Premium Capping Schemes in German Health Insurance

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About

Type of presentation:

- important practical application
- straightforward problem, ideal for APL

What about:

- big chunks of surplus
- one of only a few steering mechanisms in German health insurance

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Outline

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Outline of section on (re)calculation

In this section we give some brief information about:

premium calculation
: how actuarial assumptions are used for calculating premiums

premium recalculation
: how (individual) premiums are adjusted to new actuarial assumptions

Objective: show how tightly regulated German health insurance is.
All processes presented after agreement and/or supervised by independent trustee / BAFin / auditors !

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Probabilities used for premium calculation

Calculation of premiums in German health insurance based on:

- mortality rate q_x
- lapse rate w_x ▸ q_x and w_x examples

Both probabilities:

- depend on gender, but get "unisex-ified" for newer tariffs
- depend on age (but not birth year)
- are annually revised and contain securities

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Claims and interest rate for premium calculation

Furthermore the calculation of premiums uses:

- claims per capita and year K_x ▸ K_x examples
- technical interest rate i

These actuarial assumptions are revised on (re)calculation:

- claims
  - depend on gender, but get "unisex-ified" for newer tariffs
  - depend on age (but not birth year)
  - contain securities
- interest rate is "company constant" (up to 2012 3.5% for all insurers)

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Net premium calculation

The basic premise of premium calculation is:

- premiums shall depend on [gender (for tariffs introduced up to 2012) and] age at contract
- premiums shall not depend on aging as such

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
▸ formulas ▸ consequences

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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

The result is the monthly premium b_x for contract age x. ▸ formulas
That's that: no (individual) changes allowed.

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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 ${}_mV_x$ accumulated in young years and used up in high age "flat" ${}_mV_x$ examples "steep" ${}_mV_x$ examples
- 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 ±5% of each other no recalculation, outside ±10% compulsory recalculation
- another (more recent) check on mortality rates q_x, outside ±5% compulsory recalculation
- no check on lapse rates w_x or interest rate i, company risk

The recalculation of premiums is done the same way as the original calculation. New premiums are to be used for all subsequently signed contracts.

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Recalculation of individual premiums

What do new premiums mean for business in force?

- principle is that (benefit) reserve V defines everything
- calculate ${}_mV_x$ 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 formulas
- define new individual premium as $b = b_{x+m} - h$

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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Outline of section on business modell

In this section we give some brief information about:

- **business model**: where the surplus comes from in German health insurance
- **premium capping schemes**: how surplus is used for premium capping schemes

Objective: show that capping schemes are one of a few steering opportunities.

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Surplus earned in German helath insurance

Concerning premiums we have seen:

- arbitrary (re)calculation not possible
- explicit profit margins not allowed

So where is the surplus?

- 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" ${}_mV_x$ examples "steep" ${}_mV_x$ examples

Possible sources of surplus:

- earned interest just 0.5% above average technical rate means over 150 million euros
- mortality or lapse a bit higher than assumed means high sums

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Surplus earned and the policy holders

Are security margins in truth huge profit margins?

- 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
  surplus (older) surplus
- funds cumulated in "war chest" (called "RfB")
- usage only in agreement with independent trustee (capping, premium refunding)

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The idea of capping premium increases

We know that premium increases Δb during (individual) recalculation:

- depend on plan, gender, age, but also accumulated reserve
- are that fore highly individual
- cannot be directly correlated with increases in premiums at contract time b_x

As a result some individuals may have huge increases Δb.
illustration

The idea is to avoid financial hardship by capping increases.

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Pricing the capping of individual premium increases

Premium discounts are equivalent to reserve, so

- fix a desired (new) discount Δh
- price it to ΔV (using standard actuarial formula)
- inject ΔV into the reserve

Then the premium will be permanently reduced by $\Delta b = \Delta h$ — without subsequent effects on the balance sheet.

▸ formulas

The only problem remaining is were to find the necessary money!

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Financing capping schemes

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.

▸ surplus (older) ▸ surplus

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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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

Objective: separate technically necessary preparations from capping proper.

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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

The two last points are (important but) not part of this presentation. ▸ GUI

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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
  - using individual results for the determination of special test cases
  - ...

The last points are not part of this presentation. ▸ GUI

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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)

Three simple GUIs (necessary and) provided for:

1. starting the main tasks ▸ GUI
2. determining the parameters of the main tasks ▸ GUI
3. creating capping schemes and estimating their costs (a bit more complicated) ▸ GUI

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Dependencies and technical prerequisites

Some functions and/or functionalities are imported from and/or provided by other workspaces, for example:

- 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?)
- auxiliary functions for communicating with IBM DB2 on the mainframe, Access and SQL Server (SQAPL?)
- APL-optimized sets of actuarial data

All those are of course taken for granted —
in the workspace and the presentation. . .

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Data import as a (separate) task

▸ GUI

Why save extract and save the data basis in component files?

- response times of the DB2 vary wildly (DB2 main purpose: IMS transactions) ▸ runtime
- SELECT privileges on productive databases severely restricted
- data basis much less volatile than the premium recalculation or the capping schemes

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Contents of the data basis

The necessary data extracted:

- can be test or production, explicit list of contract or whole business in force (“whole production” being the standard)
- represents one point in business and system time (therefore reproducible)
- contains key fields (contract and tariff number), properties (gender, age, entitlement), actuarial data (reserves, discounts)

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Processing the data basis

In the function acquiring the data basis:

- import of data per ado, provider MSDASQL
- some processing done (combinations of plans, partition)
- data type 4 byte integer enforced
  - possible (few alphanumerical values, small numeric precison)
  - significant performance improvement (memory use, I/O, primitives)
  - necessary rounding easier and faster
- result saved in component files ▸ runtime

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Premium recalculation as a (separate) task

▸ GUI

Why simulate premium recalculation and save results in component files?

- runtime would be added to the pricing of each capping model ▸ runtime
- actuarial tables come from another workspace (practical problems with privileges and usage)
- refreshing of actuarial data basis (based on independent calculation program dART) must be on decision (small deviations confusing)
- necessary for interactively estimating the costs of models

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Layout of premium recalculation simulation

The overall layout of the premium recalculation simulation is the following:

- import actuarial tables (annuities, tariff premiums) and other necessary information once
- data read from and results written to component files
- simulation proper done in a loop over one-million-tariffs-matrices (depending on workspace available)
- “recalculation light” in comparison to its recalculation reference system (precision, special cases, columns)

The costs of the simulation are CPU and I/O (including problems with network). ▸ runtime

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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")
- effects on premiums as well as on premium increases determined
- all steps of capping not depending on capping scheme prepared (§12a(2), §12a(3), §12a(4))

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Outline of capping section

In this section we describe the capping proper:

pricing a model how to price a capping model and create (readable and usable) results

estimating costs how to create a model and estimate its costs

Objective: finally do some capping!

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Main purpose and results of capping simulation

GUI

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

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

- price ("costs" for the board, "funds" for the trustee)
- premium increase ("additional income" for the board)
- premium increase distribution in matrix form ("the insureds's hardship" for the trustee)

That's simple, the results are no big deal!
Many more results are demanded more or less frequently, all of them agglomerated on various levels: folder
That's much more data and data processing needed...

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Additional purposes (occasionally) served

The workspace is however not only used for the regular recalculation process: scheme

- prepare for new processes (capping individual risk loadings)
- test new ideas (finance capping to maximum premium regardless of increase?) with decrease
- answer questions of supervising authority (capping of 10 year average premium increases)
- react to (proposed) law changes (unisex premiums and redistribution of reserve) without decrease

The result is high data volume and complexity, many parameters (to be used occasionally).

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Layout of the capping process proper

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
  - prepare divers agglomerations (for Excel)
- finish
  - save agglomerated data in component files
  - present results in Excel

It is possible to just do the pricing or the result presentation.
runtime

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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 formulas
  - 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))
- determines further effects (premiums, risk loadings)

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Results presented in Excel

Many kinds of results are exported, all of them agglomerated on various levels: folder

- technical statistics for internal checks (including runtime and parameters)
- various person counts, premium (increases) and changes in reserve (including minimum necessary for board / trustee)
- various mean values
- various percentile values
- various distributions in matrix form (including minimum necessary for trustee)
- special information (§12a(3), letters)

The export of the results takes longer than the pricing itself. . . runtime

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How to be faster and even more flexible?

Pricing of a model is fast and flexible:

- 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 illustration
  - additionally defining keys of the scheme must be included
  - some details (social capping) must be ignored or handled across-the-board beforehand

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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 ▸ in formulas
- for error on absolute limits compare compressed value with original ones ▸ in formulas
- error on relative limits similar but more complicated

▸ illustration

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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 ▸ GUI

The same GUI is used to estimate their costs:

- load desired capping agglomeration
- load / create / modify / save model
- estimate costs of model
- estimate costs of perturbations on selected plan groups

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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

◂ begin

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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" ${}_mV_x$ ▸ "steep" ${}_mV_x$ ▸ recalculation

▸ liabilities (older) ▸ liabilities ▸ "flat" ${}_mV_x$ ▸ "steep" ${}_mV_x$ ▸ 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

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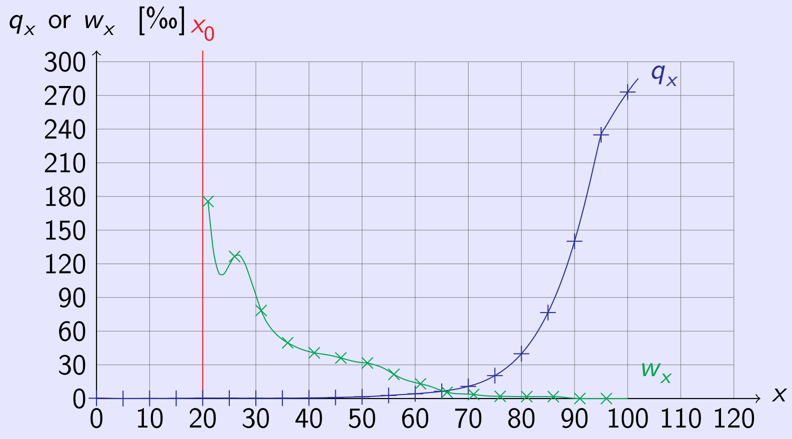
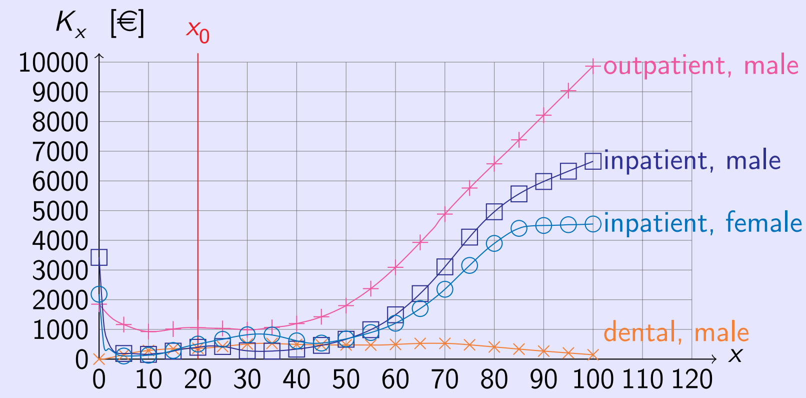
Typical examples of q_x and w_x



Typical examples of mortality rates q_x and lapse rates w_x.

calculation

Typical examples of K_x



Typical examples of claims per capita and year K_x for substitutive health coverage.

calculation

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 $\ddot{a}_x \cdot P_x = A_x$.

calculation

A different formulation of the equivalence principle

Equivalence principle is transitive and defines reserve

$${}_mV_x = A_{x+m} - \ddot{a}_x \cdot P_x$$

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

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

$$= \sum_{n=m+1}^{\omega-x} (K_{x+n} - P_x) \cdot \left(\prod_{k=m}^{n-1} (1 - q_{x+k} - w_{x+k}) \right) \cdot (1+i)^{m-n}$$

calculation

Gross premium calculation in formulas

Most of gross premiums calculated after

$$b_x = \frac{P_x + \gamma_x}{12 \cdot (1 - (\Delta_x + \frac{\alpha_x}{12 \cdot \ddot{a}_x}))}$$

where γ_x contains most of the costs, Δ_x the security margin and α_x defers direct acquisition costs (provisions) to a negative reserve.

calculation

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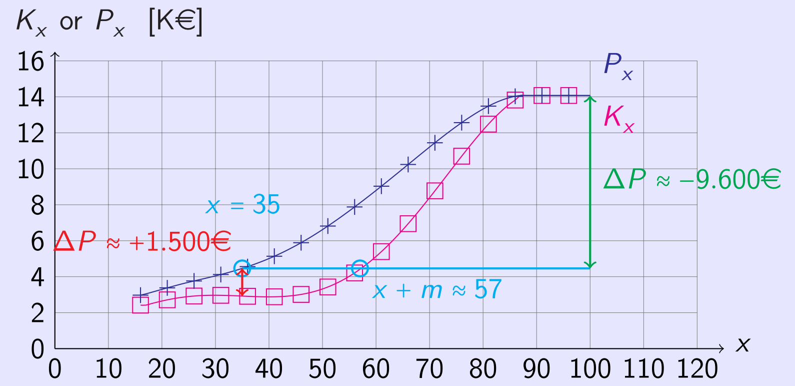
Typical example of P_x (flat K_x)



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

recalculation "steep" P_x "steep" P_x

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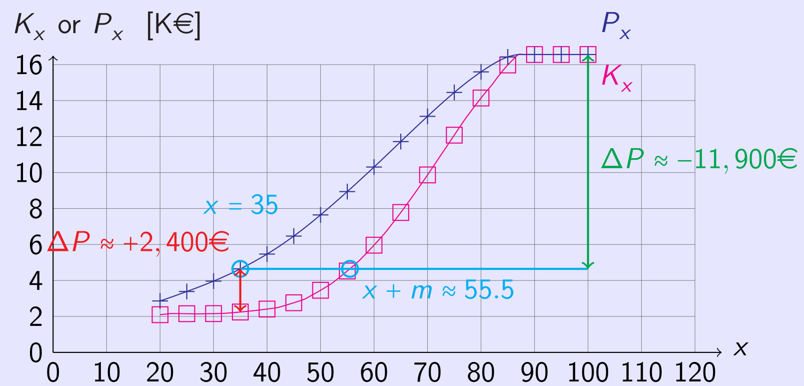
Typical example of P_x (steep K_x)



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

recalculation "flat" P_x "flat" P_x

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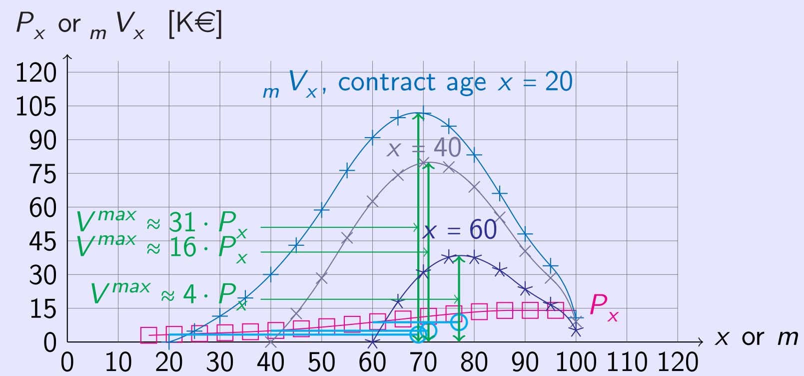
Typical examples of the (huge!) ${}_mV_x$



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

recalculation business "steep" ${}_mV_x$ "steep" ${}_mV_x$ "steep" ${}_mV_x$ "steep" ${}_mV_x$

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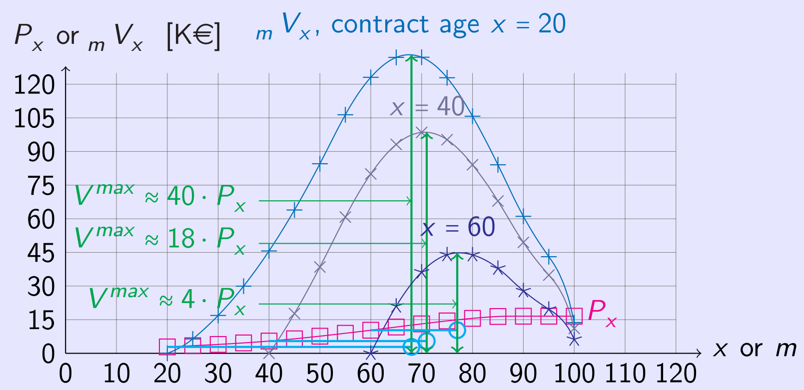
Typical examples of the (huge!) ${}_mV_x$



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

recalculation | business | "flat" ${}_mV_x$ | "flat" ${}_mV_x$ | "flat" ${}_mV_x$ | "flat" ${}_mV_x$

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Recalculation of individual premiums in formulas

Calculate reserve based on old discount ${}^oh$ and the old individual net premium ${}^oP$

$$\begin{aligned} V = {}_mV_x &= {}^oA_{x+m} - {}^o\ddot{a}_{x+m} \cdot {}^oP - {}^ob_x \cdot {}^o\alpha_x \\ &= {}^oA_{x+m} - {}^o\ddot{a}_{x+m} \cdot \left({}^oP_x - 12 \cdot (1 - {}^o\Delta_x) \cdot {}^oh\right) - {}^ob_x \cdot {}^o\alpha_x \\ &= {}^o\ddot{a}_{x+m} \cdot \left(({}^oP_{x+m} - {}^oP_x) + 12 \cdot (1 - {}^o\Delta_x) \cdot {}^oh\right) - {}^ob_x \cdot {}^o\alpha_x \end{aligned}$$

Define new discount

$${}^nh = \frac{V + {}^nb_{x+m} \cdot {}^n\alpha_{x+m}}{12 \cdot (1 - {}^n\Delta_{x+m}) \cdot {}^n\ddot{a}_{x+m}}$$

recalculation

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Liabilities of DKV (older years)

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

year	total	equity	(of total)	reserve	(of total)
2005	19,107	466	2.44%	18,007	94.24%
2006	20,835	467	2.24%	19,765	94.86%
2007	22,268	467	2.10%	21,269	95.51%
2008	23,079	467	2.02%	22,173	96.07%
2009	24,539	466	1.90%	23,537	95.92%

business model | liabilities

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Liabilities of DKV

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

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

The year 2009 has been adjusted retroactively to reflect the merge with VICTORIA Kranken per 01.01.2010.

business model | liabilities (older)

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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):

year	capping scheme	premium refunding	added surplus
2005	217	95	506
2006	137	100	515
2007	188	104	432
2008	314	112	52
2009	229	114	302

business model capping surplus

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Surplus of DKV and its use

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

year	capping scheme	premium refunding	added surplus
2009	229	114	302
2010	295	174	546
2011	309	150	541
2012	217	160	735
2013	645	157	561
2014	331	167	836

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

business model capping surplus (older)

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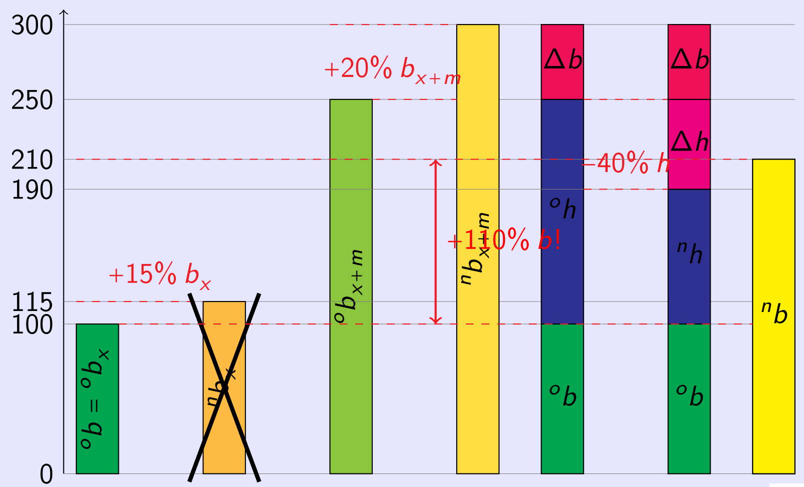
Components of individual premium increase



capping

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Pricing the capping of individual premium increases in formulas

Define desired maximal premium, for example

$$b^{max} = b^{max}({}^ob)$$
$$= \max\{{}^ob + lim^{low,abs}; \min\{lim^{upp,rel} \cdot {}^ob; {}^ob + lim^{upp,abs}\}\}$$

Define desired new discount

$$\Delta h = \left({}^ib - b^{max}\right)_+ \quad (\text{achieving} \quad {}^nb = {}^ib - \Delta h)$$

Price new discount

$$\Delta V = 12 \cdot (1 - {}^n\Delta_{x+m}) \cdot {}^n\ddot{a}_{x+m} \cdot \Delta h$$

capping pr kernel

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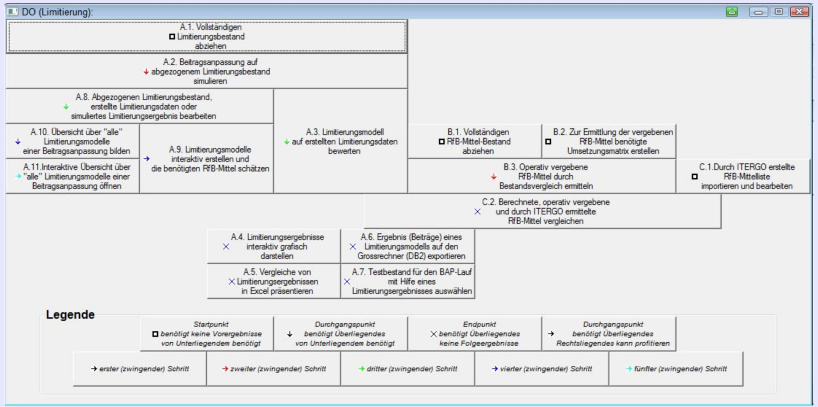
Main GUI snapshot



ws overview ws structure

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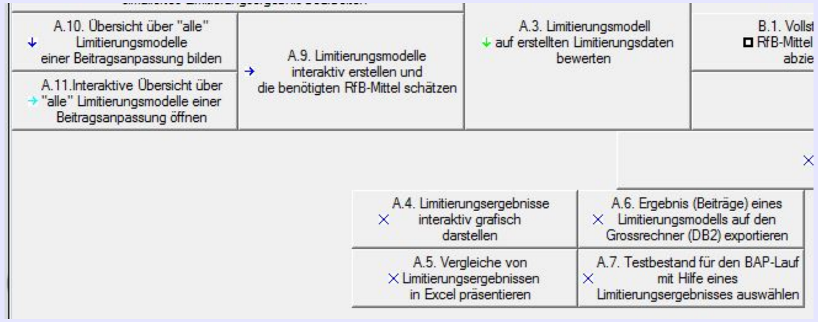
Main GUI after-capping-snapshot



workspace

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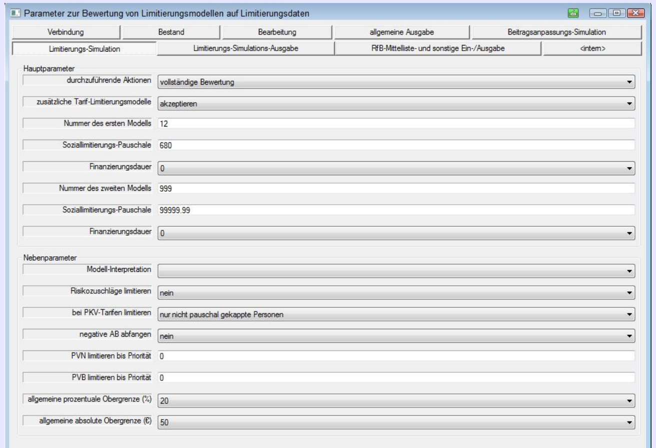
Parameter GUI snapshot



workspace

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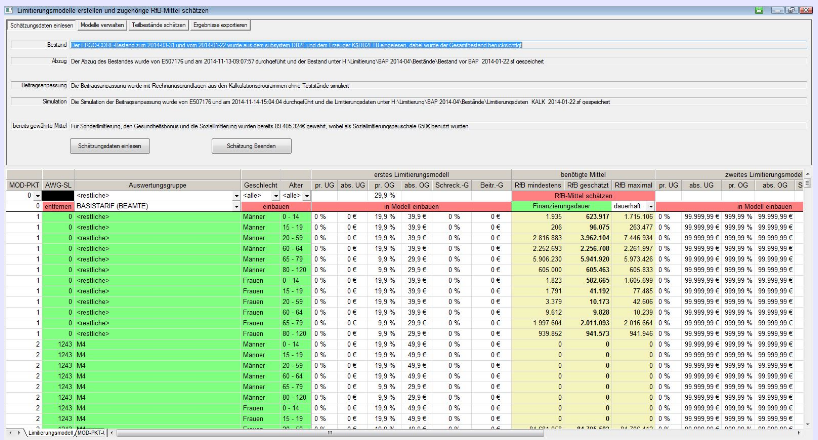
Cost estimation GUI snapshot



workspace estimating

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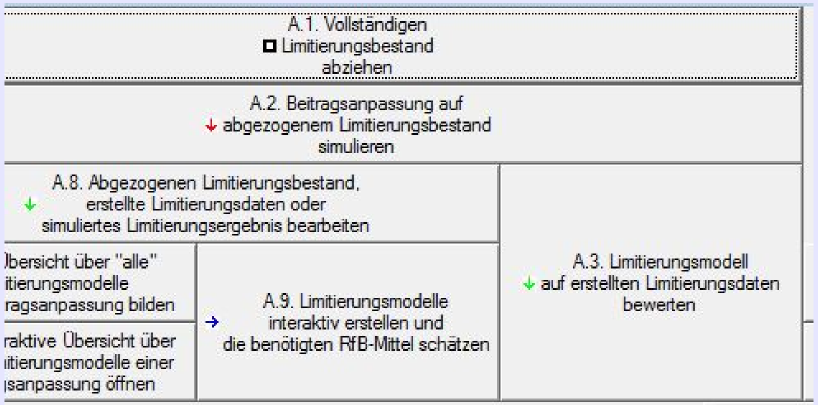
Main GUI capping-snapshot



data basis | premium recalculation | scheme pricing | estimating costs

Example of data basis runtime

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

part	sum	simu-lation	ag-glome-ration	input	output	Excel
start	15.04	0.11	0.00	9.06	0.00	5.87
main	1,928.27	166.28	232.44	1,446.89	82.67	0.00
end	20.73	0.02	1.05	0.00	15.47	4.20

data task | data processing

Example of premium recalculation runtime

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

part	sum	simu-lation	ag-glome-ration	input	output	Excel
start	13.29	1.09	0.00	11.67	0.00	0.53
main	657.35	212.39	212.21	33.17	199.58	0.00
end	12.93	0.00	1.73	0.00	6.37	4.84

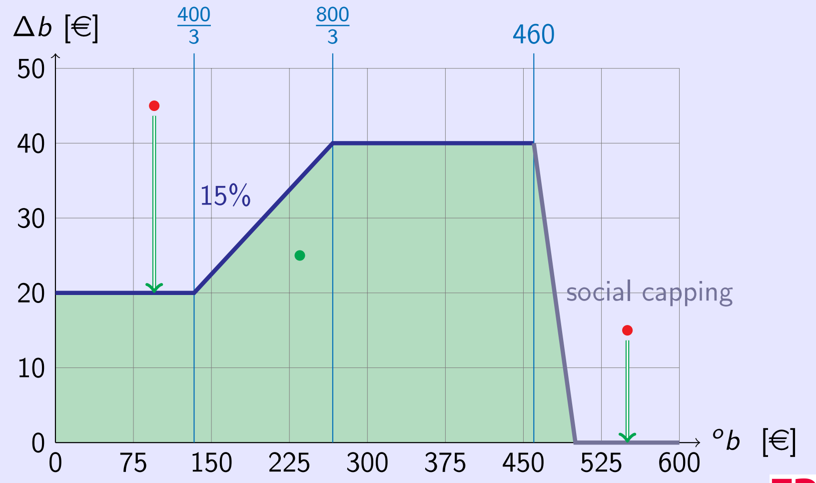
recalculation task | recalculation processing

List of results snapshot

Name	Größe	Änderungsdatum	Typ
ERGO-Beitragspercentile nach Auswertungsgruppe (Modell 77 (650,LIM)) CORE+KALK_201...	497 KB	15.01.2013 09:15	Mic
ERGO-Beitragspercentile nach Position (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.xls	52 KB	15.01.2013 09:14	Mic
ERGO-Beitragspercentile nach Tarif (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.xls	3.022 KB	15.01.2013 09:15	Mic
ERGO-Beitragspercentile nach Versicherungsart (Modell 77 (650,LIM)) CORE+KALK_2013-...	212 KB	15.01.2013 09:15	Mic
ERGO-Beitragspercentile nach Versicherungsnummer (Modell 77 (650,LIM)) CORE+KALK_...	21 KB	15.01.2013 09:14	Mic
ERGO-Bewertung nach Auswertungsgruppe (Modell 77 (650,LIM)) CORE+KALK_2013-01-14...	1.130 KB	15.01.2013 08:58	Mic
ERGO-Bewertung nach Modellpunkt (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.xls	164 KB	15.01.2013 08:58	Mic
ERGO-Bewertung nach Tarif (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.xls	7.526 KB	15.01.2013 09:05	Mic
ERGO-Bewertung nach Versicherungsart (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.xls	334 KB	15.01.2013 08:57	Mic
ERGO-Bewertungs-Übersicht (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.xls	514 KB	15.01.2013 08:57	Mic
ERGO-Durchschnittlicher Mehrbeitrag der Auswertungsgruppen (Modell 77 (650,LIM)) CORE...	348 KB	15.01.2013 09:14	Mic
ERGO-Durchschnittlicher Mehrbeitrag der Modellpunkte (Modell 77 (650,LIM)) CORE+KALK...	85 KB	15.01.2013 09:14	Mic
ERGO-Durchschnittlicher Mehrbeitrag der Tarife (Modell 77 (650,LIM)) CORE+KALK_2013-0...	1.934 KB	15.01.2013 09:14	Mic
ERGO-Durchschnittlicher Mehrbeitrag der Versicherungsarten (Modell 77 (650,LIM)) CORE+...	147 KB	15.01.2013 09:14	Mic
ERGO-Limitierungsergebnis (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.sf	1.296.494 KB	15.01.2013 08:55	AP
ERGO-Statistiken und Hinweise (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.sf	134.817 KB	17.01.2013 08:22	AP
ERGO-Statistiken und Hinweise (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.xls	3.352 KB	15.01.2013 09:15	Mic
ERGO-Verteilung nach Auswertungsgruppe (Modell 77 (650,LIM)) CORE+KALK_2013-01-14....	837 KB	15.01.2013 09:07	Mic
ERGO-Verteilung nach Modellpunkt (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.xls	117 KB	15.01.2013 09:07	Mic
ERGO-Verteilung nach Tarif (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.xls	5.257 KB	15.01.2013 09:14	Mic
ERGO-Verteilung nach Versicherungsart (Modell 77 (650,LIM)) CORE+KALK_2013-01-14.xls	227 KB	15.01.2013 09:06	Mic

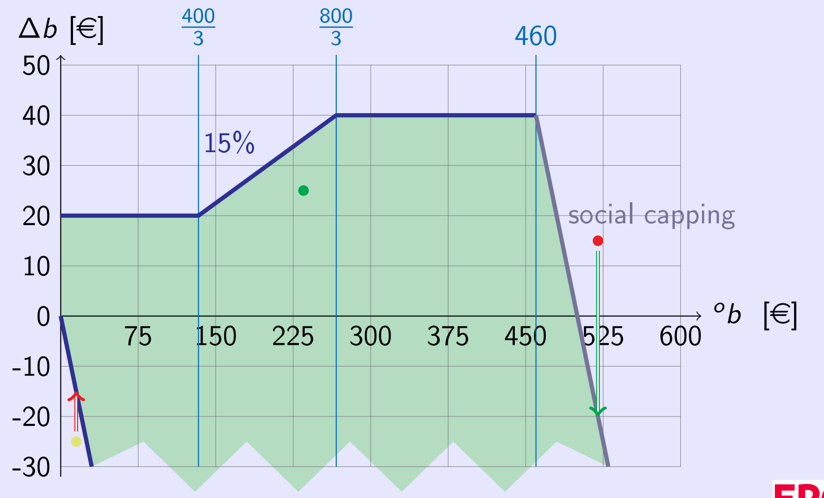
pr general | pr results

Illustration of simple capping scheme



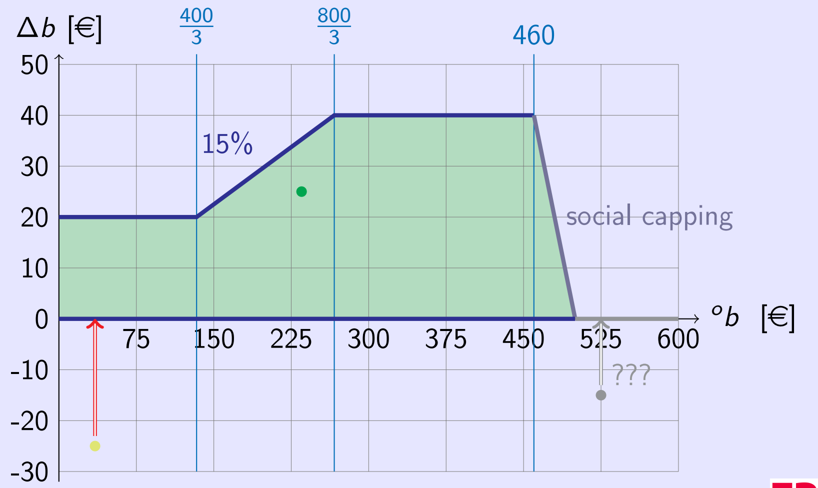
pricing

Illustration of capping scheme with premium decrease



pricing

Illustration of capping scheme without premium decrease



pricing

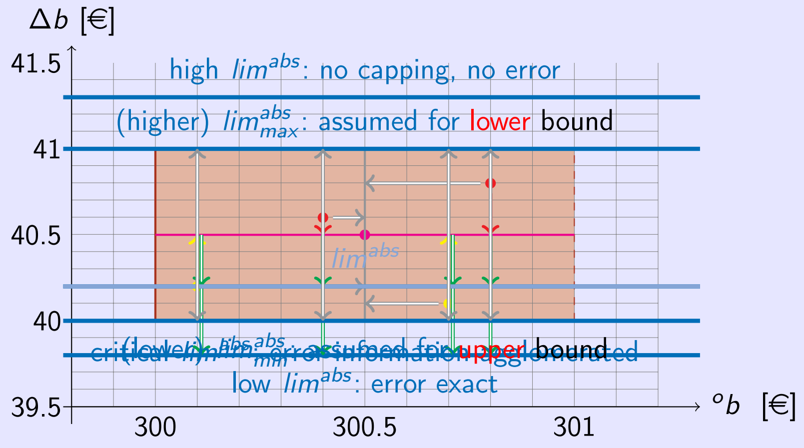
Example of capping scheme pricing runtime

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

part	sum	simu-lation	ag-glome-ration	input	output	Excel
start	10.56	0.00	0.00	10.13	0.00	0.44
main	762.65	218.39	421.74	40.62	81.89	0.00
end	1,149.68	0.52	0.97	0.00	3.65	1,144.55

pr layout pr results

Illustration of capping agglomeration and associated error



The agglomeration error with respect to absolute limits is demonstrated. ◂ est idea ◂ est agglomeration

ERGO

Capping agglomeration in formulas

Group premiums and premium increases after

$$b^{gr}_j = .5 + \lfloor b_j \rfloor \quad \text{and} \quad \Delta b^{gr}_j = .5 + \lfloor \Delta b_j \rfloor$$

This leads to weighted errors with respect to absolute limits

$$\Delta V^{err,abs}_j = g^{\Delta V}_j \cdot (\Delta b^{gr}_j - \Delta b_j)$$

$$\Delta V^{err,abs}_{bas} = \sum_j \Delta V^{err,abs}_j$$

$$\Delta V^{err,abs}_{min} = \sum_j \left(\Delta V^{err,abs}_j\right)_- \quad \text{and} \quad \Delta V^{err,abs}_{max} = \sum_j \left(\Delta V^{err,abs}_j\right)_+$$

Relative limits similar but more complicated.

◂ estimating

ERGO

Error margin of capping agglomeration in formulas

Error interval in capping cost estimation due to agglomeration

- for arbitrary absolute limits lim^{abs}
- for (each) cohort with arbitrary but fixed Δb^{gr}

given by

$$\Delta V^{ex} \in \Delta V^{est} \oplus$$

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

◂ estimating

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