Gemeinsame Einrichtung KVG
Institution commune LAMal
Istituzione comune LAMal

Risk Adjustment in a Nutshell

Konstantin Beck[1]

This paper is designed to explain cause and functioning of risk adjustment in (Swiss) health insurance. It is written for actuaries in a condensed, formal, and (hopefully) easy to follow language. It keeps the basics short and is written in English in order to serve all Swiss languages simultaneously.

1. Some Definitions

We describe risk adjustment in the context of health insurance markets, where competing insurers cover the health care expenditures net of copayment of their enrollees, each charging a community rated premium. We use C (costs) for net health care expenditures and n for the number of insured, ignoring the fact, that coverage is usually measured in months.

The basic problem in an insurance market with community rated premiums arises, when the set of all n insured, $\mathfrak{N}$, can be split by well-defined risk indicators into R different subsets (risk groups, $\mathfrak{N}_r$, with $\mathfrak{N}_r \cap \mathfrak{N}_\rho = \{\,\}$, whenever $r \neq \rho$, and $\bigcup_{r=1}^{R} \mathfrak{N}_r = \mathfrak{N}$.) such that the expected average costs per group differ systematically and predictably. This means $C_r \neq C_\rho$, with r and ρ indicating risk groups ($r, \rho \in \{1,2, \dots R\}$), C_r and C_ρ average costs of the respective risk group, and $r \neq \rho$.[2]

Total average costs of all insured within the entire market are: $C = (\sum_{r=1}^{R} C_r n_r)\frac{1}{n}$. And the distribution of n insured over R risk groups is called the "risk structure of the market". Members of risk groups r with $C_r > C$ are called "high risks", while members of risk groups ρ with $C_\rho < C$ are called "low risks".

2. The Problem

Each insurer i might deviate from the market average by costs, by risk structure, or by both. Deviation in costs means $d_{ri} = (C_{ri} - C_r) \neq 0$. This possible cost disadvantage (when $d_{ri} > 0$) remains the insurer's problem and gives the incentive to control costs. The possible advantage (with $d_{ri} < 0$) is kept by the insurer and permits insurer i to offer below average premiums.

Deviations in risk structures, $(\frac{n_{ri}}{n_i} - \frac{n_r}{n}) \neq 0$, produce cost differences as well. Insurer with an above average share of low risks show expected average costs below market average and vice versa. This cost advantage might even overcompensate for costs disadvantages due to inefficiency ($d_{ri} > 0$). Therefore, low premiums do not necessarily indicate an efficient insurer, because inefficiency might be

[1] With many thanks to Lennart Pirktl, Yannick Schwarz, Magnus Vieten, Alberto Holly, Richard van Kleef, and Randall Ellis for very helpful comments on an earlier version of this note.
[2] For practical reasons, risk groups remain unchanged from one year to another. Therefore, it might be possible, that for some groups and a given year $C_r = C_\rho$. However, these exceptions do not fundamentally alter our argumentation.

masked by an advantageous risk structure. This gives all insurer an incentive to select risks to increase/decrease the share of low/high risks.

Risk selection (in contrast to cost reduction) is unwanted in a social health insurance market, because it violates the “equal treatment”-rule. Resources invested in selection are wasted efforts in a market with mandatory coverage, where each enrollee must be covered in the end. Finally, it is inefficient, because a less efficient insurer can dominate the market as long as it is able to keep a significantly advantageous risk structure. More specifically, selection-driven premium variation might incentivize consumers to enroll in insurance plans with a successful selection strategy rather than plans with a successful cost-containment strategy (which contributes to the increase in total healthcare spending).

3. The Solution

Risk adjustment (RA) is established to prevent risk selection. The Swiss concept is to redistribute insurer’s premium money according to predictable risk (dis-)advantages. We start with a **categorical RA** where each individual is assigned to only one risk group. This type of formula has been applied from 1996 to 2019. Its straightforward structure helps to understand some basic properties of risk adjustment and keeps the notation quite simple. In a second step, we will present the more sophisticated, non-categorical formula used since 2020 and show, why the same or similar properties still hold. The predictable (dis-) advantage per risk group reads: $(C - C_r) = a_r$. This expression is, when positive, the RA-contribution every insurer must pay into the RA-fund for each of its low-risk insured who is member of risk group r. It is (when negative) the contribution every insurer gets from the RA-fund for each of its high-risk enrollees in risk group r. The insurer’s total (net) payment reads: $\sum_{r=1}^{R} n_{ri} a_r$.

We show the impact of RA arguing with any risk group r that might be preferred or not $(C - C_r) \lesseqgtr 0$, and might be over- or underrepresented in an insurer’s i set of enrollees, $\left(\frac{n_{ri}}{n_i} - \frac{n_r}{n}\right) \lesseqgtr 0$. Within this risk group r, insurer *i* might have a cost advantage, or disadvantage, $d_{ri} = (C_{ri} - C_r) \lesseqgtr 0$. For each enrollee of risk group r, a respective transfer a_r, must be paid, either by the insurer to the RA-fund or vice versa.

Taking these RA-transfers into account, the average costs after RA, C_{ri}^{RA}, of insurer i in risk group r reads: $C_{ri}^{RA} = \frac{1}{n_{ri}}[n_{ri}C_{ri} + n_{ri}a_r] = \frac{n_{ri}}{n_{ri}}[(C_r + d_{ri}) + (C - C_r)] = C + d_{ri}$. This formula reflects the market average C, plus the efficiency (dis-)advantage of the respective insurer, d_{ri}, the insurer should be held responsible for. What we found for a specific risk group holds as well for the insurer’s total average cost, $C_i^{RA} = \frac{1}{n_i}\sum_{r=1}^{R}[n_{ri}C + n_{ri}d_{ri}] = C + D_i$, with D_i denoting the weighted average of insurer’s efficiency (dis-)advantages per risk group, $D_i = \sum_{r=1}^{R} \frac{n_{ri}}{n_i} d_{ri}$.

In other words: A perfectly defined RA-formula can correct for unwanted selection (dis-)advantages, leaving efficiency gains or losses (D_i) in the insurer’s responsibility.[3]

---

[3] This holds if the risk adjuster variables are based on exogenous information (e.g., age). Variables based on prior use of health care expenditures (such as prior hospitalization or pharmaceutical costs groups, see section 7) are to some extent ‘endogenous’ in the sense that higher (lower) utilization results in higher (lower) future RE compensations.

4. Estimation of the RA Parameters

OLS is an appropriate method to estimate the necessary parameters for the RA-formula. Given individual health care expenditures-data of all *n* insured, the following regression provides the parameters needed:

(1) $$C_j = \sum_{r=1}^{R} \beta_r s_{rj} + \varepsilon_j,$$

with index *j* denoting an insured, ε_j denoting white noise with expected value equal to zero, and the dummy variable s_{rj} assigns individual *j* to risk group *r*, such that $s_{rj} = 1$, when individual *j* belongs to *r*, and else $s_{rj} = 0$, (such that $\sum_j \sum_r s_{rj} = n$). The estimation of β_r, provides average costs per risk group *r* ($\hat{\beta}_r = C_r$).[4] $\hat{\beta}_r$ is therefore the necessary input to calculate an RA-transfer, $a_r = (C - \hat{\beta}_r)$.

5. RA Parameters and Complex Premium Structures

All this holds true for a flat, community rated premium. Things become more complicated when premium structure is complex. In the Swiss case the regulator expects rebates to be granted to young adults below 26 years. (This section explains the rationale behind Art. 16a KVG.)

A rebate implies a subdivision of the set of all *n* insured, $\mathfrak{N}$, into those, entitled to get a rebate (here all adults below 26, $\mathfrak{P}_1$) and the remaining ($\mathfrak{P}_0$, with $\mathfrak{P}_0 \cap \mathfrak{P}_1 = \{\}$). Problems occur when all members of $\mathfrak{P}_1$ (entitled to get a rebate) originate from the same risk group ρ such that $\mathfrak{N}_\rho \cup \mathfrak{P}_1 = \mathfrak{N}_\rho$ (and $\mathfrak{P}_1 \neq \{\}$). An actuarial fair rebate ($C - C_\rho$) should be possible as long as $C_\rho < C$. RA transfers for this specific risk groups read: $a_\rho = C - C_\rho$. And expected costs are: $C_\rho^{RA} = C_\rho + C - C_\rho = C$. Since expected costs equal total average costs, the actuarial fair rebate for group ρ is zero, $C - C_\rho^{RA} = C - C = 0$.[5]

A fair rebate is impossible without constraining solidarity in a first step. When we reduce the transfers of group ρ by Δ (with $0 < \Delta < 1$), to $\Delta a_\rho = \Delta(C - C_\rho)$, expected costs become $C_\rho^{RA} = C_\rho + \Delta(C - C_\rho) < C_\rho + (C - C_\rho) = C$. This inequality holds because the brackets are by definition positive.

What happens to the remaining risk groups? They all lose transfers from risk group ρ. The lost amount per insured, L, reads: $L = n_\rho(1 - \Delta)(C - C_\rho)\frac{1}{(n - n_\rho)}$. Here, n_ρ and $(n - n_\rho)$ indicate the number of rebated and not rebated insured, respectively. Since all three brackets in expression L are positive, $L > 0$. Therefore, expected costs of each remaining risk group exceed total average: $C_r^{RA} = C_r + C - C_r + L = C + L > C$.

This opens a window for an actuarial fair rebate, namely: $[L + (1 - \Delta)(C - C_\rho)] > 0$.

Conclusion: A reduction of the solidarity transfer is a precondition for a rebate given to a set of entitled insured, when this set corresponds perfectly with a risk group.

It should be evident that the same conclusion holds, when the set of entitled insured, $\mathfrak{P}_1$, corresponds perfectly to the union of several risk groups, for example $\mathfrak{P}_1 = \mathfrak{N}_q \cup \mathfrak{N}_\rho$.

---

[4] For a formal proof see: Beck, 2013, Risiko Krankenversicherung, Haupt Bern, S. 407f.

[5] Unfair rebates would produce predictable losses for group ρ and gains for all other groups.

6. Two Problems of Prospective Payments

We have to distinct concurrent from prospective formulas. Concurrent formulas use estimations from year *t* to calculate transfers for the same year *t*, $a_{rt} = (C_t - \hat{\beta}_{rt})$. However, Swiss risk adjustment is applied prospectively, in order to prevent cost redistribution, since risks are projections into the future. Because of that, estimations from year $(t-1)$ are used to calculate RA contributions in year *t*, $a_{rt} = (C_{(t-1)} - \hat{\beta}_{r(t-1)})$. This has two important consequences.

First, given a continuous growth in health care expenditures, cost estimated for the preceding year, $(t-1)$, is lagging behind the costs in year t. Therefore Art. 13 sec. 2 VORA defines a surcharge $(1+\tau)$. This surcharge is not simply $(1+\tau) = \frac{C_t}{C_{t-1}}$ but $(1+\tau) = \frac{C_t}{\sum_r n_{rt} C_{rt-1}/n_t}$, neutralizing cost increases/decreases due to changes in the risk structure from year $(t-1)$ to t.

Second, OLS-estimations are true in expectation. This is to say all $\hat{\beta}_r$ fulfill the following condition: $\frac{1}{n}\sum_{r=1}^{R} \hat{\beta}_r n_r = C$, which makes RA a zero sum game: $\sum_{r=1}^{R} n_r a_r = \sum_{r=1}^{R} n_r (C - \hat{\beta}_r) = 0$. This holds as long as RA is applied as a concurrent formula.

With annually changing risk structures, the zero-sum condition is not necessarily fulfilled: $\sum_{r=1}^{R} n_{rt} (C_{(t-1)} - \hat{\beta}_{r(t-1)}) \gtreqless 0$.

To reestablish the zero-sum property, $C_{(t-1)}$ must be substituted by $\frac{1}{n_t}\sum_{r=1}^{R} n_{rt}\hat{\beta}_{r(t-1)} = \tilde{C}$ such that $\sum_{r=1}^{R} n_{rt} a_{rt} = \sum_{r=1}^{R} n_{rt} (\tilde{C} - \hat{\beta}_{r(t-1)}) = 0$. (This section describes the rational of Art. 14 VORA).

Combining both modifications, the final RA contribution reads: $a_{rt}^{mod} = (1+\tau)(\tilde{C} - \hat{\beta}_{r(t-1)})$

7. RA with Pharmaceutical Cost Groups

The RA formula discussed so far has been based on R categorical risk groups. Since 2020 the formula is extended, and insured are simultaneously assigned to a risk group r and to none, one, or several pharmaceutical cost groups (PCG). Pharmaceutical cost groups contain individuals with expected costs above average even after adjusting for risk differences between the R risk groups. Attachment to a PCG is defined by the specific set of pharmaceuticals group members consume.

Again, OLS is applied to calculate the parameters needed for risk adjustment:

(2) $$C_j = \sum_{r=1}^{R} \tilde{\beta}_r s_{rj} + \sum_{q=1}^{Q} \pi_q p_{qj} + \varepsilon_j$$

Expression (2) compared with (1) is extended by p_{qj}, a dummy variable that assigns individual *j* to PCG *q*, when equal to one, else it is equal to zero, and π_q, the additional costs members of PCG *q* predictably have after being equalized based on *R* risk groups. In other words, there are *Q* different PCG groups and $\hat{\pi}_q$ is the contribution paid by RA for each member of the specific PCG q, in order to subsidies his or her above average costs. $\hat{\pi}_q$ is positive by law, because whenever a $\hat{\pi}_q < 0$ occurs, this specific PCG must be excluded (Art. 16 sec. 3 VORA).

The PCG-subsidy for each individual *j* reads: $\Pi_j = \sum_{q=1}^{Q} \hat{\pi}_q p_{qj}$, for individuals without PCG-entitlement all their $p_{qj} = 0$, and so is their Π_j.

To express the difference between $\hat{\hat{\beta}}_r$ (from expression (2)) and $\hat{\beta}_r$ (from expression (1)), we sort all indices j according to the risk group *r*, they belong to, in ascending order, such that for each *j* belonging to *r* : $j \in [J_r^{MIN}; J_r^{MAX}]$, with $J_r^{MAX} - J_r^{MIN} + 1 = n_r$ and $J_r^{MAX} + 1 = J_{(r+1)}^{MIN}$, as long as $(r+1) \leq R$. Average PCG-subsidy per risk group *r* reads:

(3) $\quad \bar{\Pi}_r = \frac{1}{n_r} \sum_{j=J_r^{MIN}}^{J_r^{MAX}} \Pi_j$.

Now $\hat{\beta}_r - \hat{\hat{\beta}}_r = \bar{\Pi}_r$, since $\bar{\Pi}_r$ this is the average amount of money taken out from the respective risk group to be transferred to the PCG-people of risk group *r*.

We know from section 6, that the sum of transfers in between risk groups is zero: $\sum_{r=1}^{R} n_r a_r = \sum_{r=1}^{R} n_r \left(C - \hat{\beta}_r\right) = 0$. Since $\hat{\hat{\beta}}_r + \bar{\Pi}_r = \hat{\beta}_r$ it follows: $n_r \left(C - \hat{\hat{\beta}}_r\right) = n_r \bar{\Pi}_r$ which is equivalent to all PCG-transfers of the respective risk group: $\sum_{j=J_r^{MIN}}^{J_r^{MAX}} \Pi_j$. Therefore, PCG transfers are a zero-sum game within each risk group, or all PCG transfers for members of group *r* are financed by all members of the respective group *r*. The contribution for insured *j* in risk group *r* reads:

(4) $\quad a_j^{PCG} = C - \tilde{\beta}_{r(j)} - \Pi_j,$

And the average RA contribution per risk group r reads: $a_r^{PCG} = C - \tilde{\beta}_r - \bar{\Pi}_r = C - (\beta_r - \bar{\Pi}_r) - \bar{\Pi}_r = C - \beta_r = a_r$. This implies for any risk group: Expected RA contributions per risk group remain unchanged, $a_r^{PCG} = a_r$, and all conclusions from section 5 still hold.

8. Further Reading

This paper’s focus is on the “why” of Risk Adjustment. The “how” can be derived from Bürgin, while the legal grounds are discussed in Beck. Readers interested in a more profound discussion of this topic might also have a look at Schmid et al. or McGuire and van Kleef. Mathematical proofs are given in Frisch, Waugh, and Lovell.

R. Bürgin, 2020: Berechnungsformeln für den Risikoausgleich mit PCG ab 2020. PDF, Bundesamt für Gesundheit, 2020.

K. Beck, 2020: KVG Art. 16-17a. In: Blechta / Colatrella / Rüedi / Staffelbach (Hrsg.): Basler Kommentar KVG & KVAG. Helbing Lichtenhahn, Basel, 168-278.

Th. G. McGuire & R.C. van Kleef, 2018: Risk Adjustment, Risk Sharing and Premium Regulation in Health Insurance Markets – Theory and Practice. London (Elsevier).

C.P.R. Schmid, K. Beck, L. Kauer, 2018: Health Plan Payment in Switzerland, in: McGuire/van Kleef: ebenda, 2018, S. 453-489.

R.R. Frisch, F. Waugh, 1933, Partial time regressions as compared with individual trends, Econometrica, 45, S. 939-953.

M. Lovell, 1963, Seasonal adjustment of economic time series, Journal of the American Statistical Association, 58, 993-1010.