

Typical examples of $m \cdot V_x$ in high end tariff for different contract ages $x$ compared with (annual) net premiums $P_x$.

$V_{\text{max}} \approx 31 \cdot P_x$
Typical examples of the (huge!) $m \, V_x$

Typical examples of $m \, V_x$ in high end tariff for different contract ages $x$ compared with (annual) net premiums $P_x$.

\[ V_{\max} \approx 16 \cdot P_x \]
Typical examples of the (huge!) $m V_x$

Typical examples of $m V_x$ in high end tariff for different contract ages $x$ compared with (annual) net premiums $P_x$.

$V_{max} \approx 4 \cdot P_x$

$x = 60$

$V_{max} \approx 4 \cdot P_x$

$V_{max} \approx 4 \cdot P_x$

Typical examples of $m V_x$ in high end tariff for different contract ages $x$ compared with (annual) net premiums $P_x$. 

*reulalcation* *business* *“steep”* $m V_x$
Typical examples of the (huge!) $m V_x$

$$P_x \text{ or } m V_x \quad [\text{K\\euro}]$$

$$m V_x, \text{ contract age } x = 20$$

$$x = 40$$

$$x = 60$$

$$P_x$$

Typical examples of $m V_x$ in high end tariff for different contract ages $x$ compared with (annual) net premiums $P_x$.
Typical examples of the (huge!) $mV_x$ in high end tariff for different contract ages $x$ compared with (annual) net premiums $P_x$.

$$V_{\max} \approx 40 \cdot P_x$$

Typical examples of $mV_x$ compared to $P_x$. The graph illustrates how $mV_x$ varies with different contract ages ($x$) and how it relates to the net premiums ($P_x$) in a typical high end tariff scenario.
Typical examples of the (huge!) $m V_x$

$P_x$ or $m V_x$ [K€]

$V_{max} \approx 18 \cdot P_x$

Typical examples of $m V_x$ in high end tariff for different contract ages $x$ compared with (annual) net premiums $P_x$. 

“flat” $m V_x$
Typical examples of the (huge!) $m V_x$ in high end tariff for different contract ages $x$ compared with (annual) net premiums $P_x$. 

$V^{\text{max}} \approx 4 \cdot P_x$
Typical examples of the (huge!) $m V_x$

$P_x$ or $m V_x$ [K€]

$m V_x$, contract age $x = 20$

$x = 40$

$x = 60$

Typical examples of $m V_x$ in high end tariff for different contract ages $x$ compared with (annual) net premiums $P_x$. 

"flat" $m V_x$
Recalculation of individual premiums in formulas

Calculate reserve based on old discount \( ^0h \) and the old individual net premium \( ^0P \)

\[
V = mnV_x = ^0A_{x+m} - ^0\ddot{a}_{x+m} \cdot ^0P - ^0b_x \cdot ^0\alpha_x
\]

\[
= ^0A_{x+m} - ^0\ddot{a}_{x+m} \cdot \left( ^0P_x - 12 \cdot (1 - ^0\Delta_x) \cdot ^0h \right) - ^0b_x \cdot ^0\alpha_x
\]

\[
= ^0\ddot{a}_{x+m} \cdot \left( (^0P_{x+m} - ^0P_x) + 12 \cdot (1 - ^0\Delta_x) \cdot ^0h \right) - ^0b_x \cdot ^0\alpha_x
\]

Define new discount

\[
nh = \frac{V + nb_{x+m} \cdot n\alpha_{x+m}}{12 \cdot (1 - n\Delta_{x+m}) \cdot n\ddot{a}_{x+m}}
\]
Liabilities of DKV (older years)

Liabilities of DKV as shown in the balance sheet (in millions of euros):

<table>
<thead>
<tr>
<th>year</th>
<th>total</th>
<th>equity</th>
<th>(of total)</th>
<th>reserve</th>
<th>(of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>19,107</td>
<td>466</td>
<td>2.44%</td>
<td>18,007</td>
<td>94.24%</td>
</tr>
<tr>
<td>2006</td>
<td>20,835</td>
<td>467</td>
<td>2.24%</td>
<td>19,765</td>
<td>94.86%</td>
</tr>
<tr>
<td>2007</td>
<td>22,268</td>
<td>467</td>
<td>2.10%</td>
<td>21,269</td>
<td>95.51%</td>
</tr>
<tr>
<td>2008</td>
<td>23,079</td>
<td>467</td>
<td>2.02%</td>
<td>22,173</td>
<td>96.07%</td>
</tr>
<tr>
<td>2009</td>
<td>24,539</td>
<td>466</td>
<td>1.90%</td>
<td>23,537</td>
<td>95.92%</td>
</tr>
</tbody>
</table>
Liabilities of DKV as shown in the balance sheet (in millions of euros):

<table>
<thead>
<tr>
<th>year</th>
<th>total</th>
<th>equity</th>
<th>(of total)</th>
<th>reserve</th>
<th>(of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>27,833</td>
<td>512</td>
<td>1.84%</td>
<td>26,732</td>
<td>96.04%</td>
</tr>
<tr>
<td>2010</td>
<td>29,416</td>
<td>509</td>
<td>1.73%</td>
<td>28,411</td>
<td>96.58%</td>
</tr>
<tr>
<td>2011</td>
<td>31,249</td>
<td>508</td>
<td>1.63%</td>
<td>30,216</td>
<td>96.69%</td>
</tr>
<tr>
<td>2012</td>
<td>33,066</td>
<td>507</td>
<td>1.53%</td>
<td>32,075</td>
<td>97.00%</td>
</tr>
<tr>
<td>2013</td>
<td>34,885</td>
<td>505</td>
<td>1.45%</td>
<td>33,853</td>
<td>97.04%</td>
</tr>
<tr>
<td>2014</td>
<td>36,680</td>
<td>505</td>
<td>1.38%</td>
<td>35,762</td>
<td>97.50%</td>
</tr>
</tbody>
</table>

The year 2009 has been adjusted retroactively to reflect the merge with VICTORIA Kranken per 01.01.2010.
### Surplus of DKV and its use (older years)

Using surplus for capping scheme and premium refunding by DKV as shown in the balance sheet (in millions of euros):

<table>
<thead>
<tr>
<th>Year</th>
<th>Capping Scheme</th>
<th>Premium Refunding</th>
<th>Added Surplus</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>217</td>
<td>95</td>
<td>506</td>
</tr>
<tr>
<td>2006</td>
<td>137</td>
<td>100</td>
<td>515</td>
</tr>
<tr>
<td>2007</td>
<td>188</td>
<td>104</td>
<td>432</td>
</tr>
<tr>
<td>2008</td>
<td>314</td>
<td>112</td>
<td>52</td>
</tr>
<tr>
<td>2009</td>
<td>229</td>
<td>114</td>
<td>302</td>
</tr>
</tbody>
</table>
Using surplus for capping scheme and premium refunding by DKV as shown in the balance sheet (in millions of euros):

<table>
<thead>
<tr>
<th>year</th>
<th>capping scheme</th>
<th>premium refunding</th>
<th>added surplus</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>229</td>
<td>114</td>
<td>302</td>
</tr>
<tr>
<td>2010</td>
<td>295</td>
<td>174</td>
<td>546</td>
</tr>
<tr>
<td>2011</td>
<td>309</td>
<td>150</td>
<td>541</td>
</tr>
<tr>
<td>2012</td>
<td>217</td>
<td>160</td>
<td>735</td>
</tr>
<tr>
<td>2013</td>
<td>645</td>
<td>157</td>
<td>561</td>
</tr>
<tr>
<td>2014</td>
<td>331</td>
<td>167</td>
<td>836</td>
</tr>
</tbody>
</table>

The year 2009 is not directly comparable to the rest as it does not reflect the merge with VICTORIA Kranken per 01.01.2010.
Components of individual premium increase

\[ \circ b = \circ b_x \]
Components of individual premium increase

\[ \Delta b_{x+\Delta x} - \Delta b_{x+\Delta x} - 40\% \Delta b_{x+\Delta x} + 110\% b \]
Components of individual premium increase

- $b_x = b_x$
- $b_{x+m} = b_{x+m}$
- $+15\% b_x$
- $+20\% b_{x+m}$
Components of individual premium increase

- \( +15\% \, b_x \)
- \( +20\% \, b_{x+m} \)
- \( -40\% \, h \)
- \( \Delta b \)
- \( \Delta h \)

\[ \begin{align*}
\Delta b &= \Delta b \\
\Delta h &= \Delta h
\end{align*} \]
Components of individual premium increase

- **+15% \( b_x \)**
- **+20% \( b_{x+m} \)**
- **-40% \( h \)**

**Equations:**

\[
\begin{align*}
\Delta b &= b_{x+m} \\
\Delta h &= h \\
\Delta b &= b \times 40\% \\
\Delta b &= b \times 20\% \\
\Delta b &= b \times 15\% \\
\end{align*}
\]
Components of individual premium increase

\[ o b = o b_x + 110\% \times b! \]
Pricing the capping of individual premium increases in formulas

Define desired maximal premium, for example

\[ b^{\text{max}} = b^{\text{max}}(o\ b) \]
\[ = \max\{o\ b + \lim^{\text{low},\text{abs}}; \min\{\lim^{\text{upp},\text{rel}} \cdot o\ b; \ o\ b + \lim^{\text{upp},\text{abs}}\}\} \]

Define desired new discount

\[ \Delta h = (i\ b - b^{\text{max}})_+ \quad (\text{achieving} \quad n\ b = i\ b - \Delta h) \]

Price new discount

\[ \Delta V = 12 \cdot (1 - n\Delta_{x+m}) \cdot n\dot{a}_{x+m} \cdot \Delta h \]
Main GUI snapshot
Main GUI after-capping-snapshot

A.10. Übersicht über "alle" Limitierungmodelle einer Beitragsanpassung bilden

A.11. Interaktive Übersicht über "alle" Limitierungmodelle einer Beitragsanpassung öffnen

A.9. Limitierungsmodule interaktiv erstellen und die benötigten RfB-Mittel schätzen

A.3. Limitierungsmodell auf erstellten Limitierungsdaten bewerten

B.1. Vollständige abziehen

A.4. Limitierungsergebnisse interaktiv grafisch darstellen

A.5. Vergleiche von Limitierungsergebnissen in Excel präsentieren

A.6. Ergebnis (Beiträge) eines Limitierungsmodells auf den Grossrechner (DB2) exportieren

A.7. Testbestand für den BAP-Lauf mit Hilfe eines Limitierungsergebnisses auswählen
Parameters GUI snapshot

- **Parameter zur Bewertung von Limitierungsmodellen auf Limitierungsdaten**

  - **Hauptparameter**
    - durchzuführende Aktionen: vollständige Bewertung
    - zusätzliche Tarif-Limitierungsmode: akzeptieren
    - Nummer des ersten Modells: 12
    - Soziallimitierungs-Pauschale: 600
    - Finanzierungsdauer: 0
    - Nummer des zweiten Modells: 559
    - Soziallimitierungs-Pauschale: 5555,99
    - Finanzierungsdauer: 0

  - **Nebenparameter**
    - Modell-Interpretation
    - akzept. limitiert: nein
    - bei PKV-Tarif limitiert: nur nicht pauschal gekapselte Personen
    - negative AB abfangen: nein
    - PVN limitieren bis Priorität: 0
    - PVG limitieren bis Priorität: 0
    - allgemeine prozentuale Obergrenze (%): 20
    - allgemeine absolute Obergrenze (€): 50
## Examples and illustrations

### Premiums in German health insurance
- Business model and surplus
- Overview of the implementation
- Capping schemes

## Cost estimation GUI snapshot

![Cost estimation GUI snapshot](image.png)

### Table: Limitation models and related RB Mittel schätzen

<table>
<thead>
<tr>
<th>MODKLPT</th>
<th>AVGS-SL</th>
<th>Auswertungsgruppe</th>
<th>Geschlecht</th>
<th>Alter</th>
<th>pr. UG</th>
<th>abs. UG</th>
<th>pr. OG</th>
<th>abs. OG</th>
<th>Sché-G</th>
<th>Erstbau</th>
<th>Beltr-G</th>
<th>benötigte Mittel</th>
<th>RBD mindestens</th>
<th>RBD geschätzt</th>
<th>RBD maximal</th>
<th>erste Limitierungsmode</th>
<th>zweites Limitierungsmode</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>männlich</td>
<td>0-14</td>
<td>0 %</td>
<td>0.00</td>
<td>0.00</td>
<td>0 %</td>
<td>0.00</td>
<td>0 %</td>
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<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>männlich</td>
<td>15-19</td>
<td>0 %</td>
<td>0.00</td>
<td>0.00</td>
<td>0 %</td>
<td>0.00</td>
<td>0 %</td>
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<td>0 %</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>männlich</td>
<td>20-59</td>
<td>0 %</td>
<td>0.00</td>
<td>0.00</td>
<td>0 %</td>
<td>0.00</td>
<td>0 %</td>
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<td>0 %</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>männlich</td>
<td>60-64</td>
<td>0 %</td>
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<td>0.00</td>
<td>0 %</td>
<td>0.00</td>
<td>0 %</td>
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<td>0.00</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>männlich</td>
<td>65-79</td>
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<td>0.00</td>
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<td>80-120</td>
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<td>0.00</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>weiblich</td>
<td>0-14</td>
<td>0 %</td>
<td>0.00</td>
<td>0.00</td>
<td>0 %</td>
<td>0.00</td>
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<td>0.00</td>
</tr>
<tr>
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<tr>
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<td>60-64</td>
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<tr>
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<td>65-79</td>
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<td>0.00</td>
<td>0 %</td>
<td>0.00</td>
<td>0 %</td>
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</tr>
<tr>
<td>0</td>
<td>0</td>
<td>weiblich</td>
<td>80-120</td>
<td>0 %</td>
<td>0.00</td>
<td>0.00</td>
<td>0 %</td>
<td>0.00</td>
<td>0 %</td>
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<td>0 %</td>
<td>0.00</td>
<td>0 %</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Notes
- The table shows the estimated costs for different age groups and genders.
- The estimated costs are calculated based on the initial data provided.
Main GUI capping-snapshot

A.1. Vollständigen Limitierungsbestand abziehen

A.2. Beitragsanpassung auf abgezogenem Limitierungsbestand simulieren

A.8. Abgezogenen Limitierungsbestand, erstellte Limitierungsdaten oder simuliertes Limitierungsergebnis bearbeiten

A.9. Limitierungsmodelle interaktiv erstellen und die benötigten RfB-Mittel schätzen

A.3. Limitierungsmodell auf erstellten Limitierungsdaten bewerten

data basis  premium recalculation  scheme pricing  estimating costs
### Example of data basis runtime

Runtime of data base extraction (complete business in force) in seconds

<table>
<thead>
<tr>
<th>part</th>
<th>start</th>
<th>main</th>
<th>end</th>
</tr>
</thead>
<tbody>
<tr>
<td>sum</td>
<td>15.04</td>
<td>1,928.27</td>
<td>20.73</td>
</tr>
<tr>
<td>simulation</td>
<td>0.11</td>
<td>166.28</td>
<td>0.02</td>
</tr>
<tr>
<td>agglomeration</td>
<td>0.00</td>
<td>232.44</td>
<td>1.05</td>
</tr>
<tr>
<td>input</td>
<td>9.06</td>
<td>1,446.89</td>
<td>0.00</td>
</tr>
<tr>
<td>output</td>
<td>0.00</td>
<td>82.67</td>
<td>15.47</td>
</tr>
<tr>
<td>Excel</td>
<td>5.87</td>
<td>0.00</td>
<td>4.20</td>
</tr>
</tbody>
</table>
## Example of premium recalculation runtime

Runtime of recalculation in individual premiums (complete business in force) in seconds

<table>
<thead>
<tr>
<th>part</th>
<th>sum</th>
<th>simulation</th>
<th>aggregation</th>
<th>input</th>
<th>output</th>
<th>Excel</th>
</tr>
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### List of results snapshot

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Illustration of simple capping scheme

\[ \Delta b \ [\text{€}] \]

\[ \frac{3}{4} \ 400 \ 800 \ \frac{3}{3} \]

15%

\[ \begin{align*}
0 & \quad 75 & \quad 150 & \quad 225 & \quad 300 & \quad 375 & \quad 450 & \quad 525 & \quad 600 \\
0 & \quad 10 & \quad 20 & \quad 30 & \quad 40 & \quad 50 \\
\end{align*} \]
Illustration of simple capping scheme

\[ \Delta b \ [\€] \]

\[ \frac{400}{3} \]
\[ \frac{800}{3} \]
\[ 460 \]

15%

social capping

\[ \circ \ b \ [\€] \]
Illustration of simple capping scheme

- Social capping
- Capping schemes
Illustration of simple capping scheme

\[
\Delta b \ [\€] \quad \begin{array}{c}
400 \\
800 \\
460
\end{array}
\]

\[
\begin{array}{c}
0 \quad 75 \quad 150 \quad 225 \quad 300 \quad 375 \quad 450 \quad 525 \quad 600
\end{array}
\]

social capping

15%
Illustration of capping scheme with premium decrease

\[
\Delta b \ [\text{\euro}] \quad \frac{400}{3} \quad \frac{800}{3}
\]

-30  -20  -10   0    10    20    30    40    50

75    150   225   300   375   450   525   600

°b \ [\text{\euro}]
Illustration of capping scheme with premium decrease

\[ \Delta b \ [\text{\euro}] \]

\[ \frac{400}{3} \quad \frac{800}{3} \]

15%

\[ 75 \quad 150 \quad 225 \quad 300 \quad 375 \quad 450 \quad 525 \quad 600 \]

\[ \circ b \ [\text{\euro}] \]

-30 -20 -10 0 10 20 30 40 50

ERGO

Mitsos

Premium Capping Schemes in German Health Insurance 27/32
Illustration of capping scheme with premium decrease

Δb [€]  400  800  460

0  10  20  30  40  50

75  150  225  300  375  450  525  600

15%

social capping

Premium Capping Schemes in German Health Insurance
Illustration of capping scheme with premium decrease

- Δb [€]
  - 400/3
  - 800/3
  - 460

- OBJ [€]
  - 75 150 225 300 375 450 525 600

- 15%

- Social capping
Illustration of capping scheme with premium decrease

- $\Delta b \ [\text{€}]$
- $\frac{400}{3}$
- $\frac{800}{3}$
- 460

Social capping
Illustration of capping scheme without premium decrease

Δ$b$ [€]

400/3

800/3

15%

75 150 225 300 375 450 525 600

°$b$ [€]

Mitsos

Premium Capping Schemes in German Health Insurance
Illustration of capping scheme without premium decrease

\[ \Delta b \text{ [€]} \]

- 75
- 150
- 225
- 300
- 375
- 450
- 525
- 600

-30
-20
-10
0
10
20
30
40
50

15%

400/3
800/3
460

Social capping

Premium Capping Schemes in German Health Insurance

Mitsos
Illustration of capping scheme **without premium decrease**
Illustration of capping scheme **without premium decrease**

- **Δb [€]**
- **b [€]**

- **400/3**
- **800/3**
- **460**

- **15%**

- **Social capping**

- **0**
- **10**
- **20**
- **30**
- **40**
- **50**

- **75**
- **150**
- **225**
- **300**
- **375**
- **450**
- **525**
- **600**

- **-30**
- **-20**
- **-10**
- **0**
- **10**
- **20**
- **30**
- **40**

- **ERGO**

Mitsos

Premium Capping Schemes in German Health Insurance 28/32
Illustration of capping scheme *without premium decrease*

- Δb [€]
- \( \frac{400}{3} \)
- \( \frac{800}{3} \)
- 460

- 15%
- Social capping

- 0
- 10
- 20
- 30
- 40
- 50

- 75
- 150
- 225
- 300
- 375
- 450
- 525
- 600

- -30
- -20
- -10
- 0
- 10
- 20
- 30

- 460
- 3
- 800
- 3

- Mitsos
- Premium Capping Schemes in German Health Insurance

28/32
### Example of capping scheme pricing runtime

Runtime of capping scheme pricing (complete business in force) in seconds

<table>
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<tr>
<th>part</th>
<th>sum</th>
<th>simulation</th>
<th>agglomeration</th>
<th>input</th>
<th>output</th>
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<td>3.65</td>
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Illustration of capping agglomeration and associated error

The agglomeration error with respect to absolute limits is demonstrated.
The agglomeration error with respect to absolute limits is demonstrated.
Illustration of capping agglomeration and associated error

The agglomeration error with respect to absolute limits is demonstrated.
The agglomeration error with respect to absolute limits is demonstrated.
The agglomeration error with respect to absolute limits is demonstrated.
The agglomeration error with respect to absolute limits is demonstrated.
The agglomeration error with respect to absolute limits is demonstrated.

\[ \Delta b \, [\text{€}] \]

\begin{align*}
300 & \quad 300.5 & \quad 301 \\
39.5 & \quad 40 & \quad 40.5 & \quad 41 & \quad 41.5
\end{align*}

\( \text{lim}^{\text{abs}}_{\text{min}} \): assumed for upper bound

\( \text{lim}^{\text{abs}}_{\text{max}} \): assumed for lower bound

\( \text{high} \) lim\( ^{\text{abs}} \): no capping, no error

\( \text{low} \) lim\( ^{\text{abs}} \): error exact

\( \text{critical} \) lim\( ^{\text{abs}} \): error information agglomerated
Illustration of capping agglomeration and associated error

The agglomeration error with respect to absolute limits is demonstrated.

(higher) \( \text{lim}_{\text{max}}^{\text{abs}} \): assumed for lower bound

\( \text{lim}_{\text{abs}}^{\text{est}} \): assumed for upper bound

\( \text{lim}_{\text{abs}}^{\text{min}} \): assumed for lower bound

\( \Delta b \) [€]
Group premiums and premium increases after

\[ b_j^{gr} = 0.5 + \lfloor b_j \rfloor \quad \text{and} \quad \Delta b_j^{gr} = 0.5 + \lfloor \Delta b_j \rfloor \]

This leads to weighted errors with respect to absolute limits

\[ \Delta V_{j, abs}^{err} = g_j^{\Delta V} \cdot (\Delta b_j^{gr} - \Delta b_j) \]

\[ \Delta V_{bas}^{err, abs} = \sum_j \Delta V_j^{err, abs} \]

\[ \Delta V_{min}^{err, abs} = \sum_j \left( \Delta V_j^{err, abs} \right)_- \quad \text{and} \quad \Delta V_{max}^{err, abs} = \sum_j \left( \Delta V_j^{err, abs} \right)_+ \]

Relative limits similar but more complicated.
Error margin of capping agglomeration in formulas

Error interval in capping cost estimation due to agglomeration

- for arbitrary absolute limits \( \text{lim}^{abs} \)
- for (each) cohort with arbitrary but fixed \( \Delta b^{gr} \)

given by

\[
\Delta V^{ex} \in \Delta V^{est} \oplus \\
\begin{cases}
\left[ \left( \Delta V_{bas}^{err,abs} \right)_-, \left( \Delta V_{bas}^{err,abs} \right)_+ \right] & \text{for } \text{lim}^{abs} < \Delta b^{gr} - .5 \\
\left[ \Delta V_{min}^{err,abs}, \Delta V_{max}^{err,abs} \right] & \text{for } \text{lim}^{abs} \in \Delta b^{gr} \oplus [-.5,+.5) \\
[0,0] & \text{for } \text{lim}^{abs} \geq \Delta b^{gr} + .5
\end{cases}
\]