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Financing future public health services

Die Finanzierung künftiger staatlicher Gesundheitsleistungen (englischsprachig)

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Abstract
These days, many states apply a national health system that is financed through pay-as-you-go. As people get older their expected annual health expenses increase. In this paper we analyse the effect of rising public medical expenditure caused by population ageing. Thereby, we focus our attention on the German public health system. As a result, the need for building a so called demography reserve becomes apparent. The paper further illustrates the introduction of a capital funding method for the publicly insured population. In particular, we explore the cost development associated with a switch of financing systems.

Keywords
ageing population, capital funding method, demography reserve, national health system, pay-as-you-go

1 Introduction

There has been plenty of debate both in politics and science on the effect of population ageing on pensions and annuities. It has been widely acknowledged that people tend to live longer whilst fertility rates continue to remain at a low level in most countries of the Western World and Germany in particular. This insight has led to anticipation of shortcomings with respect to public financing of future old age provisions.

It is not far fetched to suspect that population ageing may also have an effect on other parts of the social welfare system (Wasem 1997). In this respect, we focus our attention on the German public health care system, which is build on so called state sickness funds (Gesetzliche Krankenversicherung, GKV) operating on a pay-as-you-go basis.

Our aim is to single out and analyse the implications of population ageing on future medical expenditure in the German pay-as-you-go public health care system. Furthermore, we determine the costs associated with a capital funding method to finance the German national health care system going forward.

Our paper is organised as follows. As a starting point in section two we project the German population into the future. We then briefly describe the German public health care system in section three. Furthermore, we forecast total public health expenditure over the next fifty years.

Based on statistics for private medical insurance we price health premiums that remain constant over time in section five. Applied to the publicly insured German population, we are then able to estimate total medical expenses based on the capital funding method in section six. The paper concludes in section seven with a comparison of these two financing systems and a summary of results.

2 Projecting the German population size

In this section we analyse the development of the German population over time. To do so, we have to make several assumptions. Without forestalling, it should be stated at this point that our results on future health expenditure are not sensitive to our assumptions made on mortality and fertility. In fact, we have run our model with different assumptions, yet the results remain robust.

As a starting point we take the current German population as published in the human mortality database, which is run by the Max Planck Institute for Demographic Change amongst others (Human Mortality Database 2007). As for mortality, we use the life table published in relation to the German private medical insurance industry (Private Krankenversicherung, PKV) which is recommended for the purpose of reserving and balance sheet projections (BaFin 2005). In this context, trend factors to incorporate future mortality improvements have been provided, too.

To be precise, let q_x^t be the probability of a male aged between x and $x + 1$ in calendar year t. Furthermore let f_x be the annual mortality improvement factor at age x that is independent of calendar years. Then the following recursive formula holds

$$q_x^{t+1} = q_x^t \cdot f_x \ .$$

In order to calculate the number of lives l_x^t aged between x and x + 1 in calendar year t we have

$$l_x^{t+1} = l_{x-1}^t - l_{x-1}^t \cdot q_{x-1}^t \quad \text{for } 1 \le x \le 100 \text{ and } 2005 \le t \le 2060 .$$

Analogue formulae hold for females which we identify by the subscript y.

As far as future fertility is concerned, we assume that the birth rate, i.e. the number of newborn to the number of females able to bear children, will remain constant over time:

$$f_t = \frac{l_{x=0}^{2005} + l_{y=0}^{2005}}{\sum_{k=16}^{45} l_{y=k}^{2005}} \quad .$$

Our data yields 42.211 children per 1.000 females aged 16 to 45. As a consequence we are able to derive the number of male and female newborn lives for each calendar year:

$$l_{x=0}^{t+1} = 0,51 \cdot 42.211 \cdot \sum_{k=16}^{45} l_{y=k}^{2005} \quad \text{for } 2005 \le t \le 2060$$

$$l_{y=0}^{t+1} = 0,49 \cdot 42.211 \cdot \sum_{k=16}^{45} l_{y=k}^{2005} \quad \text{for } 2005 \le t \le 2060 \quad ,$$

whereas we assume that 51% of the newborn children are male and 49% female.

Within our model we neglect immigration and emigration. Finally, we are able to derive German population sizes of the future. Our results for selected calendar years are shown below.

	2010	2020	2030	2040	2050	2060
total population	82,410,479	80,963,419	77,806,412	73,249.341	67,168,205	59,292,442
children age 0 – 17	13,499,900	11,497,.164	9,849,702	8,586,764	7,351,.404	6,314,420
adults age 18-64	51,493,649	49,045,549	42,676,521	36,354.017	31,893,258	27,262,893
old age people age 65+	17,416,931	20,420,707	25,280,189	28,308,560	27,923,543	25,715,129
adults to old age people	3.0	2.4	1.7	1.3	1.1	1.1
average age	43.7	47.2	50.3	53.0	55.2	56.0

Table 1: German population for selected future calendar years

Moreover, the average age of the German population increases by 13.7 years of age over the next 50 calendar years. Furthermore on average, life expectancy of a newborn child increases by about 2 months each calendar year. Thus, a baby that is born six years later will have a life expectancy of one additional year. With respect to this statement, we have ignored any further mortality improvements after birth, i.e., we compute the life expectancy of a newborn in calendar year *t* as follows:

$$e_0^t = \frac{1}{2} + \sum_{k=0}^{99} \frac{l_{k+1}^t}{l_0^t} \ .$$

In addition, we find that the share of old age people compared to the whole population will steadily increase over time. There will be too few breadwinners who have to pay for the needs of old age people in society. This so called demographic time bomb does not only affect public old age provisions but also public health expenses in the pay-as-you-go system. In the following, we analyse the impact of the above population change on public spending for medical services in Germany.

3 Public health care in Germany

The German health care system provides compulsory cover for medical expenses for all those people earning less than a certain minimum wage. It is administered by state sickness funds. The GKV insure about 85% of the German population, i.e. about 70 million people, in respect of all types of healthcare. Coverage extends to the full range of medical benefits including inpatient and outpatient services, dental care, medicine, rehabilitation and medical provision.

Notably, German sickness funds are financed through pay-as-you-go. According to the German Federal Statistical Office health expenditure of the GKV was 135.9 Euro million in 2005 (destatis 2007). There are certainly a number of possible reasons as to why medical expenses may increase over time. To name but a few, there is supply and demand, medical inflation, lack of competition amongst providers, moral hazard amongst consumers, etc. In the following, we isolate the effect of population ageing on public medical expenses.

4 Projecting pay-as-you-go expenditure

In order to project public medical expenses we consider data collected form the insurance industry. Private medical insurers reimburse actual costs. The provider issues an invoice to the patient who has to settle it in the first place. Subsequently, the insurer indemnifies the insured.

National sickness funds on the other directly deal with health service providers. Various scales of charges and tariffs exist to keep costs at a minimum. The patient is cut out; he does not receive any invoices. Furthermore, certain benefits of the national hearth service are restricted or limited. In addition, patient deductibles are in place.

All of the above means that there are structural differences between private medical insurance and coverage provided by the national health service. In particular, expected annual claim amounts per risk are smaller for health sickness funds than private medical insurers.

Niehaus (Niehaus 2006) found out that the demographic change of the German population has got the same effect on PKV and GKV. Results based on analysing changes of average cost per private medical claim over time may therefore be applied to public medical expenses. We follow this approach by resorting to statistics relating to private medical insurance as published by the German Federal Financial Supervisory Authority called BaFin.

The BaFin has published statistics based on private medical insurance for various medical benefits (BaFin 2005). The insurance product we have analysed provides inpatient and outpatient services as well as dental coverage. Long term care elements have been neglected. For such a comprehensive product comparable to the cover provided by the GKV we are able to determine the expected average medical claim amount by gender and age, K_x and K_y, for 2005.

These payments can be normalised. For either gender we express the average claim amount as a multiple of the amount for a risk aged 40. Then, we arrive at a cost profile by gender. Thus, we define

$$k_x = \frac{K_x}{K_{x=40}}$$

$$k_y = \frac{K_y}{K_{y=40}} \quad .$$

Age	K_x	K_y	k_x	k_y
0	3,638.75	3,289.82	215%	103%
10	1,278.16	1,230.94	76%	38%
20	1,282.39	2,020.52	76%	63%
30	1,399.40	3,159.92	83%	99%
40	1,689.00	3,200.00	100%	100%
50	2,495.32	3,782.70	148%	118%
60	4,251.01	5,268.72	252%	165%
70	6,794.16	6,907.33	402%	216%
80	9,161.31	8,573.70	542%	268%
90	10,803.20	9,908.44	640%	310%
100	12,252.36	10,865.04	725%	340%

Table 2: Expected claim amounts per risk in Euro and cost profile for males and females in percent of the claim amount for a 40 year old person

It is well known that private medical cover pays out more for the same claim than the GKV does. Therefore, the above absolute amounts may not be used for projecting public medical expenses.

Instead, we assume that the above cost profile derived on the basis of private medical insurance data likewise applies to the publicly insured population. I.e., we assume that the cost profile of the GKV is directly proportional to the one based on PKV data. It is therefore feasible to calculate the annual percentage increase of public medical expenses for German state sickness funds based on statistics relating to private medical insurance.

Mortality projections for Germany generally show that life expectancy will further increase over time. Our population projection does incorporate future mortality improvements. It is not clear, though, whether old age morbidity will be disproportionately affected. There is a view that elderly people in the future will suffer from more diseases than in the past. On the other hand, it is possible that old people will be able to enjoy more years in good health than before (Hof 2001). International studies have arrived at differing conclusions (Niehaus 2006). Within our model, we have assumed that the age specific cost profile that we have derived for 2005 will remain constant over time:

$$k_x^t = k_x \text{ and } k_y^t = k_y \text{ for } 2005 \le t \le 2060 \text{ .}$$

Notably, we have allowed for mortality improvements whilst we assume that the cost profile will remain the same. Considering the past, one has observed that about half of total medical expenses of an individual occur during the last two years of life. If life expectancy increases than the cost profile of medical expenses should be stretched (Breyer and Felder 2006). It is not clear, though, whether said presumption will prevail in the future. Hence, it remains to be seen whether the compression theory or the opposite applies.

Now, we multiply the projected number of lives of a certain age and gender in a given calendar year with the specific expected claim amount as per 2005. Then we sum over all ages and both genders to arrive at the total medical expenditure for the calendar year in consideration:

$$E_t = \sum_{x=0}^{100} l_x^t \cdot K_x + \sum_{y=0}^{100} l_y^t \cdot K_y$$

Finally, by comparing total medical expenses from one year to the next we derive incremental adjustment factors:

$$a_t = \frac{E_t}{E_{t-1}} \quad \text{for } t = 2006, \cdots, 2060$$

Each such factor may be interpreted as the annual percentage increase of public medical expenditure. By applying these annual adjustment factors to the figure of public medical expenditure in Germany in 2005 as quoted above we are able to make projections for the future. It should be noted that we have implicitly assumed that the age profile of the publicly insured population is equivalent to the German population as a whole.

	2010	2020	2030	2040	2050	2060
total public health expenditure in bln €	142.974	156.032	164.815	168.515	164.512	148.475
cost per head aged 18-64 in €	2,777	3,181	3,862	4,635	5,158	5,446
cost per head aged 0-100+ in €	1,735	1,927	2,118	2,301	2,449	2,504

Table 4 Projection of German public medical expenses 2010 – 2060

We found out that total medical expenditure of German public sickness funds will increase by about 1.04% to 0.96% per annum between 2010 and 2025. This finding shows a certain robustness concerning the assumptions made in respect of mortality and fertility.

From 2042 onwards the increase of medical expenses per head starts to level off. Total public medical expenditure of German sickness funds will decrease because of the diminishing population size.

It is noteworthy elucidating the fact that the above initial annual increase of about 1% per annum is solely caused by population ageing. We have explicitly ignored any medical inflation as well as any changes in the medical cost profile derived for 2005. As a result, the rate of contribution towards the GKV will have to go up each year by about 1%. This robustly projected figure highlights the need for a so called demography reserve in respect of future public medical expenses in Germany. The chart shows that total expenditure for public health services increases whilst the population size reduces. To illustrate this point further, the next graph shows medical cost per German head.

The increase of medical cost per German head over the next fifty years is dramatic. The effect of population ageing causes a significant increase over 50 years. Public medial expenses per head will almost double for people aged 18 to 64. It is unclear how future generations could be able to cope with this additional financial burden.

As a way out, it has been suggested to replace the current pay-as-you-go scheme by a capital funding method (Börsch-Supan 2000; Rürup and Henke 2002). In the following we determine the cost of a capital funding method applied to GKV business.

5 Pricing public medical insurance

Notably, medical insurance business may be priced in line with life insurance. Taking the expected claim amounts per risk for the above mentioned comprehensive private medical insurance product into account we are able to derive constant net premiums according to the equivalence principle of actuarial science. The actuarial interest rate is set to 3.5% per annum as currently prescribed for private medical business in Germany.

In the standard notation the net level premium is

$$P_x^N = \frac{\sum_{n=0}^{\omega-x} K_{x+n} \cdot l_{x+n} \cdot v^{x+n}}{\sum_{n=0}^{\omega-x} l_{x+n} \cdot v^{x+n}} ,$$

whereas the following denotations hold:

K_x	expected claim amount per risk at age *x*, $0 \le x \le 100$
$l_{x+1} = l_x \cdot (1-q_x) \cdot (1-w_x)$	number of active lives aged *x*+1, with $l_0 = 100.000$,
q_x	probability of death for a risk aged *x*, $0 \le x \le 100$
w_x	probability of cancellation for a risk aged *x*, $0 \le x \le 100$
$v = 1{,}035^{-1}$	discount rate.

The resulting net premium may be additively split into three components: the natural risk premium, the savings premium, and the so called inheritance premium. The first part relates to the expected claim amount according to the attained age of the insured. The second part is used to build up the reserve, and the third part is inherited by the totality of insured lives in case of death of the individual or policy cancellation. Hence, the premium split is given by

$$P^N = P^S + P^R + P^I$$

where

$$P^S = -{}_tV_x + {}_{t+1}V_x \cdot v \quad ,$$

$$P^R = K_{x+t} \quad ,$$

$$P^I = -{}_{t+1}V_x \cdot \left(q_{x+t} + w_{x+t}\right) \cdot v \quad .$$

Here we define

${}_tV_x$	net reserve at the end of year t for a risk initially aged, $0 \le x \le 100$ and $0 \le t \le \omega - x$
P^S	savings premium,
P^R	risk premium,
P^I	inheritance premium.

Notably, the net premium remains level through the life of the insured. At each point in time the savings premium, the risk premium, and the inheritance premium add up the net level premium.

It is noteworthy that in actuarial terms we essentially consider a lapse supported product. There is no surrender value in case of cancellation. However, as we consider compulsory insurance lapse rates are equal to zero. In case of death the surrender value is equal to the net reserve.

If we accept that the cost profiles of private and public medical insurance are proportional then we are able to apply the ratio of net premium to risk premium in order to project the total amount of public medical expenses according to the capital funding method.

6 Projecting national health expenses using the capital funding method

Assuming a constant cost profile over time and ignoring any medical inflation, we calculate the constant premium that each insured person is supposed to pay for comprehensive private medical cover. Every individual pays the same amount of premium until his death. Newborn children, in particular, will pay the constant premium calculated for a zero year old as of 2005 for all their live.

Total premium divided by the number of population leads to average premium per head. Consequently, we are able to compare average risk premium and average net level premium:

$$\overline{P}_t^R = \frac{\sum_{x=0}^{100} P_x^R \cdot l_x^t + \sum_{y=0}^{100} P_y^R \cdot l_y^t}{\sum_{x=0}^{100} l_x^t + \sum_{y=0}^{100} l_y^t}$$

and analogously

$$\overline{P}_t^N = \frac{\sum_{x=0}^{100} P_x^N \cdot l_x^t + \sum_{y=0}^{100} P_y^N \cdot l_y^t}{\sum_{x=0}^{100} l_x^t + \sum_{y=0}^{100} l_y^t} \quad .$$

By so doing, we implicitly assume that the age profile of publicly insured population under GKV is equal to the whole population. Our findings are summarised below.

Premium	2010	2020	2030	2040	2050	2060
average risk premium per head	1,735 €	1,927 €	2,118 €	2,301 €	2,449 €	2,504 €
average net level premium per head	2,535 €	2,273 €	2,020 €	1,787 €	1,584 €	1,397 €
ratio	146%	118%	95%	78%	65%	56%

Table 5 Average risk premium and average net level premium based on private medical insurance data

We then consider the ratio of net level premium to risk premium for each calendar year:

$$c_t = \frac{\overline{P}_t^N}{\overline{P}_t^R} \quad .$$

If we multiply these factors with the total public expenditure computed above and shown in table 4 we are able to derive total medical expenditure based on the capital funding method. Hence, we are able to determine total public medical expenditure for the German state sickness funds GKV over the next fifty years according to either financing system.

Medical Expenses	2010	2020	2030	2040	2050	2060
pay-as-you-go	142.974	156.032	164.815	168.515	164.512	148.475
capital funding	208.948	184.040	157.135	130.897	106.408	82.807

Table 6 Comparing public medical expenditure by funding method in billion Euro.

With hindsight it becomes clear that for consistency sake we had to base both cost projections on the same cost profile. For the capital funding method private medical insurance data is naturally preferred. Therefore, we have also applied the relative cost profile based on PKV data to compute medical expenditure increases for the GKV.

Whilst we have assumed that the profile is independent of time, any other assumption would affect both financing options similarly. In this respect our results are robust.

In conclusion, we find out that total medical expenditure based on the capital funding method reduces over the next twenty years by about 1.1% to 1.6% per annum due to the diminishing German population size. The decrease is almost linear in absolute terms.

In 2010, total medical expenses based on the capital funding method are 66 billion Euro higher. For the first time in 2028, expenditure based on pay-as-you-go overtake the expenses derived by constant premiums. During those initial 18 years, the capital funding method requires additional financing in the order of nominal 610 billion Euro. Hence, an immediate switch of financing system for public medical expenses in Germany is very costly.

In 2060, the capital funding method comes in at 65.7 billion Euro lower than the pay-as-you-go scheme. Nominal savings that can be achieved from 2028 to 2060 are 1.392 billion Euro, which is more than double the extra cost from 2010 to 2027. This result demonstrates the effect of compound interest. The following chart elucidates the development of the expense differential over time.

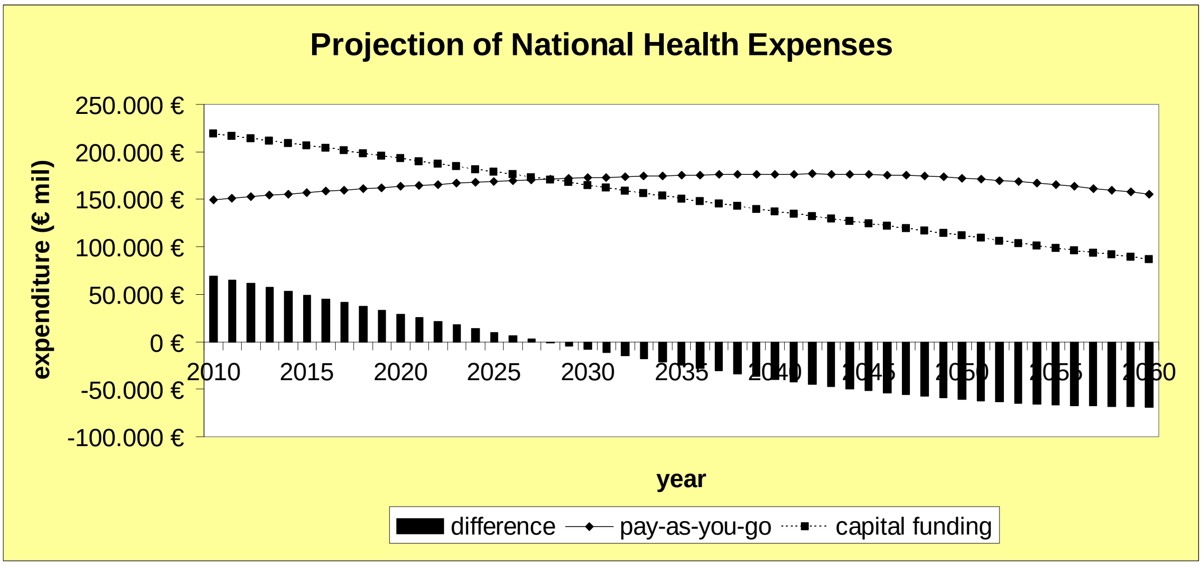

Chart 1 Projection of national health expenses

7 Conclusions

On the basis of population projections and current statistics for private medical business we were able to forecast public medical expenses in Germany over the next fifty years. Our results are robust in respect of the assumptions made for mortality, fertility and claims amounts per risk.

The expected increase of public medical expenses in the future is material. Therefore, the financial burden can not be neglected. Over the next twenty years the annual increase solely caused by population ageing is about 1% per annum based on health expenditure for 2010. Over the next fifty years, medical expenses per head, aged 18-64, will almost double. These findings imply the need for a so called demography reserve in order to alleviate the financial strain on future generations.

In a pay-as-you-go scheme actual costs have to be met by current generations. A way out might be a switch of financing systems to the capital funding method. Therefore, we have calculated public medical costs based on a system that is similar to the way in which the private medical insurance industry operates. Whilst the effect of compound interest would significantly reduce future costs - in fact by much more than it takes to build up reserves - the immediate requirement for additional amount of capital is huge.

It may be interesting to model the effect of changing cost profiles over time. Any assumptions in this respect could potentially alter the outcome of future medical expenditure significantly. However, the change of the cost profile does affect both financing options. Notably, the cost for switching to the capital funding method has turned out to be fairly robust with respect to changes in the claims cost profile over time.

We have shown that science and politics need to further address the issue of population ageing. A solution for the public health care sector based on switching to a capital funding method is very costly. Yet, a demography reserve is needed to cope with rising medical costs in the future. These results should be born in mind when considering the long term implications of population ageing on national health services. We suppose that our findings in relation to financing the German national health system may likewise apply to a number of other states with similar demographics and public health care service conditions.

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