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Abstract

We consider lifetime health insurance contracts in which ageing provisions are used to smooth the premium profile. The capital stock accumulated for each individual can be decomposed into two parts: a premium insurance and an annuitised life insurance, only the latter being transferable between insurers without triggering premium changes through risk segmentation. In a simulation based on German data, the transferable share declines in age and falls with an increasing age of entry into the contract. In spite of different benefit profiles, it is almost identical for women and men.

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1 Introduction

In Germany and Austria, private health insurance contracts are typically purchased by individuals and are made on a lifetime basis. A capital stock is built up so as to keep the annual premium constant during the contract period. One of the insurer's obligations involved in these contracts is making ageing provisions. These are accumulated in order to deal with an increase in expected benefits which can be attributed to two major reasons. First, even low risks experience a continuous deterioration of their health status over the life cycle. Second, the fraction of individuals who have turned into high risks rises as a birth cohort grows old. The latter phenomenon would be reflected in sharply increasing premiums if contracts were written on an annual basis. But, as insurers are neither allowed to terminate the contract nor to adjust the premium according to individual experience rating, lifetime contracts protect the insured against this premium risk.[1]

So far, public regulation imposes that individuals who would like to switch to another insurer cannot take any fraction of their ageing provision with them. Since this involves substantial losses already after a few years of duration of the contract, the insured are effectively tied to their insurer, which hampers competition. Indeed, Dowd and Feldman (1992), and Hendel and Lizzeri (2003) consider the fear of being locked into a long-term contract with an insurer providing an unpleasant service as a major obstacle against establishing long-term health insurance contracts in the US. On the other hand, transferring total ageing provisions to the new insurer would trigger a process of risk segmentation. Individuals who still represent low risks would switch to a new insurer in order to save premiums. For the remaining insured cohort premiums would have to be increased.

This paper explores how a scheme of transferable ageing provisions can be designed

[1] By international standards, these features are next to unique. In most countries, unfunded systems of public health care or public health insurance solve the premium risk problem. In countries where private health insurance has a considerable market share, like in the US, an analogous, but limited, kind of cover is often provided through employer-based group insurance contracts.

without imposing disadvantages on those who stay with the initial insurer. The basic idea is to reconstruct German-style, lifetime insurance contracts through a series of annual contracts with guaranteed renewability (Pauly et al. 1995) that are supplemented by an annuity meant to smooth the premium profile. Taking into account that becoming a high risk is associated with a reduction in life expectancy, the present value of the annuity of a low risk exceeds the corresponding amount of a high risk. The capital stock accumulated for the annuity of a low risk constitutes the transferable share of total ageing provisions. In a competitive insurance market, healthy individuals could then switch to other insurers without incurring any financial loss. As in the original proposal of Pauly et al., there would be no lock-in for low risks. In fact, the lock-in for low risks in the German scheme is created through imposing a level premium, and the transfer scheme would be unnecessary without this regulation. At the same time, individuals facing higher health risks would be protected against the financial consequences of low risks systematically leaving the pool. Given that the insurer is bound to keep the premium constant while having to serve the liabilities, the proposed transfer scheme just makes him indifferent between continuing and terminating the contract of a low risk. Nothing would change if he had to agree to the decision of the insured, as the deterioration of the risk structure would just be offset by the higher provisions per remaining insured.

Such a solution is efficient if transfers that are differentiated by health status are not feasible and low risks and high risks are sufficiently distinct (Meier, 2005). Since there is still no premium risk and low risks can terminate unsatisfactory relationships with their insurer, a Pareto improvement is achieved compared to the current situation with a level premium and a ban on ageing provision transfers. While the annuity contract can also exist as a separate arrangement to achieve perfect consumption smoothing across time and states of health, integrating this element into the health insurance contract is neutral with respect to efficiency.

If transfers could be made contingent on the state of health of the switching individual, it would be superior to assign higher transfers to high risks who want to terminate an unpleasant relationship with their insurer, in line with Cochrane's (1995) idea of time-consistent health insurance. Ideally, the transfer could then subsidize higher premiums to be paid to the new insurer such that high risks also would not incur any financial loss when switching. Designing such a scheme in practice is however difficult. In particular, if the health prospects of an individual cannot be verified at court at a low cost, there would be a substantial risk of wasteful disputes between old and new insurer. The new insurer would tend to ask for a high transfer, declaring that the insured constitutes a high risk, while the old insurer could save money if the individual were assessed as being healthy. Analogous problems arise if there are several types of high risks, associated with different amounts of transfer payments.

Using official German data on mortality and expenditure in private health insurance and setting plausible parameters for transitions between health states, we find that the share of ageing provisions that is transferable is generally positive until death. This result goes along with the finding in Herring and Pauly (2006) that the premium profile in health insurance contracts with guaranteed renewability is increasing in age almost everywhere. As pointed out earlier by Pauly et al. (1995) and Frick (1998), this conclusion is not immediate from theoretical considerations alone. In contracts with guaranteed renewability, the premium consists of two components, reflecting expected health care costs of a low risk in the current year and a contribution to the premium insurance. The latter captures the increase in the present value of expected benefits when turning into a high risk during the year. This present value becomes small when the remaining life expectancy is getting short. It is therefore easy to construct examples where the total premium declines in age. Smoothing the premium profile would then involve a reverse annuity, implying negative transfers of provisions, or exit premiums, for those who would like to leave their insurer.

Our paper shows how the decomposition of ageing provisions could work in practice and demonstrates that the share of transferable ageing provisions generally decreases in age. This is due to the fact that the share of recipients in the premium insurance increases over time. Consequently, the capital stock per surviving insured that can be attributed to the annuity reaches its peak several years earlier than the stock that funds the premium insurance. In our baseline simulation where a male cohort is considered that enters the health insurance contract at age 30 and dies out 70 years later, the share of transferable ageing provisions falls from 91 per cent after one year to about 34 per cent after 69 years. The absolute amount of the potential transfer peaks after 33 years when individuals are aged 63.

According to our simulations, the profile of transferable shares is about the same for women and men. This is because two impacts offset each other. First, the profile of average benefits is less steep for females, annual benefits exceeding those for males before individuals reach the retirement age, while they are lower than the corresponding values for males afterwards. Therefore, the amount of ageing provisions for women is smaller than that for men, and the role of the annuity in smoothing total premiums is less pronounced. Second, the excess benefits of high risks are smaller for women than for men. This reduces the amount of ageing provisions related to the premium insurance. For men and women alike, entering the contract at higher age implies that the difference between maximum and minimum expected annual benefits goes down. Since some years are missing that are relatively inexpensive, the weight of the annuity insurance becomes smaller at any given age, and the share of transferable ageing provisions decreases.

The remainder of the paper is organized as follows. In section 2, we introduce the model and the parameters that are needed to run the simulations. In section 3, we describe the data and discuss some of the methodological issues involved. The results of the simulations are presented in section 4. Section 5 discusses the main findings and possible extensions.

2 The model

2.1 Structure and parameters

The model considers individual lifetime health insurance contracts. At any age x the insured population can be divided into two risk groups, low risks (l) with a time series of expected annual health care costs K_x^l and high risks (h) with expected health care costs K_x^h, where

$$K_x^h = f_x K_x^l \qquad \text{with} \qquad f_x > 1 \tag{1}$$

for $x = x_0, ..., \omega$. Because of risk screening by the insurer, all insured represent low risks at the age of entry x_0. At the end of each year x, a fraction $(1 - \lambda_x)$ of the low risks experiences a permanent deterioration of the health status. These individuals represent high risks from age $x + 1$ until they die. Thus, a long-term risk arising from variations in expected health costs, being reflected in the cost factor f_x, is added to the short-term cost risk. Over time, individuals die with risk-specific probabilities w_x^l and w_x^h at the end of each year, where $w_x^h \geq w_x^l$. The contract expires at the end of year ω when all members of the insured cohort will be dead. The evolution of the two risk groups (l_x, h_x) is described by equations (2) and (3):

$$l_{x+1} = l_x \lambda_x (1 - w_x^l), \tag{2}$$

$$h_{x+1} = h_x(1 - w_x^h) + l_x(1 - \lambda_x)(1 - w_x^l). \tag{3}$$

Average expected benefits per insured at age x, K_x, are given by a weighted average of K_x^l and K_x^h,

$$K_x = \frac{l_x + f_x h_x}{l_x + h_x} K_x^l, \tag{4}$$

and the average survival probability for year x, $(1 - w_x)$, equals

$$(1 - w_x) = \frac{l_x}{l_x + h_x}(1 - w_x^l) + \frac{h_x}{l_x + h_x}(1 - w_x^h). \tag{5}$$

To calculate insurance premiums we need to know the present values of expected benefits. With i being the (time-invariant) interest rate, the present value of average health care costs at age x, A_x, is

$$A_x = \frac{1}{l_x + h_x} \sum_{z=0}^{\omega - x} K_{x+z}(l_{x+z} + h_{x+z})(1+i)^{-z}, \tag{6}$$

which equals

$$A_x = K_x + \frac{1 - w_x}{1+i} A_{x+1}. \tag{7}$$

The risk-specific values A_x^l and A_x^h can be computed in the same way as in equation (7), using risk-specific mortality rates. In the case of an individual who is currently a low risk, we have to take into account the possibility of a transition into the high-risk status:

$$A_x^l = K_x^l + \frac{1 - w_x^l}{1+i}[\lambda_x A_{x+1}^l + (1 - \lambda_x) A_{x+1}^h], \tag{8}$$

$$A_x^h = K_x^h + \frac{1 - w_x^h}{1+i} A_{x+1}^h. \tag{9}$$

2.2 Level premium and ageing provisions

Lifetime health insurance contracts in Germany have to be calculated in such a way that premiums stay constant during the whole contract period. Risk assessment only takes place at the beginning of the contract. In subsequent periods, the insurer must not adjust premiums according to individual experience rating, and he is not allowed to terminate the contract. This implies that the level premium $\overline{P}_{x_0}$ which depends on the age of entry x_0 has to be equal to the annualized present value of total health care costs expected at the beginning of the contract. Note that, due to risk screening by the insurer, all insured represent low risks at their age of entry. Therefore, $\overline{P}_{x_0}$ is given by

$$\overline{P}_{x_0} = \frac{A_{x_0}}{a_{x_0}} = \frac{A_{x_0}^l}{a_{x_0}^l}, \tag{10}$$

where a_x is the value of an annuity of one capturing the average probabilities of dying, with

$$a_x = \frac{1}{l_x + h_x} \sum_{z=0}^{\omega - x} (l_{x+z} + h_{x+z})(1+i)^{-z} = 1 + \frac{1 - w_x}{1+i} a_{x+1}. \tag{11}$$

The corresponding risk-specific values for low and high risks, a_x^l and a_x^h, respectively, are given by

$$a_x^l = 1 + \frac{(1 - w_x^l)}{1+i}[\lambda_x a_{x+1}^l + (1 - \lambda_x) a_{x+1}^h] \tag{12}$$

and

$$a_x^h = 1 + \frac{(1 - w_x^h)}{1+i} a_{x+1}^h. \tag{13}$$

Since expected health care costs rise with age, the level premium first exceeds expected costs per insured. A capital stock, the ageing provision, is built up from the surpluses which is used in subsequent periods to pay for the difference between increasing average benefits and constant premiums.

The evolution of the ageing provision per insured at the end of year x, V_x, depends on average expected benefits and survival probabilities and can be described retrospectively or prospectively. Retrospectively, V_x is given by the sum of all net-injections (i.e., annual premiums minus expected annual benefits), plus interest payments and redistributed ("bequeathed") ageing provisions of individuals of the same age cohort who have died in the year under consideration. Therefore,

$$V_x = (V_{x-1} + \overline{P}_{x_0} - K_x)\frac{1+i}{1 - w_x}. \tag{14}$$

Prospectively, provisions are equal to future net liabilities of the insurer. These can be derived from the difference between the present value of expected insurance benefits and the present value of expected premium payments per insured. Using equation (11) to rewrite the premium payment as

$$\overline{P}_{x0} = \overline{P}_{x0}(a_x - \frac{1 - w_x}{1+i} a_{x+1}), \tag{15}$$

and isolating K_x in equation (7), equation (14) can be transformed into

$$V_x = (V_{x-1} + \overline{P}_{x_0} a_x - A_x)\frac{1+i}{1 - w_x} + (A_{x+1} - \overline{P}_{x_0} a_{x+1}). \tag{16}$$

Starting from zero provisions at the beginning of the contract ($V_{x_0-1} = 0$) and taking into account equation (10), it follows that

$$V_x = A_{x+1} - \overline{P}_{x_0} a_{x+1}. \tag{17}$$

If expected health care costs rise with age, ageing provisions are positive until the end of period ω.

2.3 Short-term health insurance and premium insurance

The contractual structure described here can be seen as a combination of three single arrangements: (*i*) a repeated short-term health insurance contract covering annual health costs year after year; (*ii*) a premium insurance meant to avoid variations in short-term insurance premiums that arise from changes in the risk classification of the insured; and (*iii*) an annuity that is used to smooth the premium schedule. The premium insurance deserves particular attention because it is the core element of the long-term relationship between insurer and insured. The premium risk arises from the possibility of a transition from the low risk to the high risk status during the contract period. It does not deal with variations in premiums due to increases in expected health costs for low risks growing old.

Pauly et al. (1995) describe a long-term health insurance contract which consists of the first two components, the short-term health insurance and the premium insurance. The resulting insurance contract with guaranteed renewability covers the premium risk by offering a guaranteed premium profile that is independent of any changes in the risk status of the insured. The premium schedule P^{GR} is constructed in a fashion that it never pays for anybody to leave the insurer. In other words, the present value of premium payments does not exceed the present value of expected health care costs for a low risk or a high risk at any point in time. Financing the higher costs of high risks is accomplished by introducing an element of front-loading. Formally, this element originates in the fact that the possibility of turning into a high risk is always reflected in the expected present value of benefits of a low risk. Risk-averse individuals will prefer such a scheme to an arrangement where short-term premiums vary with the current health status.

The way in which contracts with guaranteed renewability are calculated is summarized in equation (18). In general, the expected present value of premium payments of a low risk (PV_x^l) is equal to the present value of expected health care costs of a current low risk in all periods:[2]

$$PV_x^l(P^{GR}) = A_x^l \qquad \forall x = x_0, ..., \omega. \tag{18}$$

As risk screening by the insurer implies that all insured are of the low-risk type when entering the contract, lifetime premium payments cover expected health costs in full. Decomposing the right-hand and left-hand side expressions in equation (18) yields

$$\begin{aligned} P_x^{GR} + \frac{1-w_x^l}{1+i}[\lambda_x PV_{x+1}^l(P^{GR}) + (1-\lambda_x)PV_{x+1}^h(P^{GR})] \\ = K_x^l + \frac{1-w_x^l}{1+i}[\lambda_x A_{x+1}^l + (1-\lambda_x)A_{x+1}^h] \end{aligned} \tag{19}$$

and, therefore,

$$P_x^{GR} = \underbrace{K_x^l}_{P_x^S} + \underbrace{(1-\lambda_x)[A_{x+1}^h - PV_{x+1}^h(P^{GR})]\frac{1-w_x^l}{1+i}}_{P_x^{PI}}. \tag{20}$$

The premium P_x^{GR} can be interpreted as the long-term risk equivalent health insurance premium of a low risk at age x and consists of two parts. The first component, covering expected health care benefits of a low risk in the current year, represents the premium for short-term insurance, P_x^S. The second component, P_x^{PI}, relates to the premium insurance. It is determined based on the probability of becoming a high-risk type during the period, multiplied with the total loss should this actually happen. The latter is given by the difference between the present value of expected health care costs and premium payments

[2] As Kifmann (2002) argues, a premium schedule satisfying $PV_{x_0}^l(P^{GR}) = A_{x_0}^l$ and $PV_x^l(P^{GR}) \leq A_x^l$ with strict inequality for some x can also be interpreted as a scheme with guaranteed renewability. However, the construction in equation (18) is associated with the minimum front-loading element and enables us to isolate the premium insurance of the pure health insurance contract in a convenient fashion.

of a high risk, which would be reflected in higher annual premiums in a series of short-term contracts with experience rating. Note that, in our model, premiums are paid at the beginning of each period, while any changes in the health status occur at the end of the year – a timing which necessitates discounting the P^{PI}-term in equation (20) using the low risk mortality rate w_x^l. In contrast to the level premium, the premium schedule of the insurance contract with guaranteed renewability is independent of the age at entry.

The additional premium payments P_x^{PI} are used to accumulate a capital stock in order to finance higher annual costs of those individuals who turn into high risks. The financial flows related to these funds can be interpreted as follows. In each period, all insured individuals pay contributions to the premium insurance. Accumulated funds are then used to offset the difference between benefits and premiums of high risks in short-term health insurance. At the end of each period x, total funds of the premium insurance, V_x^{PI}, amount to

$$\begin{aligned} V_x^{PI} &= (V_{x-1}^{PI} + (l_x + h_x)P_x^{PI} - h_x(K_x^h - P_x^S))(1+i) \\ &= V_{x-1}^{PI}(1+i) + l_x(1-\lambda_x)(1-w_x^l)[A_{x+1}^h - PV_{x+1}^h(P^{GR})] \\ &\quad + h_x(1+i)(P_x^{GR} - K_x^h). \end{aligned} \tag{21}$$

Using equation (3) it follows that

$$\begin{aligned} V_x^{PI} &= V_{x-1}^{PI}(1+i) + h_{x+1}[A_{x+1}^h - PV_{x+1}^h(P^{GR})] - h_x[(1+i)K_x^h \\ &\quad + (1-w_x^h)A_{x+1}^h - (1+i)P_x^{GR} - (1-w_x^h)PV_{x+1}^h(P^{GR})] \\ &= (V_{x-1}^{PI} - h_x[A_x^h - PV_x^h(P^{GR})])(1+i) \\ &\quad + h_{x+1}[A_{x+1}^h - PV_{x+1}^h(P^{GR})]. \end{aligned} \tag{22}$$

Starting again with provisions of zero ($V_{x_0-1}^{PI} = 0$) finally yields

$$V_x^{PI} = h_{x+1}[A_{x+1}^h - PV_{x+1}^h(P^{GR})]. \tag{23}$$

The accumulated stock of capital equals the difference in the present values of future benefits and premium payments for all those who are currently high risks.

It turns out that the construction of insurance contracts with guaranteed renewability is indeed robust with respect to risk segmentation. Even if all individuals of an age cohort who still represent low risks leave their initial insurer at the end of period x, there is no need to increase premiums for the remaining members of the cohort. The additional costs they are facing are fully covered by the funds of the premium insurance. On the other hand, high risks are tied to the old insurer. They would incur substantial financial losses when switching to another insurer, thereby forfeiting their claims against the old insurer's premium insurance.

From a theoretical point of view it cannot be ruled out that the scheme described here violates the participation constraint of high risks in some periods. This would be the case if, due to a reduced life expectancy, the present value of premium payments exceeds the present value of expected health care costs for a high risk, that is $PV_x^h(P^{GR}) > A_x^h$. In this case, high risks in short-term health insurance represent low risks of the guaranteed renewable contract. Avoiding such a scenario requires a profile of premiums that satisfies

$$P_x^{GR} = \min \begin{bmatrix} A_x^l - \dfrac{1-w_x^l}{1+i}[\lambda_x PV_{x+1}^l(P^{GR}) + (1-\lambda_x) PV_{x+1}^h(P^{GR})]; \\ A_x^h - \dfrac{1-w_x^h}{1+i} PV_{x+1}^h(P^{GR}) \end{bmatrix}. \tag{24}$$

The change ensures that nobody will ever have an incentive to quit the insurer. When compared to the standard case given by (18), the front-loading element becomes stronger, smaller premiums in some periods being compensated by higher premiums in earlier periods. Neither the premium insurance premium nor the provisions related to it can ever become negative. Since a situation with an inverse risk structure does not arise in our simulations, we stick to the standard case in the following.

2.4 Annuities and the decomposition of ageing provisions

In the calculations so far, premiums for contracts with guaranteed renewability are not constant over time. Their time profile depends on the profiles of health care costs for low and high risks and on the probabilities of a transition from state l to state h. In addition, it is influenced by the interest rate and by the mortality rates. A premium that is entirely flat can be achieved by adding an annuitised life insurance that accumulates and decumulates another stock of capital. The resulting total premium is formally computed as the annualized present value of P^{GR}, the full premium profile for contracts with guaranteed renewability. It equals the level premium $\overline{P}_{x_0}$,

$$\overline{P}_{x_0} = \frac{PV_{x_0}^l(P^{GR})}{a_{x_0}^l} = \frac{A_{x_0}}{a_{x_0}}. \tag{25}$$

Net injections into the annuity funds, P_x^A, are given by the difference between the constant premium $\overline{P}_{x_0}$ and the premium schedule of contracts with guaranteed renewability. Since the net injections simply reallocate total premium payments over time, their expected present value equals zero at the beginning of the contract. The evolution of the additional capital stock for the whole insured cohort, V_x^A, is given by

$$V_x^A = (V_{x-1}^A + (l_x + h_x)P_x^A)(1+i). \tag{26}$$

Uniform net contributions P_x^A for the two risk types can be written as

$$P_x^A = PV_x^l(P^A) - \frac{1-w_x^l}{1+i}[\lambda_x PV_{x+1}^l(P^A) + (1-\lambda_x)PV_{x+1}^h(P^A)] \tag{27}$$

and

$$P_x^A = PV_x^h(P^A) - \frac{1-w_x^h}{1+i}PV_{x+1}^h(P^A). \tag{28}$$

Using equations (2) and (3), equation (26) can be transformed to

$$\begin{aligned} V_x^A &= V_{x-1}^A(1+i) + l_x[(1+i)PV_x^l(P^A) \\ &\quad -(1-w_x^l)(\lambda_x PV_{x+1}^l(P^A) + (1-\lambda_x)PV_{x+1}^h(P^A))] \\ &\quad +h_x\left[(1+i)PV_x^h(P^A) - (1-w_x^h)PV_{x+1}^h(P^A)\right] \\ &= \left(V_{x-1}^A + l_x PV_x^l(P^A) + h_x PV_x^h(P^A)\right)(1+i) \\ &\quad -\left(l_{x+1}PV_{x+1}^l(P^A) + h_{x+1}PV_{x+1}^h(P^A)\right). \end{aligned} \tag{29}$$

As again $V^A_{x_0-1}=0$, the provisions amount to

$$V_x^A = l_{x+1}\underbrace{\left(-PV_{x+1}^l(P^A)\right)}_{V_x^{A;l}} + h_{x+1}\underbrace{\left(-PV_{x+1}^h(P^A)\right)}_{V_x^{A;h}} \tag{30}$$

Since life expectancy differs across risk groups, the funds of the annuity attributed to each group have to be differentiated. The capital stock per low (high) risk, $V_x^{A;l}$ ($V_x^{A;h}$), equals the net liabilities of the annuity insurer given by the difference of the present value of future P^{GR}-premiums and level premium payments of low (high) risks per insured, that is

$$\begin{aligned} V_x^{A;\alpha} &= -PV_{x+1}^{\alpha}(P^A) \\ &= PV_{x+1}^{\alpha}(P^{GR}) - \overline{P}_{x_0} a_{x+1}^{\alpha}, \end{aligned} \tag{31}$$

with $\alpha \in \{l, h\}$. Equations (30) and (31) do not rule out that the reserves of the annuity are negative at some point in time between x_0 and ω. But if the P^{GR}-schedule predominately rises with age, intersecting the level premium just once and from below, these amounts are positive at any point in time. The annuity serves as an instrument to partly prefund for higher insurance premiums when the insured cohort grows old. As high risks face a higher probability of dying, the provisions per low risk exceed the provisions per high risk at any given age. Low risks in the health insurance are high risks with respect to the annuity due to their higher life expectancy. Consequently, undifferentiated net injections P_x^A are lower than the payment needed to establish annuity funds that are sufficient for a low risk at the end of the period, $\left[\left(1-w_x^l\right)/\left(1+i\right)\right] V_x^{A;l} - V_{x-1}^{A;l}$.

Differentiating between funds that are related to the guaranteed renewable health insurance and to the annuity, we are now able to calculate the premium insurance part of the combined contract. This component should be held back for the high risks in the insured cohort. Combining equations (23) and (30) leads to

$$\begin{aligned} V_x^{PI} + V_x^A &= h_{x+1}\left[A_{x+1}^h - PV_{x+1}^h(P^{GR}) + V_x^{A;h}\right] + l_{x+1}V_x^{A;l} \\ &= h_{x+1}\left[A_{x+1}^h - PV_{x+1}^h(P^{GR}) - \left(V_x^{A;l} - V_x^{A;h}\right)\right] \\ &\quad + \left(l_{x+1} + h_{x+1}\right)V_x^{A;l}. \end{aligned} \tag{32}$$

Total provisions can be decomposed into the annuity funds of low risks attributed to each insured irrespective of the current health status, and the modified premium insurance. Provisions of the premium insurance are reduced by the difference between the risk-adjusted provisions of the annuity for low and high risks. The term $\left[A_{x+1}^h - PV_{x+1}^h(P^{GR}) - \left(V_x^{A;l} - V_x^{A;h}\right)\right] < V_x^{PI}$ represents the amount which, in addition to the funds of the annuity insurance for a low risk, has to be held back by the insurer to finance the extra-costs of a high risk, while low risks could take $V_x^{A;l}$ with them when switching to another insurer. Using equations (18) and (31), the last expression can be transformed into

$$\begin{aligned} V_x^{PI} + V_x^A &= h_{x+1}\left[A_{x+1}^h - A_{x+1}^l + \overline{P}_{x0}\left(a_{x+1}^l - a_{x+1}^h\right)\right] \\ &\quad + \left(l_{x+1} + h_{x+1}\right)V_x^{A;l}. \end{aligned} \tag{33}$$

Provisions related to the modified premium insurance per high risk are determined by adding the difference in expected present values of future health care costs to the present value of expected additional level premium payments of low risks. By theoretical considerations alone it cannot be ruled out that the funds of the modified premium insurance are negative at some points in time. Given that the provisions of the annuity insurance are positive and keeping in mind that $a_{x+1}^l - a_{x+1}^h > 0$, negative provisions in the modified premium insurance can occur only if the present value of future health care costs is lower for high risks than for low risks, $A_{x+1}^h < A_{x+1}^l$. If becoming a high risk is associated with a sharp drop in life expectancy, it may be the case that $A_{x+1}^l - \overline{P}_{x0}a_{x+1}^l > A_{x+1}^h - \overline{P}_{x0}a_{x+1}^h > 0$. Then, provisions of the modified premium insurance would indeed be negative. In this case, the high risks of the short-term health insurance are not the high risks of the combined contract at each point in time, and transferring $V_x^{A;l}$ to the new insurer would imply an incentive to switch for high risks. In our simulations this scenario does not arise.

Finally, we can demonstrate that combined provisions of the guaranteed renewable health insurance and the annuity, both assessed on a per person basis, equal the ageing provisions of the level-premium contract calculated earlier. This result must hold because the level premium is the sum of the premium payments for the short-term health insurance, the premium insurance contract, and the net contributions to the annuity insurance.

$$\begin{aligned}\frac{V_x^{PI}+V_x^A}{l_{x+1}+h_{x+1}} &= \frac{h_{x+1}\left[A_{x+1}^h - A_{x+1}^l + \overline{P}_{x_0}\left(a_{x+1}^l + a_{x+1}^h\right)\right]}{l_{x+1}+h_{x+1}} + V_x^{A;l} \\ &= \frac{h_{x+1}A_{x+1}^h + l_{x+1}A_{x+1}^l - \overline{P}_{x_0}\left(h_{x+1}a_{x+1}^h + l_{x+1}a_{x+1}^l\right)}{l_{x+1}+h_{x+1}} \\ &= A_{x+1} - \overline{P}_{x_0}a_{x+1} = V_x. \end{aligned} \tag{34}$$

Ageing provisions per capita can therefore be decomposed into funds related to the annuity required for a low risk and the capital stock related to the modified premium insurance. While the funds of this latter component are ear-marked to be used for high risks who, due to fresh risk assessment, cannot change their insurer without incurring substantial financial losses, the remaining funds serve both low and high risks alike. They could thus be transferred to a new insurer without harming those who stay with the old insurer. This transferable share mirrors the funds of the annuity insurance per low risk.

3 Data

The basic data used for our simulations, covering average mortality rates and average insurance benefits of individuals insured in German private health insurance, is taken from official German sources. The Federal Authority for the Supervision of Financial Services regularly publishes life tables and benefit statistics that insurance companies are obliged to use when calculating their premiums. Life tables (BAV, 2000) take into account that life expectancy is somewhat higher among those insured in private health insurance than in the general population. Benefit statistics (BaFin, 2002) are differentiated according to age, sex, and type of health care services (out-patient, hospital, and dental treatment). The information provided can thus be combined to form time profiles of expected total health costs for individuals who represent an "average risk" at each point in time during their life-cycle.

We consider a standard type of contract in which about 320 Euro per year have to be paid out of pocket for out-patient treatment; hospital treatment is covered at twin-room rates; and the co-payment rate for dentures is around 25 %. Figure 1 shows the profiles of expected insurance benefits for both males and females aged 20 to 100 disregarding, for the moment, their survival probabilities. In the following, we will consider only individuals aged 30 and over. Since the regulatory framework in Germany requires employed individuals to stay with public health insurance until their earnings exceed about 150 per cent of average earnings, the majority of entrants into private health insurance is indeed around age 30.

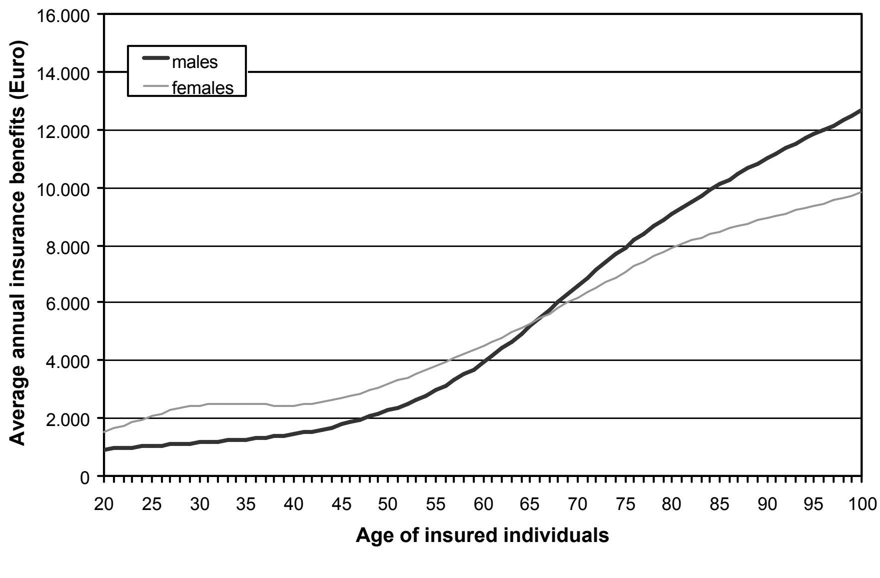

Figure 1: Average annual health insurance benefits

Usually, health insurers are rather successful in picking only individuals in good health when writing lifetime contracts. Later on, however, there will always be some members of the initial cohort whose health status deteriorates, implying that they are lifted to a higher profile of expected insurance benefits. For the purpose of our simulations, a distinction between just two types of risks, "low risks" and all kinds of "high" ones, is sufficient. As a workable definition, we consider a "low" risk an individual who would be offered a health insurance contract at a standard rate that may be contingent on age and sex, but does not involve any risk-specific surcharge.

We assume that transitions always turn low risks into high ones at annual rates that are increasing with age. In other words, we ignore the possibility that individuals may recover from a health deterioration in terms of expected health care costs. We also neglect the possibility that the hazard rate of becoming a high risk may actually decrease once individuals have survived until very high ages.

Unfortunately, the data on private health insurance in Germany that is publicly available offers no information which could be used to differentiate mortality rates and average benefits by risk types. Assuming that the relevant structures are similar to those in the United States, we therefore impute the missing pieces of information exploiting the estimations of Herring and Pauly (2006) who, for similar purposes, analyze the rich micro data emerging from the US Medical Expenditure Panel Survey (MEPS). Since Herring and Pauly cover only individuals aged less than 65, we extrapolate values for higher ages based on the trends that show up in their results. Further, we adapt their structure with temporary high risks to our scenario of a uniform type of average high risks without any transitions back to the low risk state.

Specifically, we first construct a series of annual probabilities of leaving the low-risk status within the next year that turns out to be s-shaped, going up from about .2 per cent for a 30-year old to about 3.5 per cent when reaching age 99.[3] Second, we determine

[3] As differentiation by gender does not appear to play a major role in this context, we interpolate the figures of Herring and Pauly (2006, Table 2) related to individuals aged 18, 25, 35, 45, 55, and 63 in

a life-cycle profile of risk-specific mortality rate differentials that effectively starts from a factor of about 8.0 for the higher mortality of high risks at age 31. It curves down fast and approaches a factor of 1.1 towards the end of the life cycle.[4] Taken together, this implies that, for a cohort of individuals who enter a private health insurance contract as low risks at age 30, 13.8 per cent of those who survive have turned into high risks at age 60, 35.0 per cent at age 80, and 54.6 per cent at age 100, that is, in the final year of our simulation (see Figure 3 below). Third, we need to know by how much expected health expenditure for a high risk exceeds the corresponding figure for a low risk. We assume that, against the background of a sharp rise in age-specific average benefits that is similar both in the US and in Germany, the benefit factor of high risks peaks at age 64, being 3.5 for males then and 2.7 for females, but is symmetrically lower for younger and older individuals (about 3.0 for males aged 30 and 100, respectively, about 2.3 for females at both ends of the age distribution).[5]

Given these assumptions regarding the distribution of risk types and the cost differential, we are able to calculate time profiles of insurance benefits for both low and high risks starting from age 30 that are consistent with the profile of average costs taken from existing data for Germany. Before doing so, however, we have to adjust the data displayed in Figure 1 for the impact of successful risk selection by insurers on average health costs

terms of a unisex profile. In line with the trends in the MEPS data, we assume that the increase slows down rather than accelerates at higher ages.

[4] Herring and Pauly (2006, Footnote 14) estimate this factor to be close to 10.0, irrespective of gender, remaining constant until age 64. However, their model allows for transitions back to the low risk state. Moreover, the mortality factor necessarily falls when average mortality rates become high. A scheme of mortality factors declining in age is thus a natural consequence of translating and extrapolating Herring and Pauly's estimations to our scenario of uniform high risks without recovery.

[5] Our time profiles differentiated by gender are based on Herring and Pauly (2006, Table 3), again extending these to cover also older individuals. Reducing the factor over time at higher ages reflects both a declining share of fresh high risks and a diminishing excess mortality of high risks. As the first months after becoming a high risk and the last months before dying are particularly costly, a decrease in the relative importance of these two factors tends to reduce the cost factor of high risks.

related to early years of insurance; the same applies to the data regarding average mortality rates of insured individuals. In both cases, the original data include 30-year olds who entered a contract several years ago, already being hit by a deterioration of their health status with some probability. Thus, average costs and average mortality rates related to a cohort of fresh entrants aged 30 should be lower than the average figures indicated by the data. For simplicity, we assume health costs and mortality rates for a cohort of low risks to be 24 per cent lower than those for the mixed group, phasing out this reduction by 2 percentage points a year over the first 12 years. These adjustments are only made to keep things as realistic as possible, while they do not at all affect the structure of our results.

Figure 2 displays the benefit profiles for males obtained through these operations. Average benefits of individuals who are low risks (high risks) increase from 872 Euro (2,779 Euro) at age 30 to 6,101 Euro (18,118 Euro) at age 100. They will enter the following simulations of lifetime health insurance contracts in an environment where contracts cannot be terminated by insurers and experience rating is ruled out.

Last, the real interest rate is set to 3.5 per cent throughout. All calculations refer to constant 2001 prices.

4 Results

In our simulations, we take as given the level and structure of expected insurance benefits, the probabilities of a change in health status and the mortality rates that have been introduced in the previous section. All figures refer to a scenario in which nobody leaves the original insurer. As a baseline case, we consider a cohort of males who enter private health insurance at age 30. We then turn to the case of females entering the contract at age 30. Females face a time profile of health costs that differs substantially from the profile for males. With a less steep increase of expected benefits, pre-funding for future benefits is less important than in the baseline case. We then return to the case of males,

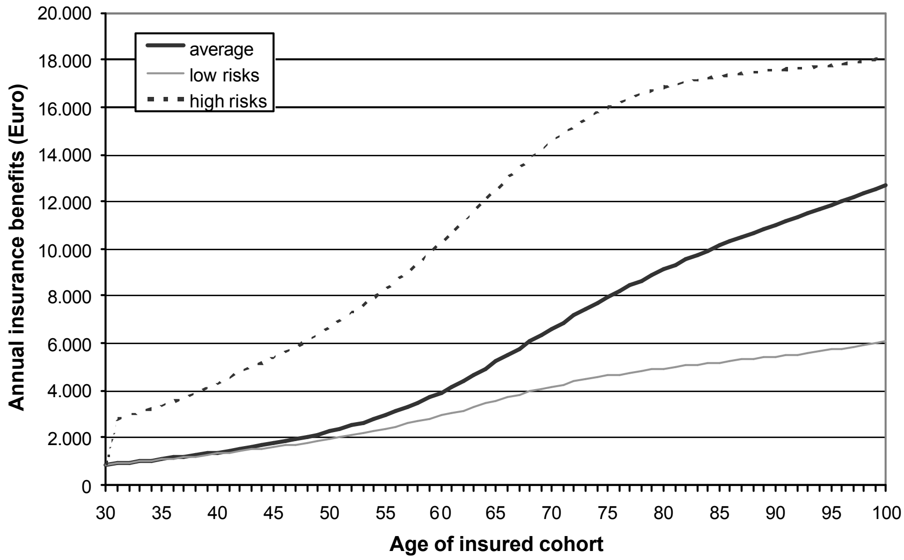

Figure 2: Health insurance benefits by risk type

now introducing some variation with respect to the age of entry, as it turns out that the length of the potential accumulation period is important for the transferable share of total ageing provisions.

4.1 Males (baseline case)

Figure 3 summarises how a cohort of 30-year old low-risk males will develop – both in terms of their numbers and their structure by health status – over the maximum length of the contract period. Over time, the cohort size shrinks to 1.9 per cent of the original population until these individuals reach age 100. We assume that the cohort dies out at the end of this year. Among those who survive, there is a growing portion of individuals in bad health, facing expected health cost that are considerably higher than those for good risks at the same age.

Annual total real premiums are determined in such a way that they are constant over the total contract period. During the early years, the level premium $\overline{P}_{30}$ involved in

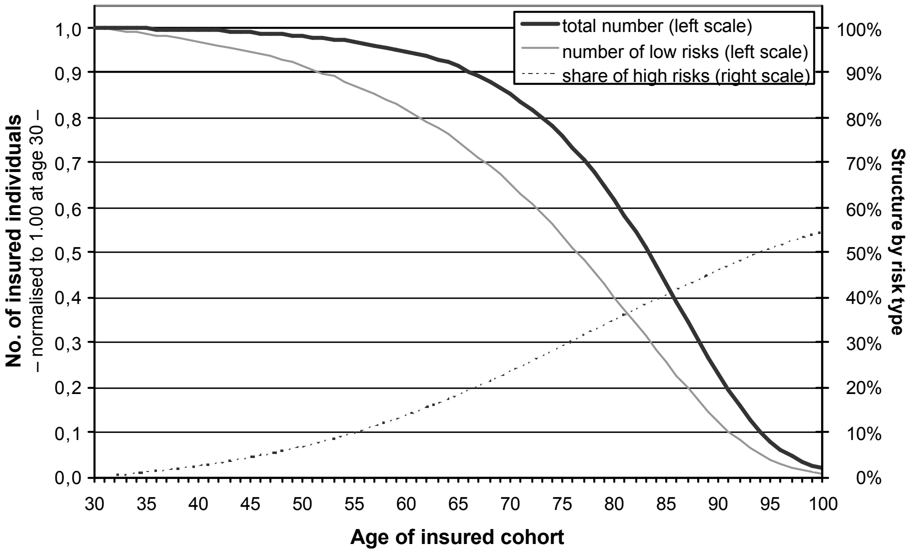

Figure 3: Evolution of the cohort of insured individuals

German-type lifetime contracts will exceed current average health costs, while in later years it can be substantially lower. Surpluses accruing initially are accumulated as ageing provisions which are also nourished from two other sources: returns to invested funds, plus the "bequests" involved in redistributing the ageing provisions of individuals who die in a given year.

Figure 4 illustrates the development of all these transactions over time. It turns out that a level premium of about 2,760 Euro is enough to cover current expected health costs which, on average, are increasing from 871 Euro to 12,666 Euro a year in our baseline case. Premiums fall short of current health costs starting from age 54, but fund yields and within-cohort bequests ensure that total ageing provisions – measured per capita of insured individuals who survive – keep growing until the individuals reach age 67. Afterwards, they start decreasing at accelerating speed. As mortality gets substantially higher with age, bequests become more important when individuals are aged 80 or over. Nevertheless, funds are declining very rapidly then until they are fully exhausted at age

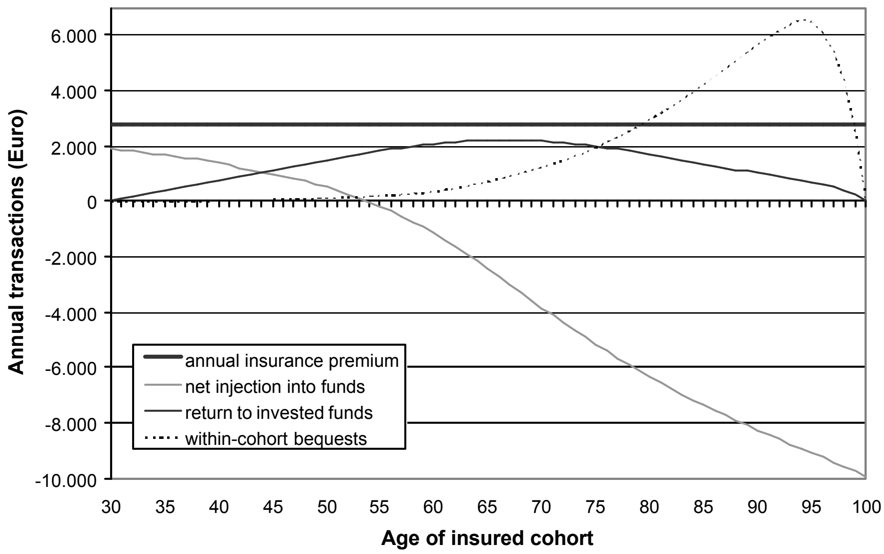

Figure 4: Lifetime contracts with constant premiums

100.

As indicated before, total ageing provisions can be decomposed into a capital stock related to the premium insurance and funds that finance the annuity. This is done by reconstructing the lifetime contract with a level premium based on a guaranteed-renewability arrangement, combined with an annuitised life insurance. Figure 5 shows the development of short-term health insurance premiums of low risks, average insurance benefits, and the premiums in a contract with guaranteed renewability, constant total premiums of course being identical with those displayed in Figure 4. Figure 6 illustrates the time profile of total ageing provisions per capita in a German-type health insurance contract and, respectively, the shares that are attributable to the modified premium insurance and the annuity insurance of a low risk.

On a per-capita basis, total ageing provisions that have to be accumulated for a male individual entering the contract at age 30 peak at about 66,300 Euro when the cohort reaches age 67 and then decline. For the decomposition into two separate stocks of funds

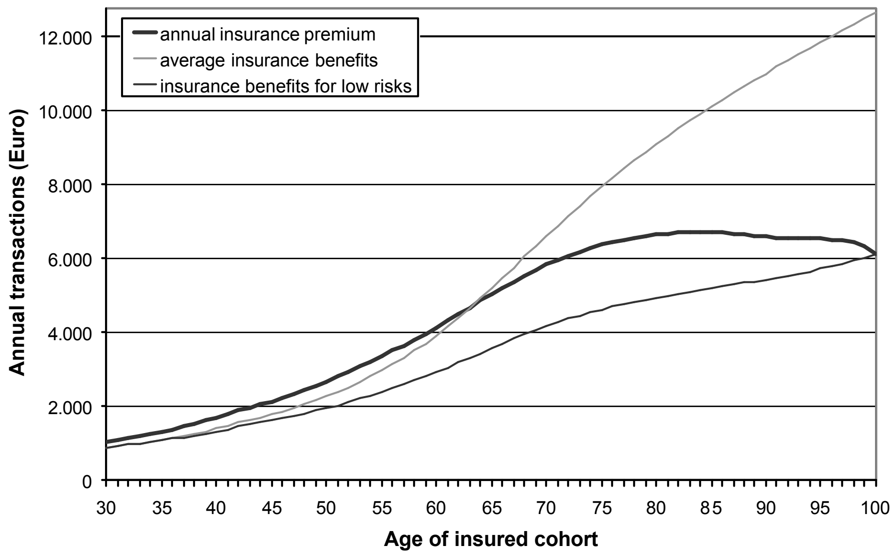

Figure 5: Contracts with guaranteed renewability

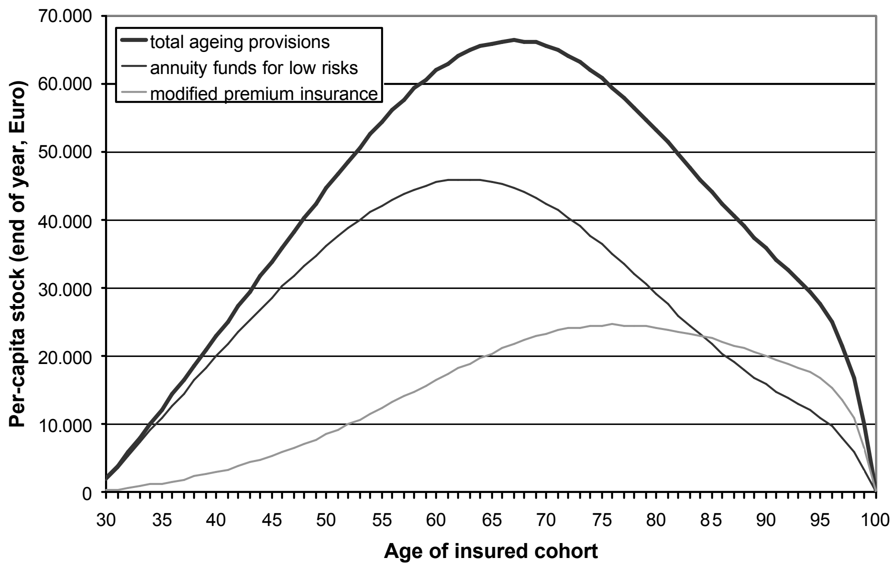

Figure 6: Decomposition of ageing provisions

– one related to the modified premium insurance, the other to the annuity for a low risk – two aspects are particularly important. Our assumptions regarding the relevant probabilities of transition imply that the risk of a change in health status is relatively low at early stages of the contract period. At the same time, health costs for males show a strong age-related trend even for those who are good risks throughout. The consequence is that the timing of the accumulation and decumulation of funds is significantly different for the two components. Stocks that are needed to fund the annuity of low risks reach their peak at about 45,900 Euro when individuals are aged 63, ahead of the maximum of total provisions, while stocks that belong to the modified premium insurance peak at 25,900 Euro when individuals are aged 76. Since, in spite of a higher mortality of high risks, the fraction of beneficiaries in the premium insurance is increasing over time, the share of transferable funds in total ageing provisions is constantly declining with age. In our baseline simulation, it is in fact declining in an almost linear fashion from 91.2 per cent of total provisions at age 30 to 33.7 per cent at age 99 (see Figure 7).

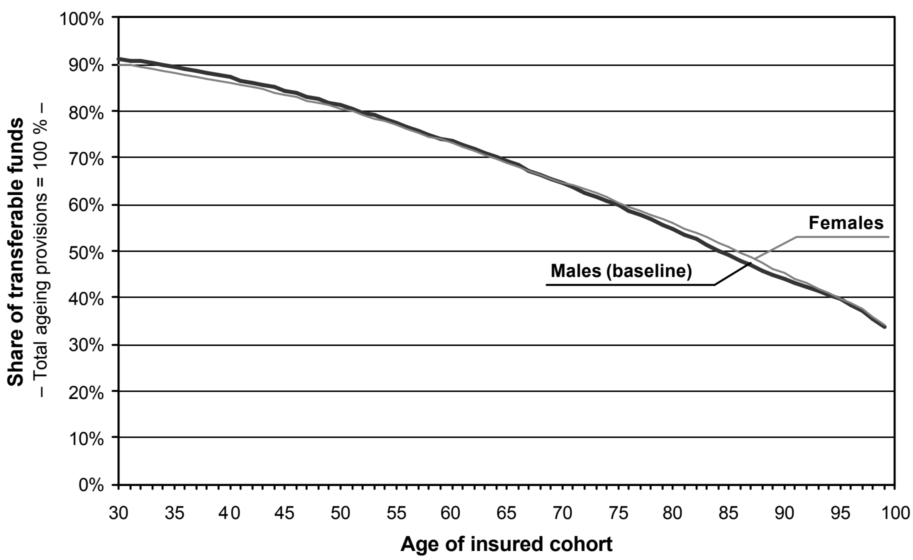

Figure 7: Share of transferable funds (males vs females)

4.2 Females

Considering mortality rates and cost profiles for females in our simulations, the transferable shares of ageing provisions turn out to be almost identical to the baseline case (see Figure 7). Hence, a legal scheme for defining transferable shares of ageing provisions in German-type insurance contracts need not differentiate between men and women. This surprising outcome occurs with age-related profiles of average health insurance benefits and risk-specific cost differentials that vary considerably by gender. Yet, in terms of the share of annuity funds of low risks in total ageing provisions, the consequences of these changes almost exactly offset each other.

The females enter private health insurance as low risks at age 30 where 4.7 per cent survive until they reach age 100. Figure 1 indicates that, when assessed in terms of lifetime present values, average health costs for females are higher than those for males. In addition, their profile is clearly less steep – a feature that carries through to the profiles attributed to low risks and high risks, respectively, using the procedures explained in section 3. For individuals who are low risks (high risks), these risk-specific profiles increase from 1,859 Euro (4,596 Euro) at age 30 to 5,683 Euro (13,216 Euro) at age 100, implying that purely age-related trends are weaker and that the spread between risk types is smaller at any given point in time than in the baseline simulations.

As a consequence, the time-invariant level premium is substantially higher for females than for males, amounting to about 3,540 Euro a year. In contrast, total ageing provisions in health insurance contracts are lower than in the baseline case at any point in time. The less steep profile of premiums in the guaranteed renewability scheme requires a lower amount of annuity funds. At the same time, the smaller spread between risk-specific benefit profiles is associated with lower funds related to the premium insurance. In sum, the changes do not affect the structure of total funds.

It turns out that total ageing provisions per capita of surviving individuals peak at about 54,100 Euro when individuals reach age 67. For a low risk, funds that can be attributed to the annuity reach their peak at about 37,400 Euro when individuals are aged 63, while funds accumulated for the modified premium insurance peak at 20,600 Euro when individuals are aged 75. At each point in time, the transferable share of total ageing provisions clearly remains positive throughout the contract period. Furthermore, it turns out to be almost exactly the same as in the baseline case of males, declining from about 90.1 per cent at age 30 to 34.0 per cent at age 99.

4.3 Variation of the age of entry

The precise age of entry is obviously important for the process of accumulating and decumulating ageing provisions in general and the funds related to the annuity that smoothes premiums over time in particular. Therefore, in addition to the two gender-specific scenarios considered so far, we also introduce some variation with respect to this parameter, now looking at males who enter the contract aged 40, 50, and 60, respectively.

Figure 2 illustrates that, even for cohorts of pure low-risk types in each of these categories, there are considerable age-related differences in expected benefits between the age of entry and the end of the contract period. The same holds for the premium profile for contracts with guaranteed renewability (see Figure 5). On the other hand, the relative importance of measures applied to smoothing these differences must be expected to decrease the more the effective age of entry moves up the scale. This happens because the number of years with very low premiums in a guaranteed-renewability arrangement is reduced. Hence, some years are missing in which a high fraction of the constant level premium serves the annuity function. As a consequence, the share of annuity funds in total ageing provisions should decline with the age of entry.

Our calculations confirm this expectation. We construct cohorts of individuals aged 40, 50, and 60, respectively, who enter insurance as low risks and then develop over time as implied in our assumptions regarding mortality rates and transitions in health status. For each of these cohorts, we can consistently use the relevant part of the "low-risk" graph

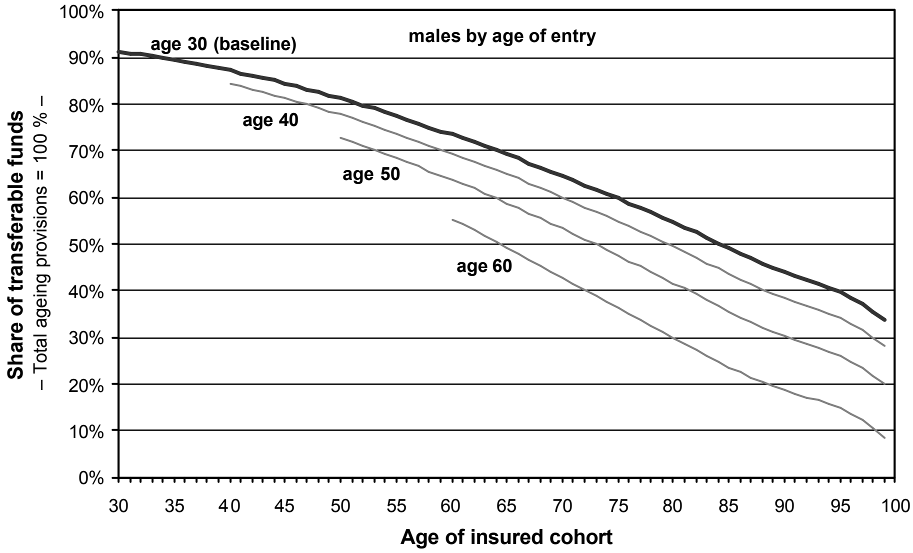

Figure 8: Share of transferable funds by age of entry (males)

in Figure 2 as representing health costs for those who are in good health throughout. Transition probabilities and cost differentials assumed in the baseline case then give us the time profile of average health costs. The level premium is based on the present value of expected health care costs of a low risk which coincides with the present value of average health costs, differentiated by the age of entry in each new scenario. The premium profile of contracts with guaranteed renewability remains unchanged.

With a variable age of entry, we still find that there is always a positive fraction of total ageing provisions which can be attributed to the annuity. Yet, the share of these funds which could be transferred to another insurer is smaller for 50-year olds who entered the contract at age 40 than it is for those who entered the contract at age 30. Figure 8 shows that this result goes through for any other combination of current age and age at entry. For example, the share of annuity funds for males entering at age 50 goes down from about 72.8 per cent at age 50 to 19.8 per cent at age 99.

5 Concluding discussion

The main results of this paper are that the share of transferable funds in individual lifetime health insurance contracts with a level premium declines in age and age of entry into the contract, while it is approximately the same for females and males. Significant gender-specific differences of transferable shares of ageing provisions may of course be obtained for other specifications of parameters. It has been shown that a substantial share of ageing provisions could be made portable across insurers without harming those left behind with the initial insurer. The main reason for the decline in age lies in the fact that the share of beneficiaries in the premium insurance is increasing over time.

These considerations also shed some light on what happens if other parameters of the model are changed. Reducing either the probabilities of transition into the high-risk state or the cost differential between high risks and low risks decreases the weight of the premium insurance and therefore raises the transferable share of ageing provisions related to the annuity for a low risk. With given average mortality, higher excess mortality factors for high risks also increase the share of transferable annuity funds of low risks. Changes in average mortality rates or the interest rate are quite important for the volume of total ageing provisions. Yet, they will have only a modest impact on the shares of premium insurance and annuity funds.

A substantial problem arises from the phenomenon of unexpected permanent cost shocks hitting the entire cohort from time to time. Technological progress in the health care sector, high sectoral inflation rates, and rising life expectancy have caused regular increases in real insurance premiums in the past. In this event, the two components of ageing provisions both turn out to be smaller than necessary to keep premiums constant. Since those who have already turned into high risks have to be protected against losses from risk segmentation through low risks leaving the insurer, part of the capital stock accumulated for the annuity has to be reassigned to the premium insurance. In other words, the estimated shares of transferable ageing provisions in our simulations are systematically overstated. In the case of German private health insurance, a partial solution for this problem can be found in a recent regulation requiring insurers to collect a surcharge of 10 per cent on gross premiums, the additional capital stock being meant to reduce expected premiums after age 65. Again applying our decomposition into premium insurance and annuity insurance shows that a major fraction of the additional capital stock would have to be assigned to the annuity function. Only a small portion has to be used to offset the deficit in the premium insurance. Therefore, combining the additional capital stock with total ageing provisions and assuming moderate cost shocks, shares of transferable annuity funds in the aggregate capital stock tend to be close to the profiles derived here.

All in all, our considerations suggest that a simple formula could be devised, indicating how much of the ageing provisions accumulated for a given individual in German-type lifetime health insurance contracts could be made portable across insurers. Essentially, the rule would be based on individual characteristics that are very easy to verify, namely current age and age at entry.

The new scheme will probably also have an impact on the insurance market. As we can expect a higher elasticity of demand and more switches between insurers, competition is intensified. This may imply a pressure on profits and general administrative costs, but also more marketing activities and improved service qualities towards good risks. Further, as the average duration of contracts can be expected to fall, insurers may accordingly reduce the share of long-term assets in their portfolio. Finally, the solvency of an insurer may deteriorate faster in periods in which the insurer suffers from a loss that does not affect its competitors. This issue in itself calls for tighter monitoring by the regulatory authority. However, as reinsurance does not play any significant role in the health insurance market and the premium policy is already regulated, the rising importance of the solvency problem should not represent a serious obstacle against implementing the proposed transfer scheme of ageing provisions.

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