Premium indexing in lifelong health insurance*

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Abstract

For lifelong health insurance covers, medical inflation not incorporated in the level premiums determined at policy issue requires an appropriate increase of these premiums and/or the corresponding reserves during the term of the contract. In this paper, we investigate appropriate premium indexing mechanisms, based on a given medical inflation index. First, we consider a general relation between benefit, premium and reserve increases, which can be used on a yearly basis to restore the actuarial equivalence that is broken due to observed medical inflation over the past year. Next, we consider an individual premium indexing mechanism, depending on the age at policy issue, which makes the relative premium increases above the observed medical inflation more stable over time. Finally, we consider an aggregate premium indexing mechanism for a portfolio of new entrants, where the relative premium increase above observed inflation is independent of age-at-entry, introducing intergenerational solidarity.

Key words: medical expense insurance, lifelong contract, medical inflation index, reserve.

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1 Introduction

We consider health insurance contracts, more specifically medical expense reimbursement policies (or forfeiture daily allowance policies) offered as term or lifelong insurance covers with level premiums. As is the case in life insurance, level premiums lead to asset accumulation in a reserve.

In general, the benefits that will be paid over the years for a term or lifelong health insurance portfolio will be impacted by a number of unpredictable factors, such as changes in prices for medical goods and services and demographic evolutions of the insured population. Given the long-term nature of health insurance contracts and the impossibility to predict or hedge against medical inflation, insurers often do not take into account or are not able to fully account for this medical inflation in the setting of the premium level at policy issue. Instead, during the term of the contract, they adapt the premium amounts at regular times (e.g. yearly), based on some predefined medical inflation index. This practice is used in several EU member countries (for instance, in Germany and in Belgium). This approach efficiently counteracts the systematic risk induced by medical inflation impacting all the policies of the portfolio in the same direction.

The reference medical index may be based on a representative basket of medical goods and services of which the price is followed over time, or on industry-wide loss data. Besides public agencies, also private consulting firms develop indicators for medical insurance. See, e.g., Da Silva (2007), Devolder and Yerna (2008) and Ranjee et al. (2011). In this paper, we do not discuss the construction of the index but, given a certain medical index, we propose several premium indexing mechanisms aimed at maintaining fairness between policyholders and insurer. The medical index considered in this paper is assumed to account for all sources of inflation, not only the increase in medical costs above the inflation taken into acount by the "usual" consumer price index. Important to notice is that not only future premiums need to be increased to take into account the medical inflation, but also the reserve may need to be adapted in order to restore the actuarial equivalence that must exist between the liabilities of both partners of the insurance contract.

The remainder of this paper is organized as follows. Section 2 discusses a premium indexing mechanism. This method is illustrated with numerical examples in Section 3. The final section briefly concludes.

2 Indexing for medical inflation

2.1 Benefit structure

We consider health insurance contracts with non-transferable reserves (that is, the reserve is not paid out to the insured when he lapses the contract), as it is typically the case on the Belgian market. It is obvious that the non-transferability of the reserves has a premium-reducing effect. Hereafter, time t measures the seniority of the policy (i.e., the time elapsed since policy issue). Policyholder's age at policy issue is denoted by x, so that age at time t is $x+t$. We denote the ultimate age by ω (in case of a lifelong cover, the policy is assumed to cease at age ω).

The superscript "(0)" is used to denote quantities determined at policy issue. The average annual claim amount at age $x+j$, $j=0,1,2,\ldots,\omega-x-1$, is denoted as $c_{x+j}^{(0)}$. Notice that j refers to the time passed since policy issue and that the the superscript "(0)" indicates that the benefits $c_{x+j}^{(0)}$ are determined at time 0.

Henceforth, we assume that the annual claim amounts are subject to inflation, whereas the other elements of the technical basis (interest rate, mortality rate and lapse rate) are in line with the reality that unfolds over time (which implies that these elements don't have to be indexed over time in order to maintain actuarial equilibrium). This simplifying assumption is not realistic but allows us to isolate and investigate the effect of medical inflation.

2.2 Level premiums

The non-exit probability ${}_kp_{x+t}$ is the probability that a policy in force at age $x+t$ is still in force k years later, that is,

$$
\begin{aligned}
{}_kp_{x+t} &= \exp\left(-\int_0^k \big(\mu_{x+t+s}+\lambda_{x+t+s}\big)ds\right), \\
&= \left(1-\ {}_kq_{x+t}^{[d]}\right)\left(1-\ {}_kq_{x+t}^{[w]}\right),
\end{aligned}
$$

where μ_{x+t+k} is the instantaneous death rate at age $x+t+k$, while λ_{x+t+k} is the instantaneous lapse rate at the same age. The notations ${}_kq_{x+t}^{[d]}$ and

${}_kq_{x+t}^{[w]}$ are used to denote the absolute rates of decrement (also called the independent probabilities of exiting), i.e.

$$ {}_kq_{x+t}^{[d]} = 1 - \exp\left(-\int_0^k \mu_{x+t+s} ds\right) \text{ and } {}_kq_{x+t}^{[w]} = 1 - \exp\left(-\int_0^k \lambda_{x+t+s} ds\right). $$

Assuming that the benefits are paid at the beginning of the year (a convenient and conservative, yet unrealistic assumption), the expected present value of all future benefits, evaluated at policy issue, is denoted by

$$ B_x^{(0)} = \sum_{k=0}^{\infty} c_{x+k}^{(0)} v(0,k)\ {}_kp_x, $$

where $v(s,t), s \leq t$, is the discount factor over the period (s,t). Notice that the sum in this expression is a finite sum, as ${}_kp_x = 0$ if $k \geq \omega - x$.

Assuming that level premiums of amount $\pi_x^{(0)}$ are paid yearly in advance as long as the policy is in force, the actuarial equivalence principle gives rise to

$$ \pi_x^{(0)} = \frac{B_x^{(0)}}{\ddot{a}_x} \text{ where } \ddot{a}_x = \sum_{k=0}^{\infty} v(0,k)\ {}_kp_x. $$

Note that the premium calculation is based on the expected costs $c_{x+k}^{(0)}$ evaluated at time 0, without allowance for future inflation. An alternative, not studied in the present paper, consists in computing $\pi_x^{(0)}$ from expected costs $c_{x+k}^{(0)}$ impacted by an assumed scenario for future medical inflation. The framework described in this paper can be adapted to take into account such a scenario.

2.3 Indexing at time $t = 1$

Henceforth, the superscript "(t)", $t = 1, 2, \ldots$, is used to indicate that the calculations include medical inflation from policy issue to time t. According to the equivalence principle, the level premium $\pi_x^{(0)}$ is determined such that the initial reserve $V_0^{(0)}$ is equal to 0:

$$ V_0^{(0)} = B_x^{(0)} - \pi_x^{(0)} \ddot{a}_x = 0. \tag{1} $$

The benefits paid in year $(0,1)$ are denoted by $c_x^{(0)}$. As mentioned before, we assume that the observed mortality, lapse and interest rates follow the technical basis assumptions. We denote the available reserve per policy in force at time 1 by $V_1^{(0)}$. This reserve is given by

$$V_1^{(0)} = \left[\pi_x^{(0)} - c_x^{(0)}\right] \left[v(0,1)\ {}_1p_x\right]^{-1}.$$

Taking into account the equivalence relation (1), one can transform this retrospective expression for $V_1^{(0)}$ into the following prospective expression:

$$V_1^{(0)} = B_{x+1}^{(0)} - \pi_x^{(0)} \ddot{a}_{x+1},$$

where

$$B_{x+1}^{(0)} = \sum_{k=0}^{\infty} c_{x+1+k}^{(0)} {}_kp_{x+1} v(1, 1+k)$$

and

$$\ddot{a}_{x+1} = \sum_{k=0}^{\infty} v(1, 1+k)\ {}_kp_{x+1}.$$

Hence, the available reserve at time 1, i.e. $\left[\pi_x^{(0)} - c_x^{(0)}\right] \left[v(0,1)\ {}_1p_x\right]^{-1}$, is equal to the required reserve at time 1, i.e. $B_{x+1}^{(0)} - \pi_x^{(0)} \ddot{a}_{x+1}$, provided all assumptions concerning the technical basis are met.

Medical inflation is taken into account ex-post as it emerges over time by adapting the premium amount from year to year according to the procedure described hereafter. Let $j_1^{[B]}$ be the medical inflation observed during the first year. Due to this observed medical inflation, at time 1 the expected present value of the future benefits $B_{x+1}^{(0)}$ has to be replaced by

$$B_{x+1}^{(1)} = (1 + j_1^{[B]}) B_{x+1}^{(0)}.$$

Note that we assumed that the yearly expected costs at all ages are impacted equally by the medical inflation, i.e. the identity $c_{x+t}^{(1)} = (1 + j_1^{[B]}) c_{x+t}^{(0)}$ is assumed to hold for all t. An alternative, not studied in the present paper, is that medical inflation depends on age. It is a rather straightforward exercise to adapt the ex-post premium indexing mechanism that we present hereafter to the situation with age-dependent medical inflation.

Due to the observed medical inflation, we find that

$$V_1^{(0)} \neq (1 + j_1^{[B]}) B_{x+1}^{(0)} - \pi_x^{(0)} \ddot{a}_{x+1},$$

which means that the actuarial equivalence is broken, i.e. the available reserve is different from the required reserve.

To restore the actuarial equivalence, the insurer has to adapt the premiums and/or reserve for this contract. Suppose that the level premium $\pi_x^{(0)}$ is from time 1 on replaced by $\pi_x^{(1)}$, while the available reserve $V_1^{(0)}$ at time 1 is changed into $V_1^{(1)}$. The proportional increases of the premium and the reserve are denoted by $j_1^{[P]}$ and $j_1^{[V]}$, respectively, that is,

$$\pi_x^{(1)} = (1 + j_1^{[P]})\pi_x^{(0)} \text{ and } V_1^{(1)} = (1 + j_1^{[V]})V_1^{(0)}.$$

Following Pitacco (1999), $j_1^{[P]}$ and $j_1^{[V]}$ are chosen such that the actuarial equivalence is restored at time 1, i.e. such that

$$(1 + j_1^{[V]})V_1^{(0)} = (1 + j_1^{[B]})B_{x+1}^{(0)} - (1 + j_1^{[P]})\pi_x^{(0)}\ddot{a}_{x+1},$$

or, equivalently,

$$V_1^{(1)} = B_{x+1}^{(1)} - \pi_x^{(1)}\ddot{a}_{x+1}.$$

This means that the available reserve at time 1, i.e. $V_1^{(1)}$ is equal to the required reserve at time 1, i.e. $B_{x+1}^{(1)} - \pi_x^{(1)}\ddot{a}_{x+1}$.

From time 1 on, the original level premiums $\pi_x^{(0)}$ that were determined at policy issue, are replaced by new level premiums $\pi_x^{(1)}$. Notice that the premium increases $j_1^{[P]}\pi_x^{(0)}$ are financed by the policyholder, while the reserve increase $j_1^{[V]}V_1^{(0)}$ is financed by the insurer. In practice, the insurer may finance the reserve increase, partially or fully, from technical gains on interest, mortality and lapses.

2.4 Indexing at time $t = 2, 3, \ldots$

Let us now suppose that we are at time t, $t = 2, 3, \ldots$. Reevaluations up to time $t - 1$ have lead to

$$\begin{aligned}
c_{x+t+k}^{(t-1)} &= c_{x+t+k}^{(0)} \prod_{h=1}^{t-1} (1 + j_h^{[B]}), \qquad k = 0, 1, \ldots, \\
B_{x+t}^{(t-1)} &= \sum_{k=0}^{\infty} c_{x+t+k}^{(t-1)} {}_k p_{x+t} v(t, t+k), \\
\pi_x^{(t-1)} &= \prod_{h=1}^{t-1} (1 + j_h^{[P]})\pi_x^{(0)}.
\end{aligned}$$

At each time $1, 2, \ldots, t-1$, the available reserve and the premium have been reset such that available and required reserve are equal. In particular, at time $t-1$, the available reserve $V_{t-1}^{(t-1)}$ and the premium $\pi_x^{(t-1)}$ have been reset such that

$$V_{t-1}^{(t-1)} = B_{x+t-1}^{(t-1)} - \pi_x^{(t-1)} \ddot{a}_{x+t-1}. \tag{2}$$

The reserve available at time t for a person aged x at policy issue, taking into account all information until time $t-1$, is then given by

$$V_t^{(t-1)} = \left[V_{t-1}^{(t-1)} + \pi_x^{(t-1)} - c_x^{(t-1)} \right] \left[v(t-1, t)\ {}_1p_{x+t-1} \right]^{-1}.$$

Taking into account (2), the following prospective expression can be derived for the available reserve:

$$V_t^{(t-1)} = B_{x+t}^{(t-1)} - \pi_x^{(t-1)} \ddot{a}_{x+t}.$$

Let $j_t^{[B]}$ be the medical inflation observed during the year $(t-1, t)$. Therefore, at time t we have to replace $B_{x+t}^{(t-1)}$ by

$$B_{x+t}^{(t)} = (1 + j_t^{[B]}) B_{x+t}^{(t-1)}.$$

The actuarial equivalence is again broken, in the sense that the available reserve is not equal to the required reserve:

$$V_t^{(t-1)} \neq (1 + j_t^{[B]}) B_{x+t}^{(t-1)} - \pi_x^{(t-1)} \ddot{a}_{x+t}.$$

In order to restore the actuarial equivalence, the premium and reserve are adapted to

$$\pi_x^{(t)} = (1 + j_t^{[P]}) \pi_x^{(t-1)} \text{ and } V_t^{(t)} = (1 + j_t^{[V]}) V_t^{(t-1)},$$

such that the available reserve and the required reserve are equal:

$$(1 + j_t^{[V]}) V_t^{(t-1)} = (1 + j_t^{[B]}) B_{x+t}^{(t-1)} - (1 + j_t^{[P]}) \pi_x^{(t-1)} \ddot{a}_{x+t}, \tag{3}$$

or, equivalently,

$$V_t^{(t)} = B_{x+t}^{(t)} - \pi_x^{(t)} \ddot{a}_{x+t}.$$

The actuarial equivalence may be restored by an infinite number of pairs $\left(j_t^{[V]}, j_t^{[P]} \right)$. When $j_t^{[V]} = 0$, the benefit increase is completely paid by the policyholder. On the other hand, choosing $j_t^{[P]} = 0$ means that the benefit increase is completely financed by the insurer.

2.5 Relationships between $j_t^{[B]}$, $j_t^{[V]}$ and $j_t^{[P]}$

The benefit inflation $j_t^{[B]}$ is equal to a weighted arithmetic average of $j_t^{[V]}$ and $j_t^{[P]}$, with weights that sum up to 1, that is,

$$j_t^{[B]} = \left(\frac{V_t^{(t-1)}}{B_{x+t}^{(t-1)}} \right) \, j_t^{[V]} + \left(\frac{\pi_x^{(t-1)} \ddot{a}_{x+t}}{B_{x+t}^{(t-1)}} \right) \, j_t^{[P]}. \tag{4}$$

This relationship between $j_t^{[B]}$, $j_t^{[V]}$ and $j_t^{[P]}$ follows immediatly from the actuarial equivalence condition (3).

The 'equilibrium restoring procedure', expressed by (3) or equivalently by (4), applied on a contract per contract basis, is an actuarial sound system (provided the assumptions we made are met). Notice however that before the procedure can be applied in practice, a choice has to be made about how the additional cost arising from the unanticipated inflation is shared between the policyholder and the insurer. A simple and transparant rule, unambigously described in the policy conditions, is appropriate here. Taking into account that we assumed that, apart from the inflation, all assumptions made in the technical basis are met, it may be reasonable to set $j_t^{[V]} = 0$, implying that the insured finances the increased future benefits. The premium increase $j_t^{[P]}$ can then be determined on a yearly basis from the equilibrium condition (3).

A problem with the procedure explained above is that the premium increases $j_t^{[P]}$ may fluctuate heavily from year to year. Therefore, we propose a more stable procedure. In particular, let us assume that the policy stipulates that the yearly premium increase $j_t^{[P]}$ is given by

$$j_t^{[P]} = (1+\alpha)\, j_t^{[B]}, \qquad t = 1, 2, \ldots \tag{5}$$

for some fixed value of α. Suppose e.g. that $\alpha = 0.5$, then a medical inflation of 4% will lead to a premium increase of 6%. The extra increase $\alpha \times j_t^{[B]}$ over the benefit inflation $j_t^{[B]}$ can be interpreted in terms of the policyholder's contribution to the reevaluation of the reserve.

Taking into account (4) and (5), we find the following results for the case where the premium increase is set equal to the benefit increase:

$$\alpha = 0 \;\Rightarrow j_t^{[P]} = j_t^{[V]} = j_t^{[B]}.$$

Hence, in case the proportional premium increase is chosen equal to the proportional benefit increase, we find that the reserve has to be increased by the same proportion in order to restore the actuarial equivalence. Also,

$$\begin{aligned}\alpha &> 0 \Rightarrow j_t^{[P]} > j_t^{[B]} \text{ and } j_t^{[V]} < j_t^{[B]},\\ \alpha &< 0 \Rightarrow j_t^{[P]} < j_t^{[B]} \text{ and } j_t^{[V]} > j_t^{[B]}.\end{aligned}$$

This means that if the proportional premium increase is set larger (respectively smaller) than the proportional benefit increase, then the required proportional increase of the reserve is lower (respectively higher) than the benefit increase. Taking into account our assumption that there are no technical gains, a strictly positive value of α will be appropriate. From equation (4) it follows that the relative required reserve increase $j_t^{[V]}$ is a decreasing function of $\alpha = \left(j_t^{[P]} - j_t^{[B]}\right)/j_t^{[B]}$.

2.6 A stable premium indexing mechanism

The advantage of a premium indexing mechanism of the form (5) is that it makes the relative increase of the premium over time more stable.The value of α in (5) could be fixed in the policy. Alternatively, it could be determined on a regular basis (e.g. every couple of years) according to a well-specified procedure, or it could be provided by the regulator on a regular basis. The choice of a 'fair' value of α is crucial. If α is too low, the insurer will have to finance the future increases of the reserves himself. On the other hand, if α is too high, the policyholder will consider the insurance contract as an unfair deal, and eventually not buy the contract. Hereafter, we present some possible ways to determine the factor α.

2.6.1 Optimal α for a given age at policy issue

To determine an appropriate value for the factor α on a single policy corresponding to the age at policy issue x, we propose to calculate the actuarial present value of all future required reserve increases as

$$APV_x(\alpha) = \sum_{t=1}^{\infty} j_t^{[V]} V_t^{(t-1)} \; {}_t p_x v(0,t). \tag{6}$$

Thus, $APV_x(\alpha)$ expresses the actuarial value of the future reserve increases for this contract. Under the appropriate assumptions, it can be interpreted as the extra capital to be injected by the insurer in order to fund all future required reserve increases.

A positive value of $APV_x(\alpha)$ points to an actuarial loss while a negative $APV_x(\alpha)$ is an actuarial gain on this contract for the insurer. Taking into account that we assumed that there emerge no technical gains on interest, mortality and lapse rates, the contract can be considered as fair for both parties if $APV_x(\alpha) = 0$. The optimal α for a given age at policy issue, which will be denoted by α_x^*, is then determined by setting the expected present value of all future required reserve increases equal to 0, i.e. α_x^* is the root of the equation $APV_x(\alpha) = 0$.

Of course, the determination of the optimal α at time 0 requires the knowledge of $j_t^{[V]}$, $t = 1, 2, \ldots$, which correspond to the future medical inflation $j_t^{[B]}$, $t = 1, 2, \ldots$, unknown at policy issue. Thus, determining α_x^* according to the principle explained above requires an assumption for the future medical inflation.

2.6.2 Optimal α for a given portfolio of new entrants

In general the optimal "extra premium increase factor α" is dependent on the age at policy issue. Although from an actuarial point of view it is possible to work with an age-dependent α_x^*, consumers and regulators may prefer a more straightforward and simple approach, where the optimal α is independent of the age at policy issue. Hereafter, we propose a possible way to determine this age-independent optimal α which will be denoted by α^*. We first define

$$APV(\alpha) = \sum_{x=x_0}^{\omega-1} n_x \times APV_x(\alpha),$$

where x_0 is the youngest age of entry and n_x is the estimated number of entrants at age x in this portfolio. Hence, $APV(\alpha)$ expresses the actuarial value of the future reserve increases for this portfolio of new entrants. A positive value of $APV(\alpha)$ corresponds to an actuarial loss, while a negative value of $APV(\alpha)$ is an actuarial gain on this portfolio for the insurer. The optimal value of α, which will be denoted by α^*, is then determined as the root of the equation $APV(\alpha) = 0$. Remark that the use of an age-independent optimal α has the advantage (or disadvantage) that it introduces intergenerational solidarity.

Determining α^* according to the principle explained above again requires an assumption for the future medical inflation. The numerical illustrations carried out in the next section show that several scenario's of future inflation lead to similar values of α^*, indicating that the optimal α^* is rather robust to the magnitude of medical inflation.

3 Numerical illustration

3.1 Technical basis

In the numerical examples, the discount factors correspond to a constant yearly interest rate of 2%. The absolute rate of decrement due to death $q_y^{[d]}$ conforms to the first Heligman-Pollard law, that is,

$$\frac{q_y^{[d]}}{1-q_y^{[d]}} = A^{(y+B)^C} + De^{-E(\ln y - \ln F)^2} + GH^y$$

with $A = 0.00054$, $B = 0.017$, $C = 0.101$, $D = 0.00013$, $E = 10.72$, $F = 18.67$, $G = 1.464 \times 10^{-5}$ and $H = 1.11$. Furthermore, we consider a lifelong cover and we fix the ultimate age to $\omega = 110$.

In line with current practice on the Belgian market, we assume that the one-year absolute rate of decrement due to lapse $q_y^{[w]}$ is equal to $0.1-0.002(y-20)$ at age $y = 25, 26, \ldots, 70$ and 0 otherwise. The lapse rate only depend on the attained age and not on the time elapsed since policy issue.

Figure 1 displays the one-year independent probabilities $q_y^{[w]}$ and $\left(1-q_y^{[d]}\right)$, as well as the non-exit probabilities p_y entering the computations.

Based on health insurance data collected by the Italian National Institute of Statistics (ISTAT) graduated by the Italian Association of Insurance Companies (ANIA), we choose the annual average claim amounts at age y and estimated at time 0, equal to

$$c_y^{(0)} = 0.204476472 \times \exp(0.038637y), \qquad y \geq 20.$$

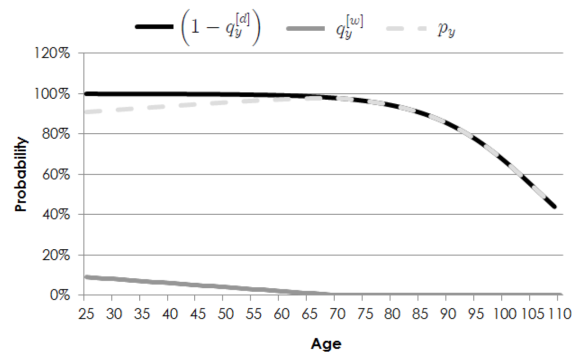

Figure 1: $q_y^{[w]}$, $\left(1-q_y^{[d]}\right)$ and p_y.

3.2 Initial premium and reserves

The level premium $\pi_x^{(0)}$ for an insured aged x at policy issue, $x = 25, 26, \ldots, 70$, is shown in Figure 2. The trajectory of the non-transferable reserves for a policyholder aged 25 at policy issue, assuming that no medical inflation is occurring during the term of the contract, is shown in Figure 3.

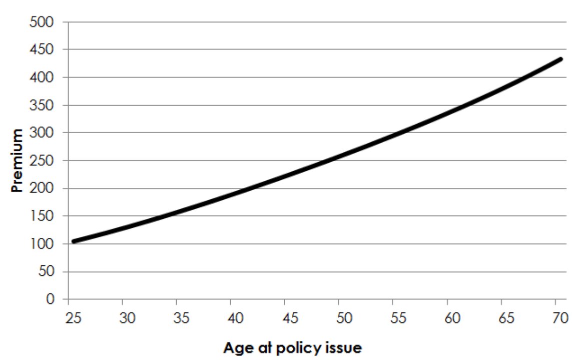

Figure 2: *Level premiums $\pi_x^{(0)}$ for different ages.*

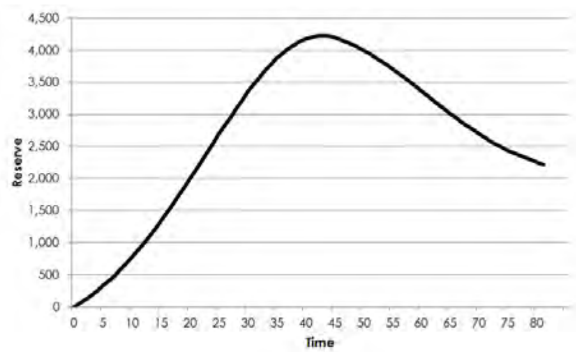

Figure 3: *Reserves* $V_t^{(0)}$ *for a person aged* 25 *at policy issue when* $j_t^{[B]} = 0$.

3.3 Optimal α as a function of the age at entry

Figure 4 displays the expected present value of all future reserve increases $APV_{25}(\alpha)$ as a function of α for 3 different scenario's of a constant inflation over time: $j_t^{[B]} = 2.5\%, 4\%$ and 6%, respectively, while $j_t^{[P]} = (1+\alpha)j_t^{[B]}$ for all t. Obviously, for a given inflation scenario, $APV_{25}(\alpha)$ is a decreasing function of α: the higher α, the more the policyholder finances the benefit increases himself. Further, for a given value of α, the function $APV_{25}(\alpha)$ is an increasing function of the level of inflation: a higher level of the inflation leads to higher required reserve increases. For the scenario where $j_t^{[B]} = 2.5\%$, the optimal α_{25}^* lies between 0.6 and 0.7. Increasing the yearly medical inflation to 4% or 6% leads to a steeper decreasing function $APV_{25}(\alpha)$ and decreases the value of the optimal value α_{25}^*. The optimal α_{25}^* turns out to be a decreasing function of the assumed medical inflation.

The previous calculations have been repeated for all ages x at policy issue between 20 and 70. The optimal values α_x^*, for the three scenarios of medical inflation ($j_t^{[B]} = 2.5\%, j_t^{[B]} = 4\%$ and $j_t^{[B]} = 6\%$), are depicted in Figure 5. The optimal factor α_x^* is a decreasing function of age x at policy issue. This is due to the shorter remaining period of the contract and the fact that the premium is an incrasing function of age at policy issue. From Figure 5, it is also clear that for older ages x, the benefit increase factor $j_t^{[B]}$ has a rather moderate effect on the optimal factor α_x^*. The explanation for this observation lies again in the shorter remaining term of the contract.

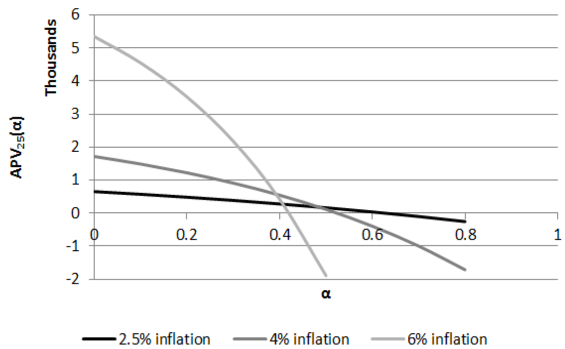

Figure 4: $APV_{25}(\alpha)$ *when* $j_t^{[P]} = (1+\alpha)j_t^{[B]}$.

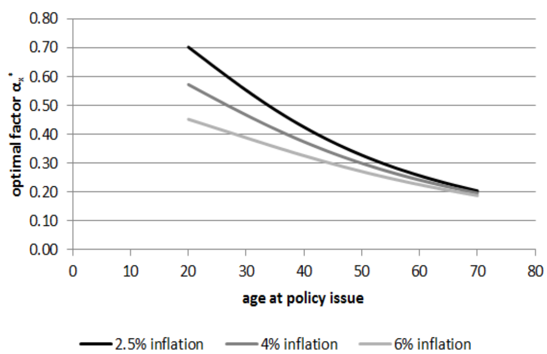

Figure 5: *The optimal factor* α_x^* *as a function of age at policy issue.*

3.4 Optimal α for a portfolio of new entrants

Let us suppose that the age of new entrants in a given year is distributed as shown in Figure 6. This distribution is based on Belgian data. The high number of new entrants at age 20 is due to the fact that contracts for ages younger than 20 are yearly renewable and priced on a risk premium basis, while the level premium structure with indexation as described above is only applied from age 20 onwards.

The actuarial present value of the future reserve increases $APV(\alpha)$ as a function of the factor α is given in Figure 7 for three scenarios of medical inflation ($j_t^{[B]} = 2.5\%, j_t^{[B]} = 4\%$ and $j_t^{[B]} = 6\%$). We observe that for a given inflation scenario, $APV(\alpha)$ is a decreasing function of α, while for a given value of α, the function $APV_{25}(\alpha)$ is an increasing function of the level of inflation. For $j_t^{[B]} = 2.5\%$, the optimal α^* lies between 0.4 and 0.5. Increasing the yearly medical inflation to 4% or 6% leads to a steeper decrease of the function $APV(\alpha)$ and decreases the value of the optimal value α^*. Despite this decreasing effect, the hight of the medical inflation seems to have only a moderate effect on the optimal value α^*.

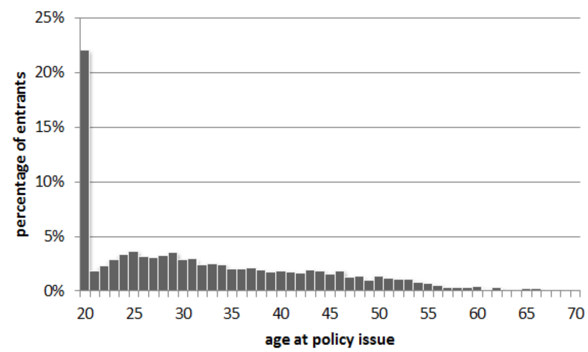

Figure 6: *Distribution of the age of new entrants.*

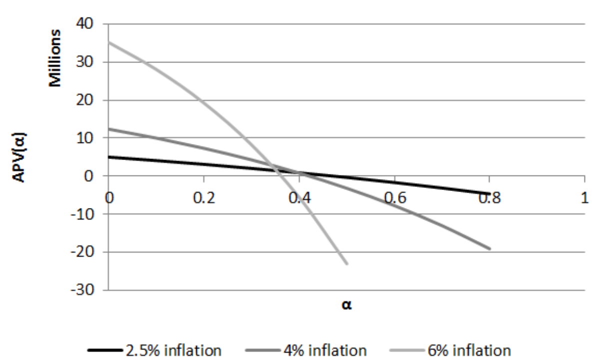

Figure 7: *$APV(\alpha)$ as a function of α in case $j_t^{[P]} = (1+\alpha)j_t^{[B]}$.*

4 Conclusion

In this paper, we considered lifelong health insurance contracts, with level premiums that are set up at policy issue, not taking into account future (upredictable) medical inflation. We propose some premium indexing mechanisms which yearly restore the actuarial equivalence, taking into account the observed medical inflation over the past year. First, we discussed the general relation that has to hold between yearly benefit, premium and reserve increases in order to account for the unanticipated inflation that has occured. This equation can in principle be used as the basis for indexing the premiums on a policy per policy and year to year basis, implying that the relative premium increase is a function of age at policy and of the number of years that the policy is in force. Next, we investigated a framework where the premium amount is supposed to be yearly impacted by the observed medical inflation multiplied with a factor $(1 + \alpha)$ for some $\alpha > 0$ which is chosen upfront. The proposed optimal value for α for a given age x at policy issue is then chosen such that the actuarial value of all future required reserve increases of the contract is equal to 0. This individual approch is supposed to make the yearly relative premium increases above the observed medical inflation more stable. Finally, we proposed an aggregate approach which is applicable to a whole portfolio of new entrants, where an overall optimal α is determined. The latter approach leads to age-independent relative premium increases above the medical inflation. Hence, it introduces intergenerational solidarity in the considered portfolio.

Throughout the paper, we have assumed that reserves are not transferable, which is in line with products currently offered on the Belgian market. Allowing for fully or partially transferable reserves is a topic for future research.

Note that the indexing mechanisms described in the present paper may also apply to other long term life and health insurance products. In life insurance for instance, adaptation to a changing mortality pattern can be performed in a similar way, defining appropriate mortality indices. This approach, which is an efficient hedge for systematic longevity risk, which is inherent in aging populations, is also a topic for future research.

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