Financing Universal Health Care: Premiums or Payroll Taxes?

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Abstract

This paper presents an overlapping generations model where agents face labor-income and health risks in order to quantify the macroeconomic and welfare consequences of reform options for the German health insurance system. In addition to labor supply, consumption and savings, households also choose health expenditures in order to improve the health status and longevity. Starting from an initial equilibrium which reflects the current public and private mixture of the German health insurance system, we simulate the transition towards a uniform system with either funded or unfunded premiums or payroll taxes. The former have favorable labor supply effects, while the latter provide an implicit insurance device against income shocks.

Our simulations indicate that even with modest risk aversion the insurance property of payroll taxes may compensate their negative impact on labor supply. Consequently, the economic benefits of health premium models versus the citizen insurance models may have been overstated in the past. We also show that individual health expenditures may have significant welfare effects, but they do not change our conclusions qualitatively.

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1 Introduction

Developed countries of the Western world spend a substantial amount of their income and wealth on health care. According to the recent data of the OECD (2019, 152f.) average spending amounted to 8.8 percent of GDP in 2018, ranging from 16.9 percent in the U.S. to 4.2 percent in Turkey. While these figures where more or less stable in the last decade, health expenditure is projected to outpace GDP growth in the future due to demographic pressures, medical progress, changes in morbidity and individual health demand. Not surprisingly, there is a growing debate about a reform and especially the financing of the health care system in many counties. While countries such as the US or Switzerland mainly rely on private health insurance financed by either funded or unfunded individual premiums, most European countries have adopted payroll taxes as the main financing source of their health expenditures. While the latter is considered to be more equitable, it distorts the labor-leisure choice which increases the pressure on the aging workforce. Individual premiums, on the other hand, do not distort labor supply. However, in a situation with uncertain labor income they will increase the risk exposure of the insured. Obviously premiums and payroll taxes share an inverse trade-off between risk sharing and distortive effects. In an uncertain world it is a priori not clear whether premiums are superior to payroll taxes from a welfare point of view.

The present paper develops a dynamic stochastic equilibrium model with overlapping generations in order to analyze the impact of alternative health care financing options on the macro economy as well as on individual and aggregate welfare. Households choose their optimal labor supply, consumption and savings facing productivity, health and longevity risk along their life cycle. While productivity shocks reduce income from work, health shocks reduce the health status and work capacity and induce cost which are at least partly borne by the public and/or private health insurance. Households are covered by the health insurance (i.e. there is no choice about insurance coverage), but may spend resources on activities that improve personal health. Such investments in health capital (Grossman, 1972) induce a direct utility gain and additional indirect benefits from increased future time endowment and longevity. Modelling endogenous health allows to quantify at least partially possible moral hazard problems of the insurance provision and to generate differences in life expectancy across and within cohorts. In addition we can quantify the feedback effects of financing reforms on health investments even if insurance coverage remains untouched.

Our numerical model displays the central elements of the German health care system in terms of financing and coverage. For various reasons, Germany serves as an interesting case study. First, total health expenditures were in 2018 at 11.2 percent of GDP the third highest level among OECD countries. Second, the German health insurance system is comprehensive and characterized by the coexistence of a public statutory health insurance (SHI) and a private health insurance (PHI). While the public system is financed by a payroll taxes, the private system is funded with age-related premiums. In principle, all employees are compulsory insured by the public system, but they may opt out when they pass a certain income threshold. In addition, civil servants and self employed are typically covered by PHI plans. Consequently, especially those households with higher income and less health problems are sheltered from the redistribution of the solidarity system. Third, despite some moderate reforms in the past, which slightly reduced coverage to dampen the cost pressure, the SHI contribution rate is steadily increasing from about 11 percent in the mid 1980ies up to almost 16 percent currently. This fuels some radical reform proposals which intend to eliminate the existing dual system and substitute a uniform health insurance financed either by premiums or by payroll taxes. Forth, Germany is also interesting in the present context, because the pension system features a tight tax-benefit linkage. Since life expectancy rises in our model with income within a cohort, the pension system becomes regressive. This favours high income households who have additional incentives to invest resources in their health. In addition, the pension system provides no insurance against labor market shocks, which might strengthen the case for a more progressive health care system.[1]

The aim of the present paper is therefore to evaluate the distributional and welfare consequences of alternative reform proposals for health care in Germany. Starting from a benchmark steady state equilibrium, which reflects the situation in year 2018, we implement various reform proposals and compute the full transition path to a new long run equilibrium. In addition we present a range of sensitivity calculations with respect to preference parameters and the initial institutional setting. Our simulation results indicate two major conclusions: First, despite the poor performance in terms of risk sharing, premium financing is superior to payroll taxation for a wide range of parameter choices due to reduced labor supply distortions. Quite surprisingly, an unfunded premium system performs better than a funded one in terms of overall welfare. Second, financing reforms may significantly change individual health investment even when the insurance coverage is not altered. This effect explains at least partly the welfare advantage of unfunded premiums in our set up. Third, our simulations indicate a strong need for supplementary social transfers to initial pensioners who otherwise would be burdened heavily.

Our study is related to the sizable literature which allows for heterogeneity in income and health shocks over the life cycle. Typically this literature focusses on the situation in the U.S., where some public health insurance is provided to retirees, additional private health insurance is not mandatory for all and health cost coverage is low. Out-of-pocket medical expenditures are therefore potentially an important driver of precautionary savings. Palumbo (1999) provides one of the first approaches to estimate preference parameters in a life cycle model where the health status affects consumption utility while the future health status and costs are uncertain. Comparing the model predictions with actual consumption data clearly showed that including health uncertainty into the pure life-cycle model allows to explain the observed consumption and savings behavior of elderly much better than before. Follow up studies by De Nardi et al. (2010) or Capatina (2015) apply better data on how medical expenses rise by age and income and discussed more channels (besides medical expenses) through which the health status affects individuals. An extended versions of the life cycle model in De Nardi et al. (2010) already allows households to choose optimally between medical goods and ordinary consumption goods. Capatina (2015) also includes important features of the relationship between public medicare and private health insurance in the U.S.

However, a detailed analysis of the economic effects of health care reforms required a more comprehensive approach. Jeske and Kitao (2009) as well as Attanasio et al. (2010) develop some early general equilibrium models with heterogenous agents which analyze the impact on health care reforms on the macro economy and household welfare. Later studies highlight the individual health insurance choice when social insurance programs such as Medicaid and a minimum consumption floor crowd out the demand for private insurance. Hsu and Lee (2013) focus on the crowding-out effect on precautionary savings and private health insurance when a universal health insurance system is introduced. Quite similar to us they also address the trade-off between risk reductions and tax distortions of different financing methods. Pashchenko and Porapakkarm (2013) as well as Hansen et al. (2014) study the implications of the "Patient Protection and Affordable Care Act" (ACA) signed in 2010 by President Obama while Zhao (2017) discusses the linkages between the public and the

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[1] See also Zhao (2014), who analyzes spill-overs between pensions and health care in the US.

private U.S. health care system. Feng and Zhao (2018) even argue that differences in the health insurance systems may explain part of the observed differences in employment rates between the U.S. and European countries.

Our approach is related to all these studies but we consider the institutional setting of the German health care system. Since all households are members either in the public or the private insurance system, cost coverage is much higher than in the U.S. and precautionary savings as well as the choice of the insurance plan are not dominant. Instead, following recent work by Jung and Tran (2016), Jung et al. (2017) as well as Halliday et al. (2019) our model highlights the impact of health investments over the life-cycle which may be affected by health insurance reforms. Our main focus is on the trade-off between labor supply effects and the implicit insurance provision of the health care system. We also isolate the importance of the institutional setting with respect to the pension and tax system. Similar to Conesa et al. (2018) our paper distinguishes between short run and long run effects by considering the transition between steady states. The latter also allows to derive an aggregate welfare measure for each reform proposal.

The next section provides a description of the main characteristics of the German health care system. Next we present the simulation model as well as its calibration of the initial steady state equilibrium. Section five explains the considered reform options and the respective simulation results followed by some final conclusions.

2 The German health insurance system

Germany provides a universal health insurance to the whole population.[2] Currently, about 87 percent of the population are covered by the statutory health insurance (SHI), about 11 percent are insured through the substitutive private health insurance (PHI) and the rest (i.e. civil servants) receive health insurance through specific governmental schemes. Insurance under the public system is compulsory for employees and pensioners earnings less then the opt-out threshold (Versicherungspflichtgrenze) of € 59.400 per year in 2018, while their non-earning dependents are insured free of charge. Individuals with an annual income above that threshold and self employed can keep SHI on a voluntary basis or purchase a substitutive PHI. Currently, the SHI market consists of 113 competing no-profit sickness funds, which basically offer a standardized health plan with a benefit package that is mainly predetermined by the government. The mandated benefit package is generous relative to international standards and includes all medically necessary treatments in addition to prescription drugs, birth control, preventive, and rehabilitation care. SHI legislation also restricts cost-sharing and prohibits deductibles and co-insurance rates. Only fairly low copayments can be charged for hospital stays and prescription drugs. Consequently, in order to attract enrollees, sickness funds only can add some non-essential benefits to their package or improve the quality of their customer service. In order to finance expenses, SHI funds charge a basic contribution of 14.6 percent and a annually adjusted fund-specific contribution on wage-related income up to a contribution ceiling (Beitragsbemessungsgrenze) of € 53.100 per year in 2018.[3] These contributions are collected in the so-called Central Reallocation Pool (Gesundheitsfonds) and supplemented with a modest subsidy (about 7

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[2] For a more detailed description of the German health insurance system see Karlsson et al. (2016) or Wasem et al. (2018).

[3] In addition to this basic rate insurance companies may impose a collateral rate to cover their expenses which currently amounts to 1.1 percent on average.

percent of the pooled money). The accumulated revenue is then reallocated to the sickness funds according to a morbidity-based risk-adjustment scheme. This procedure intends to improve the risk-pooling and competition among funds despite the wage related contributions.

As already explained above, membership in a PHI scheme is only available for self employed and for employees with a gross income above the opt-out threshold for SHI. Individuals who want to join the PHI have to apply for exemption from compulsory insurance. Coverage in the PHI can be denied or some pre-existing conditions can be excluded from coverage. While the SHI benefit package serves as a benchmark for private insurers, benefits offered by PHI are much less regulated so that coverage in the private market is typically more generous and also more heterogeneous than in the public system. PHI premiums depend on state of health, age and scope of benefits, i.e. they are risk-related but actuarially fair at the time of initial enrolment. In subsequent years, premiums may be adjusted for all health plan holders but renewability is guaranteed. Since private insurers are required to build up reserves for rising expenditures at later ages, premiums are higher than expenditures at younger ages and insurers invest the accrued reserves on the capital market. In 2018 the capital stock of private insurers amounted to roughly 288 bn € or 8.6 percent of GDP, see appendix B. Although portability of these reserves is mandated since 2009, this front-loading still creates a lock-in effect which restricts switching and competition between private insurers.

This should suffice to explain the institutional structure of public and private health insurance in Germany. The next section describes our simulation model which tries to capture the central elements of this system. However, in order to reduce the complexity of the model, we do not allow for an individual choice of the insurance system for those employees above the opt-out threshold.[4] Instead we distinguish two subgroups within a cohort that are covered initially either by the SHI or the PHI.

3 The model economy

3.1 Demographics

We consider an economy populated by J overlapping generations. At the beginning of each period t a new generation is born where we assume a population growth rate n. When individuals enter the economy at age $j = 1$, they are assigned to a subgroup $\theta \in \mathcal{S} = \{\theta_1, \theta_2\}$, which may be interpreted as a permanent shock such as an education level. This assignment determines their skill class for labor productivity and their health insurance system in the benchmark. In addition to the skill level, all households receive an identical initial endowment of health capital $\bar{h} \in \mathcal{H} = [0, \infty]$. The latter will either depreciate due to health shocks $\zeta \in \mathcal{F} = \{0, -2\}$ and regular age-dependent depreciation δ_h or improve due to individual health investments m during the life time. The health capital stock affects survival from period to period with probabilities $\psi_{j+1}(h)$ denoting the conditional survival probability from age j to age $j+1$ with the property $\psi_{J+1}(h) = 0$. In addition to health shocks, households also receive transitory labor productivity shocks $\eta \in \mathcal{E}$ until they retire at age j_R and start to live from their pensions and savings. Pension benefits are determined by so-called earning points $ep \in \mathcal{P} = [0, \infty]$ that are accumulated when working in the market.

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[4] Our simplification may be justified by the fact that we do not consider non-earning dependents such as children or married partners who work at home. Therefore we neglect central elements that govern the optimal insurance choice.

Consequently, agents are characterized by the state vector

$$z = (j, a, h, ep, \theta, \eta, \zeta) \in \mathcal{Z} = \mathcal{J} \times \mathcal{A} \times \mathcal{H} \times \mathcal{P} \times \mathcal{S} \times \mathcal{E} \times \mathcal{F}$$

where $a \in \mathcal{A} = [0, \infty]$ denotes assets held at the beginning of age $j \in \mathcal{J} = \{1, \ldots, J\}$. Assets are initially zero and restricted throughout the whole life cycle to be greater or equal to zero, i.e. agents might be liquidity constrained. In order to distinguish low- and high-skilled individuals (who may have different health insurances) we also define the state space for the two sub-groups as

$$z_i = (j, a, h, ep, \theta_i, \eta, \zeta) \in \mathcal{Z}_i \qquad \text{with} \quad i = 1, 2.$$

Similarly, the state space for a specific cohort j of subgroup i is defined by $\mathcal{Z}_{ji} = \mathcal{A} \times \mathcal{H} \times \mathcal{P} \times \mathcal{E} \times \mathcal{F}$.

Health and productivity shocks which agents receive throughout their lifetime follow a finite-state Markov process. Therefore, households know their current productivity and health shock at the beginning of each period, but have to make expectations about next period shocks when making individual consumption and labor supply decisions.

Therefore, in each period t the population cohort is fragmented into subgroups $\phi_t(z)$, according to the initial distribution at age $j = 1$ as well as mortality processes, current health and productivity shocks and optimal household decisions. Let $X_t(z)$ be the corresponding cumulated measure to $\phi_t(z)$. We abstract from health shocks in the initial period, hence

$$\int_{\mathcal{E}} \mathrm{d}X_t(z_{11}) = \varpi \qquad \text{and} \qquad \int_{\mathcal{E}} \mathrm{d}X_t(z_{12}) = 1 - \varpi \qquad \text{with} \quad z_{1i} = (1, 0, \bar{h}, 0, \theta_i, \eta, 0) \tag{1}$$

must hold where ϖ denotes the fraction of low-skilled households insured in the SHI system. The fractions of the two skill classes have to add up to the normalized newborn cohort size of unity. Let $\mathbf{1}_{k=x}$ be an indicator function that returns 1 if $k = x$ and 0 if $k \neq x$. Then, the law of motion of the measure of households is

$$\phi_{t+1}(z^+) = \int_{\mathcal{Z}_{ji}} \frac{\psi_{j+1}(h(z))}{1+n} \cdot \mathbf{1}_{a^+=a(z)} \cdot \mathbf{1}_{h^+=h(z)} \cdot \mathbf{1}_{ep^+=ep(z)} \cdot \pi(\eta^+|\eta) \cdot \pi^h(\zeta^+|h, \zeta)\, \mathrm{d}X_t(z), \tag{2}$$

where $\pi(\cdot)$ and $\pi^h(\cdot)$ denote the transition probabilities for productivity and health shocks from one period to the next, respectively and "+" indicates next periods' values.

In the following, we will omit the state indices z and the period index t for every variable whenever possible. Agents and variables are then only distinguished according to the age j.

3.2 Household behavior

Individuals have preferences over streams of consumption c_j and leisure ℓ_j and their stock of health capital h_j

$$E\left[\sum_{j=1}^{J} \beta^{j-1} \left(\Pi_{i=1}^{j-1} \psi_{i+1}(h_i)\right) u(c_j, \ell_j, h_j)\right] \quad \text{with} \quad \psi'_{i+1}(h_i) > 0,$$

where β denotes the subjective discount factor and the age-specific survival rate increases with the health capital stock.[5] Each period, the total time endowment of unity is split between leisure, working (l_j) and sick time $s(h_j)$

$$\ell_j + l_j + s(h_j) = 1 \quad \text{with} \quad s'(h_j) < 0, \tag{3}$$

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[5] Note that due to endogenous survival the age-structure of the population also becomes endogenous.

i.e. sick time increases over the life cycle when health capital decreases.[6]

During their working periods, labor productivity depends on a deterministic age-profile of earnings e_j, the fixed productivity effect θ that is drawn at the beginning of the life cycle and a transitory component η_j that evolves stochastically over time with an autoregressive structure of degree 1, i.e.

$$\eta_j = \rho\eta_{j-1} + \epsilon_j \quad \text{with} \quad \epsilon_j \sim N(0; \sigma_\epsilon^2) \quad \text{and } \eta_0 = 0. \tag{4}$$

Given this structure, a household's gross labor income y_j is defined by the wage rate w for effective labor hours times the effective hours worked, i.e.

$$y_j = \begin{cases} we_j \cdot \exp(\theta + \eta_j) l_j & \text{if} \quad j < j_R \quad \text{and} \\ 0 & \text{if} \quad j \geq j_R. \end{cases}$$

The accumulated earning points depend on the relative income position $y_j/\bar{y}$ of the worker at age $j \leq j_R$. Since the ceiling for pension contributions $\hat{y}^p$ is fixed at the double of average income $\bar{y}$, agents could collect earning points per year up to a maximum of 2, i.e.

$$ep_{j+1} = ep_j + \min[y_j/\bar{y}; 2]. \tag{5}$$

At the mandatory retirement age j_R labor productivity falls to zero and households receive a pension benefit that is computed as a product of the accumulated earning points at retirement ep_{j_R} and the so-called "actual pension amount" which is modelled as a fraction κ of average income:[7]

$$pen_j = ep_{j_R} \times \kappa\bar{y} \qquad \forall \quad j \geq j_R. \tag{6}$$

Health capital accumulation is given by

$$h_{j+1} = (1 - \delta_{h,j})h_j + g(m_j, hc_j) + \zeta_j \qquad \text{with} \quad \frac{\partial g}{\partial m_j} > 0, \frac{\partial g}{\partial hc_j} > 0. \tag{7}$$

Individual health capital depreciates at the age-specific rate $\delta_{h,j}$ and may decrease due to a shock ζ_j. The shock could be any illness or injury that causes a large reduction of health capital such as a stroke, heart attack, or a hip fracture. If an agent is hit by this shock, the (curative) health costs hc_j which are (at least partially) reimbursed by the insurance rise due to appointments at the doctor or hospital and improve the individual stock of health. In addition, agents may also increase their health status by (preventive or curative) private health investments m_j. Private health investments contain expenditures that may improve health but are not a direct response to a health deterioration, i.e. not prescribed curative care, preventive care, cost of sport activities, and healthy food consumption. In contrast, health costs hc_j are direct responses to a health shock that causes a specific, immediate need.

The probability of a health shock $\pi^h(h_j, \zeta_j)$ in the next period depends on the current health capital stock and the shock realization

$$\zeta_{j+1} = \begin{cases} -2 & \text{with prob. } \pi^h(h_j, \zeta_j) \\ 0 & \text{with prob. } 1 - \pi^h(h_j, \zeta_j) \end{cases} \tag{8}$$

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[6] Consequently, health affects the allocation of time as opposed to labor productivity as in Jung and Tran (2016), which is in line with Grossman (1972), Capatina (2015) or Halliday et al. (2019).

[7] The adjustment factor for early and late retirement is neglected in the model.

where the probability of the health shock is reduced with a higher health capital and the absence of a shock in the current period.

In order to isolate risk aversion from intertemporal substitution, we follow the approach of Epstein and Zin (1991) and write the households optimization problem during the working phase in a recursive form as

$$\begin{aligned} V(z_j) &= \max_{c_j,\ell_j,m_j,a_{j+1}} \left\{ u(c_j,\ell_j,h_j)^{1-\frac{1}{\gamma}} + \beta\psi_{j+1}(h_j)E_j\left[V(z_{j+1}|\eta_j,\zeta_j)^{1-\varrho}\right]^{\frac{1-\frac{1}{\gamma}}{1-\varrho}} \right\}^{\frac{1}{1-\frac{1}{\gamma}}} \quad \text{s.t.} \qquad (9) \\ a_{j+1} &= (1+r)a_j + y_j + b_j - T_p(y_j) - T_h(y_j) - T(\tilde{y}_j) - \vartheta hc_j - p(m_j + c_j) \\ & \quad\; c_j > 0,\ a_{j+1} \geq 0,\ m_j = 0 \text{ or } m_j \geq \underline{m}, \end{aligned}$$

together with the constraints (3), (4), (5), (7) and (8). The expectation operator E_j in equation (9) is with respect to the stochastic processes of η and ζ. The parameter ϱ defines the risk aversion coefficient while γ denotes the intertemporal elasticity of substitution.

According to the budget constraint, future assets a_{j+1} are derived from current assets (including interest), gross income from labor y_j and accidental bequests b_j net of payroll taxes $T_p(\cdot)$ and health care contributions (or lump-sum health premiums) $T_h(\cdot)$, income taxes $T(\cdot)$ (with taxable income $\tilde{y}_j$), co-payment for health cost ϑhc_j and expenditures for health and ordinary consumption. Since ordinary consumption includes consumption taxes we set the price $p = 1 + \tau^c$ with τ^c denoting the respective tax rate. Expenditures for ordinary consumption must be non-negative and the borrowing constraint must hold. In addition, we assume that private health investments need to be above a certain threshold $\underline{m}$ in order to be effective.[8] As already explained above, pension contributions are subject to a contribution ceiling $\hat{y}^p$, i.e.

$$T_p(y_j) = \tau^p \min[y_j, \hat{y}^p].$$

Similarly, contributions of SHI members are also subject to a contribution ceiling $\hat{y}^h$. In contrast, PHI members pay an individual premium q_j^{ip} which may depend on age. Consequently,

$$T_h(y_j) = \begin{cases} \tau^h \min[y_j, \hat{y}^h] & \text{for SHI members} \\ q_j^{ip} & \text{for PHI members.} \end{cases}$$

When households enter retirement, their leisure consumption is determined by their remaining healthy time (i.e. $\ell_j = 1 - s(h_j)$) and their budget constraint changes to

$$a_{j+1} = \underbrace{(1+r)a_j + pen_j - T_h(pen_j) - T(\tilde{y}_j) - \vartheta hc_j}_{x_j} + tr_j - p(m_j + c_j) \quad \text{with} \quad tr_j = \max[p\underline{c} - x_j, 0].$$

Consequently, retirees receive pensions pen_j but no bequest. Instead, they may be eligible for government transfers tr_j that guarantee a minimum consumption level $\underline{c}$.

Our model abstracts from annuity markets. Therefore, private assets of all agents who died are aggregated and then distributed uniformly among all working age cohorts $i < j_R$, i.e.

$$b_i = [N(1+n)]^{-1} \int_{\mathcal{Z}} (1 - \psi_{j+1}(h))(1 + r_{t+1})a_{j+1}(z)\mathrm{d}X_t(z)$$

where N denotes the number of all working agents.

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[8] This assumption is made for technical reasons explained in the calibration section, but seems to be intuitive. In order to improve the health status significantly, one needs to do a lot of healthy activities.

3.3 The production sector

The production sector is populated by large firms which hire capital K and effective labor L on perfectly competitive factor markets in order to produce a single good according to the Cobb-Douglas production technology

$$Y_t = \Phi K_t^{\alpha} L_t^{1-\alpha},$$

with α denoting the capital share in production. Φ is a technology parameter used to normalize wages in the initial equilibrium to unity. Capital is rented from households through an intermediary at the riskless rate and depreciates over time again with depreciation rate δ. Factor prices are determined competitively by marginal productivity conditions, i.e.

$$w_t = (1-\alpha)\Phi \left(\frac{K_t}{L_t}\right)^{\alpha} \tag{10}$$

$$r_t = \alpha\Phi \left(\frac{L_t}{K_t}\right)^{1-\alpha} - \delta. \tag{11}$$

3.4 Government sector

The government sector in our model is split into a general government and a public pension and health care system, where each budget is closed separately. While the budget of the general government is balanced by the consumption tax each period, the pension and health care budgets are balanced by the respective contribution rates or health premiums.

General government In each period t the general government issues new debt $(1+n)B_{G,t+1} - B_{G,t}$ and collects income and consumption taxes in order to finance public consumption G, transfers Tr_t as well as interest payments on its debt, i.e.

$$(1+n)B_{G,t+1} - B_{G,t} + T_{y,t} + \tau_t^c(C_t + M_t) = G + Tr_t + r_t B_{G,t}, \tag{12}$$

where C_t and M_t define aggregate consumption and health investment, while $T_{y,t}$ denotes the revenues of income taxation. In the initial long-run equilibrium we specify the debt-to-output ratio B_G/Y as well as the public consumption-to-output ratio G/Y and adjust the consumption tax rate τ^c endogenously to balance the budget. During the transition, the debt level is kept constant and public consumption is fixed per capita.

With respect to taxable income $\tilde{y}_t$ we assume that contributions to public pensions and health care are completely exempted from taxation while pension benefits are fully taxed.[9] The resulting income is then further reduced in order to account for income splitting of married partners, work related allowances, etc. (see below). Then we apply the progressive tax code of 2018 (including the solidarity surcharge τ^z of 5.5 percent), so that

$$T_{y,t} = \int_{\mathcal{Z}} T(\tilde{y}(z))\mathrm{d}X_t(z) = (1+\tau^z)\int_{\mathcal{Z}} T_{18}(\tilde{y}_j(z))\mathrm{d}X_t(z).$$

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[9] Actually, the deferred taxation of pensions will be fully implemented in 2035. But this complication is neglected in the model.

Pension system The pension system pays old-age benefits and collects payroll contributions at a rate τ^p from labor income below the contribution ceiling $\hat{y}^p$. Pensions are zero before the retirement age, i.e. we do not consider early retirement. Given the aggregate pension contribution base PCB_t and aggregate benefits PB_t in period t, the contribution rate balances the budget so that

$$\tau_t^p PCB_t = PB_t, \tag{13}$$

where

$$PCB_t = \int_{\mathcal{Z}} \min[y(z), \hat{y}_t^p] \mathrm{d}X_t(z) \quad \text{and} \quad PB_t = \int_{\mathcal{Z}} pen(z) \mathrm{d}X_t(z_j).$$

Statutory health insurance (SHI) Households insured in the public system have to pay contributions to the SHI on their labor or pension income below the contribution ceiling $\hat{y}_t^h$. Similar to public pensions, the contribution rate τ_t^h balances the SHI budget, so that

$$\tau_t^h HCB_t = SHC_t \tag{14}$$

where

$$HCB_t = \int_{\mathcal{Z}_1} \min[y(z_1) + pen(z_1), \hat{y}_t^h] \mathrm{d}X_t(z_1) \quad \text{and} \quad SHC_t = (1-\vartheta) \int_{\mathcal{Z}_1} hc(z_1) \mathrm{d}X_t(z_1)$$

define the contribution base and health cost in period t which are not covered by co-payments of the insured population group.

Private health insurance (PHI) Privately insured households born in period t pay premiums q_t^{ip} to the insurance system throughout their lifetime which balance the expected present value of their lifetime health cost.[10] Therefore we need to distinguish between the *aggregate* private health cost in period t PHC_t and the present value of expected *individual* health cost of a newborn in period t IHC_t:

$$PHC_t = (1-\vartheta) \int_{\mathcal{Z}_2} hc(z_2) \mathrm{d}X_t(z_2) \quad \text{and} \quad IHC_t = (1-\vartheta) \int_{\mathcal{Z}_2} R_{jt} hc(z_2) \mathrm{d}X_{t+j-1}(z_2),$$

where $R_{jt} = \left[\Pi_{i=1}^{j-1}(1+r_{t+i})\right]^{-1}$ defines the discount rate. PHI premiums q_t^{ip} of a newborn in period t are then defined by

$$q_t^{ip} ICB_t = IHC_t \quad \text{where} \quad ICB_t = \int_{\mathcal{Z}_2} R_{jt} \mathrm{d}X_{t+j-1}(z_2) \tag{15}$$

denotes the individual contribution base, i.e. the discounted sum of expected life time periods for a privately insured. Since at younger ages premiums are typically higher than respective health cost, the PHI accumulates an assets stock $A_{p,t+1}$, which is invested on the capital market:

$$(1+n)A_{p,t+1} = (1+r_t)A_{p,t} + \int_{\mathcal{Z}_2} q_{t-j+1}^{ip} \mathrm{d}X_t(z_2) - PHC_t. \tag{16}$$

These assets increase initially over the life cycle of a specific cohort and then decrease to zero again.

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[10] Note that individual medical cost may differ between the public and privately insured due to different shock processes.

3.5 Individual and aggregate welfare calculation

In order to assess the welfare effect of a specific policy reform we follow the literature, e.g. Jeske and Kitao (2009) or Halliday et al. (2019), and compute the consumption equivalent variation (CEV) for each agent. The CEV measures the percentage change in consumption in every state of the world that has to be given to (or taken from) an agent to make him indifferent between remaining in the initial equilibrium and moving to the situation after the reform has taken place.[11] If $V_0(z)$ and $V_1(z)$ measure the utility of household z in the initial equilibrium and the reform period, the required transfer $v(z)$ is defined by

$$V_1(j, a + v_1(z), h, ep, \theta, \eta, \zeta) = V_0(z).$$

Note that positive v's constitute welfare losses from a given reform, relative to the status quo. Denoting the aggregate transfers of a specific cohort (and insurance type) by w_{ji} we convert it into a constant consumption stream $\bar{c}_{ji}$ for the remaining lifetime

$$\bar{c}_{ji}(1 + r_0)\left(1 - (1 + r_0)^{j-J}\right)/r_0 = w_{ji} = \int_{\mathcal{Z}_{ji}} v_1(z_{ji})\mathrm{d}X_1(z_{ji}).$$

The CEV measure is then derived by dividing the computed annuity by the respective consumption value c_{ji0} from the initial equilibrium, i.e

$$CEV_{ji} = -\frac{\bar{c}_{ji}}{c_{ji0}} \times 100.$$

Similarly, aggregate welfare is computed as the present discounted value of all transfers

$$W = \int_{\mathcal{Z}} v(z)\mathrm{d}X_1(z) + \sum_{t=2}^{\infty}\left(\frac{1+n}{1+r_0}\right)^{t-1}\int_{\mathcal{S}\times\mathcal{E}} v_t(z_{1i})\mathrm{d}X_t(z_{1i}).$$

where $v_t(z_{1i})$ measure the transfers to the newborn cohort of subgroup i in period t. As before we turn the aggregate welfare measure into an annuity stream over the whole transition path and the new long run equilibrium and express the size of the annuity as a percent of initial aggregate consumption C_0, i.e.

$$CEV = -\frac{W(r_0 - n)}{C_0(1 + r_0)} \times 100.$$

3.6 Equilibrium

Given public tax and social policy $\{G, B_G, T18(\cdot), \tau^c, \tau^h, \vartheta, \hat{y}^h, \tau^p, \hat{y}^p, \kappa\}$ and private insurance policy $\{\vartheta, q^{ip}\}$ $\forall\ t$, a recursive equilibrium path is a set of value functions $V(z)$, household decision rules $c(z),\ l(z),\ m(z),\ a^+(z)$, distribution of unintended bequest $b(z)$, measures of households $\phi_t(z)$, relative prices of labor and capital w_t, r_t such that the following conditions are satisfied $\forall\ t$:

1. households' decision rules solve the households decision problems (9) subject to the respective constraints;
2. factor prices are competitive, i.e. (10) and (11) hold;

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[11] Note that this is a partial equilibrium exercise. We only capture the first order behavioral effects induced by these transfers but do not their general equilibrium repercussions in factor prices and taxes.

3. individual and aggregate behavior are consistent:

$$\begin{aligned}
L_t &= \int_{\mathcal{Z}} e_j \exp(\theta + \eta) l(z)\,\mathrm{d}X_t(z) \\
A_{t+1} &= \int_{\mathcal{Z}} a^{+}(z)\,\mathrm{d}X_t(z) \\
C_t &= \int_{\mathcal{Z}} c(z)\,\mathrm{d}X_t(z) \\
M_t &= \int_{\mathcal{Z}} m(z)\,\mathrm{d}X_t(z) \\
Tr_t &= \int_{\mathcal{Z}} tr(z)\,\mathrm{d}X_t(z)
\end{aligned}$$

4. the laws of motion (1) and (2) for the measure of households hold;

5. unintended bequests satisfy

$$\int_{\mathcal{Z}} b(z)\mathrm{d}X_{t+1}(z) = \int_{\mathcal{Z}} (1-\psi(h))(1+r_{t+1})a^{+}(z)\mathrm{d}X_t(z); \tag{17}$$

6. the budgets of the general government (12), the public pension and the health insurance systems (13) and (14) are balanced;

7. private insurance contributions are equal to expected cost (15) and the private health insurance budget (16) is balanced.

8. the capital market clears, i.e.

$$A_t + A_{P,t} = K_t + B_{G,t} + B_{F,t},$$

with net foreign assets $B_{F,t} = 0$ in the closed economy;

9. the goods market clears, i.e.

$$Y_t = C_t + (1+n)K_{t+1} - (1-\delta)K_t + G + M_t + SHC_t + PHC_t + NX_t,$$

with net exports $NX_t = 0$ in the closed economy.

4 Calibration and the initial equilibrium

This section explains the calibration of the model's parameters. Our aim is to match the German economy in year 2018 with our initial equilibrium. However, since our theoretical model structure reflects specific assumptions (i.e. closed economy, no public transfers for income redistribution, etc.), we need to adjust the original German GDP data in order to generate target moments from the data. These calculations are reported in detail in Appendix B. Table 1 summarizes the parameter values used for our benchmark model, while Table 2 compares the targeted moment conditions in the (adjusted) data and those generated by the model.

The model period is 5 years. An individual enters the labor market at the real-time age of 20. Therefore, the model period $j = 1$ corresponds to ages 20-24 and maximum age $J = 16$ corresponds to ages 95-99. Mandatory retirement at model period $j_R = 10$ is therefore at age 65-69. As already discussed above, about 10 percent of the population in Germany are members in the private health insurance.

Table 1: Key parameter values of the benchmark model

Symbol	Definition	Value	Source/Target
	Demographics		
J	Maximum life span	16	Age 95-99
j_R	Retirement age	10	Age 65-69
ϖ	Fraction of households in SHI	0.9	see Appendix B
n	Growth rate (annual)	0.0055	Dependency ratio
	Household preferences		
β	Time discount factor (annual)	0.98	Capital-output ratio
γ	Intertemporal elasticity of substitution	0.5	Common value
ϱ	Risk aversion coefficient	2.0	
ν	Intratemporal elasticity of substitution	0.1	Halliday et a. (2019)
μ	Consumption coefficient	0.4	Labor supply share
χ	Weight of consumption/leisure utility	0.9	Consumption-GDP ratio
	Labor productivity		
$\{e_j\}_{j=1}^{j_R-1}$	Age-efficiency profile		Fehr et al. (2013)
ρ	AR(1) correlation	0.96	Fehr et al. (2013)
σ_ϵ^2	Transitory variance	0.03	Income variance
σ_θ	Permanent skill variance	0.8	Income variance
	Health stock accumulation and health cost		
$\delta_{h,j}$	Depreciation rate (periodical)	$[1.2, \dots, 17.5]$	Jung et al. (2017)
ξ	Sick time coefficient	0.61	see Appendix B
ω_0, ω_1	Survival probability	-4.7, 0.285	Life expectancy (LE)
ω_2, ω_3		0.005, -0.3	
$(\lambda_1, \lambda_2, \lambda_3)$	Health production parameter	(2.9, 1.1, 0.4)	M/Y- ratio
ε_j	Health production elasticity	$[0.5, .., 2.0, .., 0.3]$	Hall and Jones (2007)
$\underline{m}$	Minimum health investment	$0.15\bar{y}$	Difference in LE
	Production sector		
α	Capital share	0.34	see Appendix B
δ	Capital depreciation rate (annual)	0.06	see Appendix B
	Policy parameters		
ϑ	Co-insurance rate	0.00	
κ	Pension accrual rate	0.061	see Appendix B
G/Y	Public consumption-to-output ratio	0.15	see Appendix B
B_G/Y	Debt-to-output ratio	0.70	see Appendix B
$\underline{c}$	Consumption floor	$0.1\bar{y}$	see text

Consequently, the fraction of those insured in the public system ϖ is set to 0.9. The growth rate n in our model includes productivity growth and population growth. Without immigration the latter is even negative while hourly productivity decreased from an average of 1.7 percent in the period 1995-2005 to 0.8 percent in the period 2005-2016, see Elstner et al. (2018, 9). Our value of 0.55 percent is in line with these figures and also generates a realistic ratio of retired and working cohorts.

The preference function is based on Halliday et al. (2019) who assumed a Cobb-Douglas specification for consumption and leisure and a CES specification between the consumption-leisure aggregate and health. The parameter μ denotes the weight of consumption in the CD-function, while χ denotes the relative importance of the consumption-leisure combination relative to health capital. The intratemporal elasticity of substitution between the consumption-leisure aggregate and health capital is denoted by ν. In our benchmark calibration we combine a value of $\gamma = 0.5$ for the intertemporal elasticity of substitution and $\varrho = 2.0$ for risk aversion. These values are also applied in Halliday et al. (2019) and are widely used as a starting point in the literature. The time discount factor β is calibrated to match the capital-to-output ratio. The weight χ of the consumption-leisure aggregate is calibrated to match the consumption share in output and the consumption weight μ is selected to match an average fraction of working time in available time endowment of about one third. The intratemporal elasticity ν is used by Halliday et al. (2019) and also helps to match a realistic level of health investments.

$$u(c_j, \ell_j, h_j) = \left[\chi[c_j^{\mu}\ell_j^{1-\mu}]^{1-\frac{1}{\nu}} + (1-\chi)h_j^{1-\frac{1}{\nu}}\right]^{\frac{1}{1-\frac{1}{\nu}}}.$$

Due to the Epstein and Zinn (1991) preference formulation, utility is positive. Since the elasticity of utility is always smaller than one, households want to live longer, see Rosen (1988).

Individual labor productivity is determined by the deterministic age-efficiency profile e_j, the skill level θ and the idiosyncratic productivity shock η. The age-efficiency profile for Germany was estimated in Fehr et al. (2013), we only aggregate the annual figures over five years. Similarly, the persistence parameter ρ of the AR(1) process is taken from that study. The variances of the white noise term σ_ϵ^2 of the idiosyncratic component η and the skill variance σ_θ^2 are then calibrated to match the variances of log income at the beginning and the end of the employment phase reported in Storesletten et al. (2004, 613). The continuous process is discretized using a Rouwenhorst method with five states, see Fehr and Kindermann (2018, 344f.).

Figure 1: Variance of logs over the life cycle

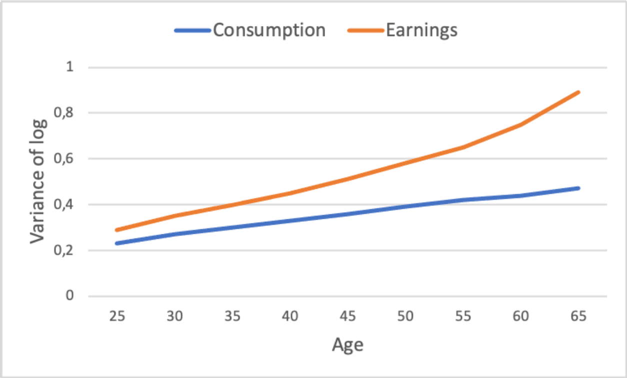

Figure 1 shows the variance of the logarithm of labor earnings and consumption over the life cycle in the initial equilibrium. The income variance rises from 0.3 to 0.9 and the consumption variance from 0.25 to 0.45. As shown in Table 2, our approach generates a realistic Gini-coefficient (see Grabka and Goebel, 2020, 235) and pre-tax income shares for 2018 (see the World Income Database http://wid.world/country/germany/) for Germany.

With respect to health accumulation process we need to pin down first the initial health capital $\bar{h}$ and the depreciation rate $\delta_{h,j}$. For simplicity we normalize the initial health status to $\bar{h} = 10.0$ and assume an (inverse) exponential relationship $\delta_{h,j} = 1 - \exp(-0.012j)$ in order to arrive at the (periodical) depreciation rates reported in Table 1 above. These figures are roughly in line with the (annual) depreciation rates computed with US health data reported in Jung et al. (2017).[12] The probability of a health shock a modification taken from Picone et al. (1998)

$$\pi^h(h_j, \zeta_j) = \frac{\exp(1 + 0.08h_j + 0.5\zeta_j)}{1 + \exp(1 + 0.08h_j + 0.5\zeta_j)},$$

where the parameters are adjusted in order to generate realistic fractions of ill agents over the life cycle. A higher health capital stock reduces the probability of a health shock and a shock in the previous period increases the respective probability in the current period. In order to generate realistic health care expenditures over the life cycle, we specify the polynominal function

$$hc_j = 0.032 + 0.034 \times j - 0.0011 \times j^2$$

where the three free parameters are calibrated in order to match the expected health cost relative to average income in the SHI as reported in Table 13 of Appendix B. As also shown there, the expected health care cost per capita are significantly higher in the PHI system. Although that could be taken into account in the model, identical health cost are assumed in both insurance systems. This allows to concentrate on the interplay between labor supply distortions and insurance effects in the policy reform scenarios described below.[13] Table 13 also reports the development of the share of ill people within a cohort over the life cycle. Table 2 shows that we match this dynamics quite well.

The health status affects individual productivity and lifespan. With respect to the former we simply set

$$s(h_j) = \exp(-\xi h_j)$$

where ξ is set in order to pin down the increase of sick days over the life cycle and the average sick days during the working phase as reported in Table 14 of Appendix B. Table 2 shows that this yields a fairly realistic sick time increase over the life cycle and in the aggregate. The survival function $\psi_{j+1}(h_j)$ fixes life expectancy. Following Halliday et al. (2019) we assume

$$\psi_{j+1}(h_j) = \frac{1}{1 + \exp(\omega_0 + \omega_1 j + \omega_2 j^2 + \omega_3 h_j)}$$

where $\omega_3 < 0$ so that the survival probability is a positive function of health. The survival probability is age-dependent, where the values of ω_1 and ω_2 insure that $\psi_{j+1}(h_j)$ is decreasing with age at an increasing rate. The ω_i's are calibrated to match a realistic life expectancy at birth and at retirement. Figure 2 below shows the resulting survival rates in the model and in German mortality tables 2017/2019.

Next, the health production function $g(\cdot)$ which generates the heterogeneity health behavior and health accumulation between the two insurance types needs to be specified. As in Picone et al. (1998)

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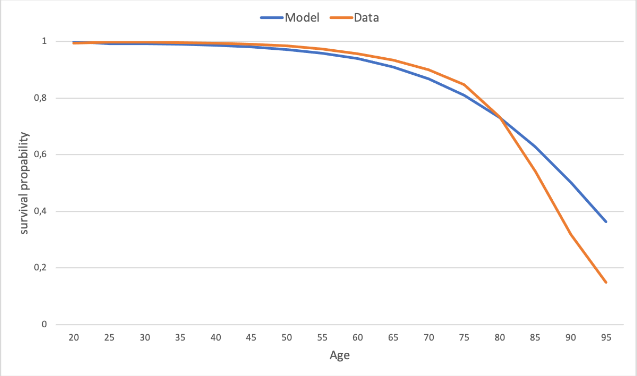
[12] Due to health depreciation, agents also invest in health even if they experience no health shocks over the life cycle.

[13] Otherwise one would also need to discuss different health cost structures after reforms.

Figure 2: Survival rates in the model and in the data

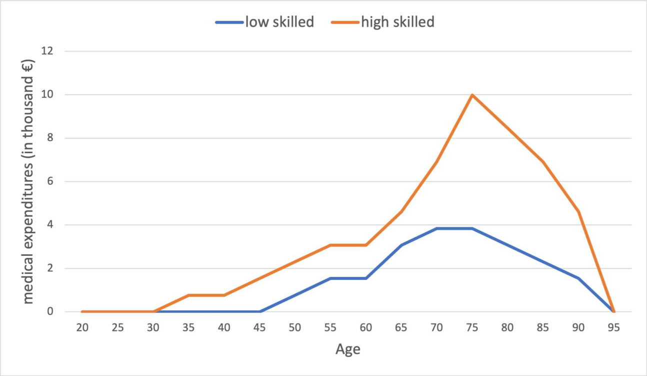


it is assumed that the health status could be increased by private investment m_j, but also by health cost (treatments) hc_j financed by the insurance system. In order to make sure that both effects are independent we set

$$g(m_j, hc_j) = (\lambda_1 - \lambda_2 \zeta_j) \cdot m_j^{\varepsilon_j} + \lambda_3 \sqrt{hc_j} \quad \text{with} \quad \lambda_i > 0, i = 1, 2, 3$$

so that the marginal products of private and insurance-financed medical expenditures are both positive and decrease with higher expenditure levels. When the agent experiences no health shock (i.e. when $\zeta_j = 0$), the marginal product of private health investment is lower than when a health shock occurs (i.e. when $\zeta_j = -2$). Following Hall and Jones (2007, 58) the elasticity of health status with respect to the health investment ε_j is hump-shaped. Values rise from 0.5 at young ages to 2.0 around retirement and then decrease again to 0.3. The remaining λ_i parameters are calibrated in order to generate a realistic aggregate level of m and a significant difference in the investment levels of the two insurance types.[14] Privately insured agents will invest more in their health because they have higher income. However, this effect alone only generates a small difference in life expectancy between the two insurance types. For this reason we assume that small amounts $m_j < \underline{m}$ of health investments have no impact on the health status. As a consequence, especially public insured agents will invest nothing in health so that the differential in life expectancy increases.

Figure 3: Health investment over the life cycle



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[14] It would be easy to generate more heterogeneity in life expectancy by assuming higher insurance expenditures or a different impact of private insurance spending on individual health. Both channels are discussed in the literature, see Frankovic and Kuhn (2019). However, this would complicate the economic interpretations of our policy reforms.

Figure 3 shows the private health investment over the life cycle for the two skill types. At young ages, households do not invest in health because they first need to build up savings in order to self insure against income shocks. In the middle of the working career health investment picks up and reaches a maximum after retirement because income uncertainty has deceased by then (and only life span uncertainty remains). The resulting difference in life expectancies of the two insurance types reported in Table 2 is still fairly small compared to the data reported in Appendix B. However, we do not capture the impact of other drivers of the mortality differential.[15]

Turning to the production parameters and the government policy, the capital share as well as the depreciation rate are computed from current German GDP data in Appendix B. For simplicity we abstract from any co-payments for private health investments in the benchmark simulation. The shares of public consumption as well as public debt relative to GDP are computed in Appendix B. The pension accrual rate κ yields a replacement rate for an average pensioner of 55 percent. This is roughly in line with the current practice, it also generates a realistic benefit to GDP ratio and contribution rate (see lower part of Table 2). We apply the German income tax code of the year 2018 to labor and pension income, i.e. the marginal tax rate schedule rises after a basic allowance from 14 to 42 (or 45) percent plus the solidarity surcharge. In order to generate a realistic income tax revenue, income net of insurance contributions is further reduced by 20 percent, i.e.

$$\tilde{y}_j = 0.8[y_j + pen_j - T_p(\cdot) - T_h(\cdot)].$$

The consumption floor $\underline{c}$ is set at 10 percent of average earnings. This level is below the social assistance level in Germany and produces hardly any budgetary cost in the initial equilibrium.[16] The consumption tax rate is then used to balance the budget. Since we abstract from any redistributive transfers, our consumption tax revenues are much lower than in the data. More important in the present context is the fact that the modelling of health care shocks and costs yields a quite realistic SHI contribution rate and PHI premium.[17]

In order to solve the model numerically, a micro- and a macroeconomic solution method is distinguished. The former solves a two stage optimization problem described in detail in Appendix A. The latter follows the Gauss-Seidel iteration procedure in order to compute equilibrium prices and quantities. For more information on the computational approach see Fehr and Kindermann (2018, 505f.). Figure 4 shows the dynamics over the life cycle of labor income and consumption on the left side and the relation between assets and average income on the right side. The consumption and income profiles are very consistent with the data reported in Fehr et al. (2013, 99) while the asset profile on the right is close to the German profile for 2017 reported in ECB (2020, 6).

5 Simulation results

Various reform proposals for the German health care system have been made in the past. They can be distinguished by the implied financing (pay-as-you-go or funded), the individual contribu-

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[15] In addition, the differences in life expectancy from the PKV Table could be exaggerated since higher survival rates are in the interest of the insurance companies.

[16] Transfer payments in the model are mainly introduced for technical reasons so that nobody runs out of resources.

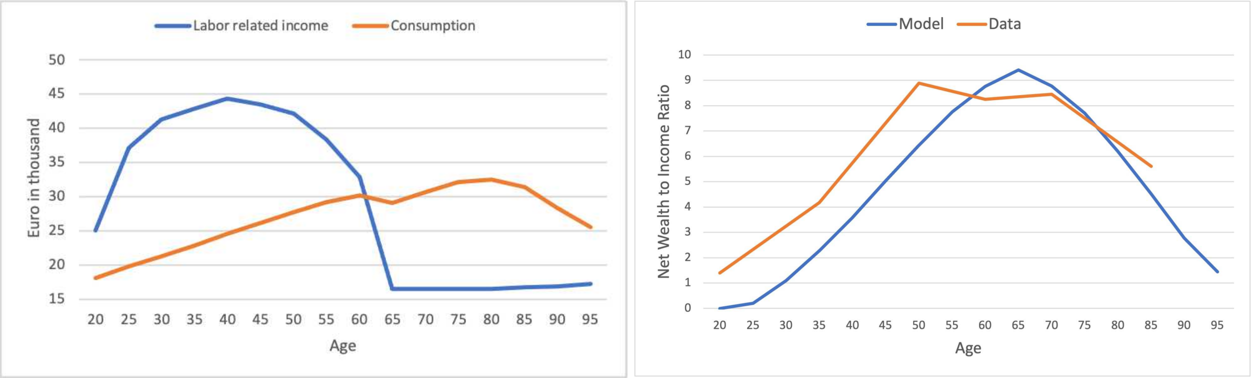
[17] Of course, the lower private spending (and premium) in the model is due to the reduced health cost in the models' private sector.

Table 2: Model solution and targets for Germany 2018 (in % of GDP)

Variable	Model	Target*
Demographics		
Dependency ratio (65+/20-64)	0.35	0.35
Life expectancy at birth	80.5/81.5	81.0
at retirement	18.1/19.0	19.5
Expenditures on GDP		
Private consumption	52.2	50.0
Government consumption	15.0	15.0
Gross investment	22.2	24.2
SHI/PHI health spending	6.8/0.8	7.0/1.1
Private health investment	3.0	2.7
Capital stock, labor market and income		
Capital-output ratio	377.5	370.0
PHI capital-output ratio	7.2	8.6
Working time (in %)	37.4	33.0
Gini (gross labor income)	0.45	0.46
Top 10 % share (in %)	41.6	37.3
Bottom 50 % share (in %)	22.2	19.1
Interest rate p.a. (in %)	3.4	–
Health indicators (average)		
Fraction of sick 30-34	16.7	13.6
Fraction of sick 75-79	27.6	25.5
Fraction of sick average	21.1	15.3
Fraction of sick time 30-34	1.1	5.3
Fraction of sick time 55-59	16.8	12.3
Fraction of sick time average	6.6	8.0
Health cost - income ratio	8.5	7.8
Government policy		
Labor income tax revenue	10.6	9.2
Consumption tax revenue	6.6	7.8
Consumption tax rate (in %)	12.0	–
Pension benefits	9.9	10.0
Pension contribution rate (in %)	19.1	–
Health care contribution rate (in %)	14.9	–
PHI premium (p.m. in €)	190	250

* See the documentation and calculations in Appendix B.

Figure 4: Labor income, consumption and assets over the life cycle



tion calculation (per-capita premiums, wage-related, income-related or risk-related), the compulsory membership structure (coverage for specific social groups or universal) and the specific regulations for the phase-out of the existing system. In the following we will focus on three major reforms:[18]

- The *citizen premium (CP) model*, where the PHI scheme is phased-out for current members and premiums q_t^{sp} with universal coverage are introduced successively. The long-run budget balance is therefore
$$q_t^{sp} \int_{\mathcal{Z}} \mathrm{d}X_t(z) = SHC_t + PHC_t.$$
- The *citizen insurance (CI) model*, where the PHI scheme would be phased-out for current members and the SHI scheme would become universal for all households in the long run.
- The *private premium (PP) model*, where the SHI scheme is phased-out for current members and the health care system is completely privatized in the long run. Health cost of SHI members during the transition are fully borne by all formerly SHI insured.

Consequently, all reforms hardly change the existing PHI insurance of those alive in the reform period.[19] Those households are only indirectly affected by changes in tax rates and factor prices. Of course, our assumption will extend the transition to the new long run system but it allows us to neglect the accumulated capital stock of the existing PHI scheme.

Before starting with the reform simulations, it is useful to analyze the impact of the two insurance systems in our model. Ideally one would like to eliminate the complete health insurance system. However, that would increase required transfer payments for pensioners. Therefore, we simulate a so-called *self insurance (SI) model*, where households in SHI and PHI have to bear a co-insurance burden of 30 percent (i.e. $\vartheta = 0.3$) of their health costs. Tax-financed transfers reduce the burden on low income pensioners.

In the following, the macroeconomic consequences of the different simulations are discussed first. Then the respective welfare effects for specific cohorts and households are compared. In all these simulations we start from the benchmark equilibrium described in Table 2 above. The third subsection

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[18] For a discussion of the different reform proposals see Kifmann and Nell (2014).

[19] Minor adjustments of the respective premiums might be required due to behavioral reactions and interest rates adjustments.

presents sensitivity analysis with respect to preference parameters and institutional arrangements. These simulations are performed in a small open economy setting with constant factor prices where the initial equilibrium will typically differ slightly from the benchmark equilibrium.

5.1 Macroeconomic effects of the reform models

Table 3 reports the consequences of the considered reform scenarios for some specific macroeconomic aggregates in the reform period 2020-24, after 10 and 20 years and in the long run. All our considered reform scenarios reduce the contribution level of the SHI system. As a consequence, the marginal tax burden on labor for the affected households is reduced so that labor supply and employment will increase. Typically, this will also induce more savings and a higher capital stock, leading further to higher wages, consumption health investment and output. Higher income tax revenues allow to reduce consumption taxation while the impact on the pension contribution rate remains mixed.

Despite these similarities in the adjustment to the new long run equilibrium, Table 3 displays significant differences the magnitudes of the macroeconomic changes. When the co-insurance rate is increased to 30 percent of health cost in the SI simulation, the SHI contribution rate falls by 5 percentage points. The PHI premium for new entrants is reduced from 192 to 139 € per month (not reported). Existing PHI members experience a stronger reduction which even rises with age since they have accumulated assets from the past. Overall, labor supply and employment rise by roughly two percent, which reduces the wage rate in the reform year. Since households now increase their precautionary savings, the long run capital stock rises by about 8 percent much stronger than long run output and consumption. The immediate jump in savings also explains why consumption and health investment fall on impact. The higher capital stock increases wages during the transition so that the average income and pensions also rise. As a consequence, the consumption tax rate falls by almost two percentage points and the pension contribution rate has to increase by 0.74 percentage points in the long run. Note that ordinary consumption increases twice as much as health investments do in the long-run. Increasing by 7 percentage points, precautionary savings are a better self insurance device than health investments. Those rise by 2 percentage points.

When the citizen premium model is introduced in the second column of Table 3, SHI contributions are immediately substituted by premiums. The latter are significantly higher than in the previous private system since the CP model is not funded and low skilled households generate higher health costs. Nevertheless, distortions decrease for these households, so that labor supply and employment react much stronger than before. However, since there is now no incentive for additional precautionary savings, consumption and health investment rise much stronger, while the capital stock increases much less. Note that health investments increase now stronger than ordinary consumption which is due to formerly SHI insured households who have not invested at all before but now change their behavior. The reduced capital stock accumulation dampens the wage dynamics and increases the interest rate compared to the previous simulation. Due to these factor price reactions labor income tax revenues decline and interest costs rise in the long run so that consumption tax rates are slightly higher than before despite higher employment and consumption.

The citizen insurance model forces high skilled households into the SHI system. Due to lower costs, the health contribution rate falls which induces an increase in employment of low skilled during the transition. At the same time, however, the labor supply distortions rise significantly for high skilled. Since the fall in high skilled employment is compensated by the increase in low skilled employment,

Table 3: Macroeconomic consequences of the reform models[a]

	SI	CP	CI	PP
Employment				
2020-24	1.75	3.78	0.05	-0.07
2035-39	1.63	3.64	0.15	0.98
2045-49	1.64	3.66	0.22	1.77
∞	1.66	3.78	0.22	3.46
Capital stock				
2025-29	2.35	2.32	-0.12	-0.44
2030-34	4.06	3.96	-0.22	-0.56
2040-44	6.22	5.89	-0.39	0.00
∞	7.94	6.18	-0.63	12.45
Output				
2020-24	1.15	2.48	0.03	-0.05
2030-34	2.46	3.75	-0.01	0.20
2040-44	3.17	4.42	-0.01	0.90
∞	3.76	4.59	-0.07	6.44
Consumption				
2020-24	-1.06	1.24	0.23	0.55
2030-34	1.26	3.58	0.20	0.36
2040-44	2.50	4.87	0.24	0.75
∞	3.67	5.60	0.02	6.61
Health investment				
2020-24	-3.89	1.34	0.22	0.16
2030-34	-1.91	3.66	0.17	0.62
2040-44	-0.21	6.06	0.41	1.15
∞	2.25	8.90	1.76	6.68
Wage rate				
2020-24	-0.59	-1.26	-0.02	0.02
2030-34	0.80	0.11	-0.11	-0.39
2040-44	1.51	0.72	-0.19	-0.46
∞	2.06	0.78	-0.29	2.87
Contribution rate/Premiums				
2020-24	-4.76	262	-0.34	191
2030-34	-4.82	256	-0.89	192
2040-44	-4.86	253	-1.28	193
∞	-4.92	259	-1.59	201
Consumption tax rate				
2020-24	-0.67	-0.50	-0.05	0.05
2030-34	-1.73	-1.54	0.05	0.32
2040-44	-2,27	-2.02	0.10	0.17
∞	-2.64	-1.95	0.31	-3.71
Pension contribution rate				
2020-24	-0.23	-0.40	0.03	0.02
2030-34	0.00	-0.12	0.03	-0.10
2040-44	0.22	0.17	0.04	-0.20
∞	0.74	0.94	-0.01	1.32

[a] Changes in tax rates are in percentage points, premiums are in €. All other changes are reported in percent of baseline path.

aggregate labor supply rises slightly. The elimination of the funded insurance reduces the capital stock, output and wages, so that the consumption tax rate now has to increase slightly. Although ordinary consumption hardly changes in the long run, health investment increases significantly. Again, low skilled households have more resources so that some of them start to invest in their health after the reform.

Quite the opposite happens when the private premium model is introduced. Low skilled households who enter the labor market are now forced to pay into a health fund which finances their health cost later in life. In addition, they also need to pay contributions to finance those who remain in the SHI system. These contributions decline to zero during the transition. As a result while their labor supply distortions hardly fall initially, they reduce savings in order to finance their additional bills and smooth consumption. As a consequence, initial employment, capital stock and output fall, while ordinary consumption rises. Therefore, wages decline and consumption tax rates increase initially. Note that the premium is significantly lower than in the CP model, which reflects the impact of funding. During the transition labor distortions are reduced and employment, capital stock, output, wages and consumption rise in the long run much stronger than before. This is due to the accumulated assets of the private insurance. The modest increase in the premium can be explained by higher health costs of low-skilled and lower interest rates.

5.2 Welfare effects of the reform models

Table 4 compares the welfare effects of the different reforms discussed above for specific cohorts and insurance types measured in CEV. On the one side, the reported welfare changes are due to intra- and intergenerational income redistribution induced by changes in financing burdens and factor prices. On the other side, all reform models change the incentives for labor supply and the insurance provision against labor productivity and (at least in the first simulation) health shocks. While the two premium models reduce labor supply distortions and the insurance provision against productivity shocks, the opposite applies to the CI model.

The increase in the share of co-payments in health care costs primarily harms the older pensioner cohorts in the SHI system. They have high costs and at the same time often low savings so that they are extremely exposed to health shocks. The retired cohorts in the PHI system are less affected, because on the one hand their premiums are reduced much stronger due to the accumulated PHI assets and the other hand they have typically higher savings. During the transition younger and future cohorts can self insure their health risk and benefit from higher wages, lower labor supply distortions and lower consumption taxes. Hence they realize a welfare increase which is significantly higher for high skilled future cohorts despite the fact that their labor supply distortions are not altered directly. The reason is that low skilled benefit from higher wages less than high skilled since they move into higher income tax brackets and have to pay higher health care and pension contributions. High skilled are often already in the top tax bracket and above the pension contribution ceiling. Therefore, with rising wages tax burdens are shifted from high to low skilled. In addition, mainly high skilled increase their health investment in order to benefit from lower health shocks. Overall, the long run welfare increase cannot fully compensate the initial cost. Therefore, the aggregate welfare measure indicates a loss of 1.47 percent of initial consumption.

The citizen premium model also induces a welfare loss for elderly formerly SHI insured pensioners, but this loss is lower and restricted to the retired cohorts. The latter now bear higher insurance

Table 4: Welfare consequences of the considered reform models[a]

Birth year	Age in reform period	SI model SHI insured	SI model PHI insured	CP model SHI insured	CP model PHI insured	CI model SHI insured	CI model PHI insured	PP model SHI insured	PP model PHI insured
1921-25	95-99	-12.26	-0.17	-6.40	2.84	0.62	0.07	-0.20	-0.12
1941-45	75-79	-9.79	0.84	-2.06	3.39	0.60	0.08	0.73	0.09
1961-65	55-59	-8.49	0.21	0.00	2.64	0.96	0.17	2.51	0.69
1981-85	35-39	-5.18	0.40	3.72	1.91	1.58	0.14	5.03	0.71
1996-00	20-24	-2.51	1.11	4.15	1.95	1.88	0.03	6.57	0.52
2006-10	10-14	-0.12	2.61	3.24	1.90	2.21	-6.41	-11.81	0.41
2016-20	0- 4	0.33	3.20	3.68	2.37	2.42	-6.39	-9.76	0.52
∞		1.19	4.15	2.84	2.06	3.07	-6.44	10.48	6.48
Aggregate Welfare		-1.47		1.78		0.18		0.90	

[a] CEV measured in percent of initial consumption.

costs than under the SHI system. The still PHI insured elderly benefit from higher interest rates and lower consumption taxes. Elderly employees in the reform period experience a significant welfare increase because their financing burden decreases while younger and future cohorts benefit from higher wages and lower consumption taxes. Decreased consumption taxes are responsible for the welfare increase of respective PHI cohorts. Overall, the aggregate welfare gain of the CP reform amounts to 1.47 percent of initial consumption. All things considered, financial burdens of health cost are more equally distributed within the society which implicitly improves the insurance provision and explains the aggregate welfare increase.[20]

The welfare effects of the CI model are quite different. On the one side, all formerly SHI insured benefit since their contributions are sequentially further reduced throughout the transition. In the long run their welfare increase corresponds to a three percent rise in initial consumption. On the other side, the already retired PHI insured realize very small welfare increases due to lower consumption taxes and higher interest rates. However, high skilled labor market entrants who are now forced into the public system are much worse off than before the reform. Their labor supply distortions rise significantly and they also have to co-finance the higher health cost of low skilled. As a result, they realize a welfare loss which amounts to roughly 6.5 percent of initial consumption. Overall welfare gains are therefore only very modest at 0.18 percent of initial consumption.

Finally, the welfare effects in the PP model are roughly the other way around. The oldest cohorts lose due to lower interest rates and higher consumption taxes. The remaining retired cohorts gain either because their contribution rate falls (for SHI insured) or because of lower premiums and higher interest rates (PHI insured). Younger low skilled cohorts who enter the labor market are dramatically hurt because they have to co-finance the health bills of elderly in the SHI insurance and need to build up assets for their own insurance. During the transition this double burden falls and turns eventually positive in the long run.[21] The long run consumption gain of more than 10 percent reflects the redistribution in health care cost towards the younger cohorts, reduced labor supply distortions as

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[20] Remember that low skilled generate higher health cost than high skilled!

[21] Of course, this specific burden sharing mechanism for the health cost of transitional cohorts in the SHI insurance is very arbitrary. One could easily image different ones which imply a more equal burden sharing.

well as higher wages and lower consumption taxes. The two latter effects are also experienced by employed high skilled cohorts, so that their long run welfare gain only amounts to 6.5 percent of initial consumption. Aggregate welfare gains in the PP model amount to 0.90 percent of initial consumption. Compared to the CP model, aggregate welfare is lower, because labor supply distortions are much higher during transitional years. Unfunded premiums could be implemented easier and faster.

5.3 Sensitivity analysis

Welfare effects reported in the previous subsection are strongly dependend on the assumptions made about preferences and the institutional setting of the public system. With respect to the latter we have assumed above (quite arbitrary) that only 50 percent of the statutory SHI payroll tax rate distorts labor supply, i.e. $T_h'(y) = 0.5\tau^h$. In addition, we have modelled a perfect linkage between contributions and later pension benefits so that the marginal payroll tax is also far below the statutory rate. This last assumption describes the situation in Germany quite well but it does not apply in many other countries which run more progressive pension systems. With respect to our modelling of household choice we would like to quantify the impact of health investment option as well as the flexibility of labor supply and risk aversion level. The problem is that every parameter change also alters the initial equilibrium which makes it difficult to compare the numerical results. We therefore compare all sensitivity calculations in a small open economy which features the same factor prices as the initial equilibrium reported in Table 2. Table 5 shows the impact of alternative assumptions on the aggregate welfare effects when we simulate the SI model and the three reform models in a small open economy.[22]

In the so-called "benchmark" simulations we always start from the initial equilibrium of Table 2, but keep the factor prices constant throughout the transition. As a consequence, international capital and trade flows balance the capital and the goods market. Table 3 above shows that (with the exception of the SI reform) wages typically decrease initially (so that the interest rate falls), but increase significantly in the long run. Due to higher income tax revenues, the consumption tax rate can be reduced at least in the long run. Without the initial fall in wages, the consumption tax can be reduced stronger initially than in the closed economy. Thus initially elderly cohorts benefit from higher interest rates and lower consumption taxes. During the transition, younger and future cohorts are worse off than in the closed economy, since the wages remain constant. The missing wage increase hurts low skilled less than high skilled, since tax burdens are now shifted back toward the latter. However, in the aggregate this redistribution of resources across and within cohorts hardly changes incentives and insurance provision. Therefore the aggregate welfare effects in Table 5 hardly change compared to the closed economy case in Table 4.

In all following simulations we change preference or institutional parameters so that the initial equilibrium will be different to the one shown in Table 2. To stay as close as possible, we keep the interest rate from Table 2 and adjust the technology parameter Φ in order to normalize the wage rate as before. As it turns out, this procedure has only minor effects on the initial tax and contribution rate.[23]

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[22] Additional tables with detailed macro and welfare effects are available upon request.

[23] With the exception of the last simulation, they always remain in a range of ± 0.5 percentage points of the initial values.

Table 5: Sensitivity analysis: Aggregate welfare effects in a small open economy[a]

	SI model	CP model	CI model	PP model
Benchmark	-1.36	1.84	0.13	0.85
Marginal payroll tax $T_h' = \tau^h$	-0.17	4.87	0.46	2.12
No health investment $m = 0$	-1.73	1.81	0.19	0.98
Fixed labor supply $l = \max[0.37; 1 - s(h)]$	-4.12	-1.91	0.12	-0.34
Higher risk aversion $\rho = 6.0$	-3.39	1.03	0.08	0.30
Flat pensions $ep = 0$	-1.23	3.39	0.11	1.56

[a] CEV measured in percent of initial consumption.

In the second line of Table 5 we assume that health care contributions fully distort labor supply. By implication, when the former SHI system is reduced or even fully eliminated, low skilled households will stronger increase labor supply than before. Higher labor income taxes allow to further reduce consumption taxation benefitting the elderly and high skilled as well. The stronger reduction of labor supply distortions further increases welfare of younger and future low skilled cohorts. Aggregate welfare effects are now always higher than in the previous line. The positive effect is strongest in CP model and much less significant in the SI reform. In the SI and the CI reform the welfare effect runs similarly.

Next we simulate the model without the choice of individual health investments. Now households react stronger with their labor supply in order to self insure. Consequently, consumption taxes decrease stronger than in the benchmark simulation which benefits all elderly households. As before, higher labor incomes induce a shift in tax burdens from high towards low skilled households which reduces welfare of the latter. Relative to the benchmark simulation, high skilled households are therefore better off although they cannot invest in health any more. The shift towards progressive taxes reduces overall welfare effects. When households have to bear a share of health cost in the SI model, the benefits of health investments have a significant impact on aggregate welfare. We will further discuss this point in the conclusions.

When the policy reform is simulated with fixed labor supply, households cannot self insure via working more and they do not benefit anymore from reduced distortions of labor supply. Consequently, aggregate welfare losses are much higher in the SI model and the formerly aggregate welfare gains turn into losses in the two premium models. Households now only suffer from the reduced insurance value of premiums. Since labor supply distortions even increase for formerly PHI insured in the CI model (which is now absent), aggregate welfare hardly changes compared to the benchmark simulation. The positive, albeit small, improvement in welfare can be related to the better risk allocation compared to the other models.

Similarly, when households are more risk avers they build higher precautionary savings. When the insurance protection is reduced, they work more and save more than in the benchmark simulation. As before this reduces consumption taxes and shifts tax burdens towards the low skilled. But now the reduced insurance against health and productivity shocks additionally reduces welfare. In the premium models especially low skilled households are harmed because they had a better insurance before. This mainly explains the significant fall in aggregate welfare reported in Table 5 above. Since we are unsure about the exact value of ρ, we assume the same value as Palumbo (1999), so that $\rho = 6$. Asset pricing studies such as Heathcote et al. (2008) simulate with $\rho \in [1;10]$.

Finally, the impact of the flat pension system need to be explained in more detail. In our model we simply substitute the pension benefit expression (6) by

$$pen_j = \kappa \bar{y} \qquad \forall \quad j \geq j_R.$$

Pension contributions are now fully distortive so that we set $T_p'() = \tau^p$ for all incomes below the contribution ceiling. In addition the replacement rate κ is reduced to 0.4 in order to generate a similar contribution rate as in Table 2. Compared to the previous pension system, the flat pension improves the insurance against productivity shocks at the cost of higher labor market distortions. When the health care coverage is now reduced, the increased risk is covered better than before, which explains the reduced welfare loss of the SI model. However, the overall welfare improvement compared to the benchmark model is quite modest since losses decrease only to 1.23 percent of initial consumption. Aggregate welfare increases significantly compared to the benchmark with the two premium models (CP and PP) because marginal tax rates are higher before the reform. Again hardly anything changes with the CI model.

6 Discussion

Our above calculations have clearly demonstrated the advantage of unfunded premiums compared to funded premiums or payroll taxes in Germany. Despite the fact that they do not insure against labor market risk, the positive labor supply effects induce significant overall welfare gains which dominate all other reform options even when risk aversion is fairly high. In our set up they are superior to funded premiums since they can be implemented immediately while funded premiums need a longer transition period until they are fully implemented. The substitution of unfunded premiums could be also introduced in the SHI system without altering the PHI system. In this case the currently PHI insured would be slightly better of then in the CP model, since there is less risk sharing with higher risk SHI insured. Our results also indicate that other, more moderate reforms of the SHI system such as a higher contribution ceilings or additional tax financing may generate more revenue but should not be implemented from an aggregate welfare point of view. They would increase existing distortions instead of lowering them.

Our results also highlight the importance of the individual health investment choice. While the complete insurance only finances the direct monetary cost of health problems, households still bear indirect cost of sick time and lower life span. Spending money (and in reality also time) on health activities could reduce these indirect cost (or increase benefits) which are not covered by the health insurance. To some extent our model can explain a significant part of the observed differential in life expectancies and improve the welfare consequences of policy reforms. Note, however, that our modeling of health investment was quite conservative. Although households change their behavior quite significantly after the reforms, the resulting effects on life expectancy and health cost were very modest. Subsidies or reduced consumption taxes applied to health investment would rather reduce welfare instead of increasing it. The impact of health activities on individual welfare works through very indirect channels in this model. Some recent studies explore more direct channels, which have much stronger effects. For example, Frankovic and Kuhn (2019) assume that health investments and not the health status alters the survival rate. They also capture differences in the ability to use the medical technology in order to identify and quantify the main drivers of longevity inequality. Their approach generates much higher differences in life expectancy within and across cohorts. Alternatively, Okzan (2017) disaggregates the health technology by distinguishing two types of health capital: While physical health capital directly generates utility and determines survival probabilities as well as sick time, preventive health capital determines the shock process to physical capital. Households are endowed with both capital types when they enter the economy. While physical capital is subject to health shocks, preventive capital decreases due to regular depreciation. Households can completely compensate these losses with healthy activities. This generates a much stronger impact on health cost and a higher differential in life expectancies between low and high skilled households.

Compared to Okzan (2017) and most of the studies cited in the introduction we do not allow households to choose their level of co-insurance. This could be justified in the current German system, but it is an open question whether full insurance is really efficient and will remain in the future. For example, Switzerland combines a public unfunded premium system which covers a certain fraction of health cost with a supplementary choice of insurance coverage, see Schmid et al. (2018). In the present model, one could substitute the choice of health investment with a choice of insurance coverage such as in Hsu and Lee (2013). Instead of only choosing between zero or full coverage, households could be given various coverage options. Kifmann and Nell (2014) even call for an individual choice between a public CI system and a private PP system. However, such a choice is beyond the scope of the present model since it requires much more intragenerational heterogeneity in terms of family types and risk preferences. This is beyond the scope of the present model.

References

Attanasio, O., S. Kitao and G.L. Violante (2010): Financing medicare: A general equilibrium analysis, in: J.B. Shoven (ed.), Demography and the Economy, Chicago: University of Chicago Press.

Capatina, E. (2015): Life-cycle effects of health risks, Journal of Monetary Economics 74, 67-88.

Conesa, J.C., D. Costa, P. Kamali, T.J. Kehoe, V.M. Nygaard, G. Raveendranathan and A. Saxena (2018): Macroeconomic effects of Medicare, Journal of the Economics of Ageing 11, 27-40.

De Nardi, M., E. French and J.B. Jones (2010): Why do the elderly save? The role of medical expenses, Journal of Political Economy 118, 39-75.

Epstein, L.G. and S.E. Zin (1991): Substitution, risk aversion, and the temporal behavior of consumption and asset returns: An empirical analysis, Journal of Political Economy 99, 263-286.

Elstner, S., L.P. Feld and C.M. Schmidt (2018): The German productivity paradox - Facts and explanations, Ruhr Economic Papers 767, Bochum.

European Central Bank (ECB) (2020): The household finance and consumption survey, Wafe 2017, Frankfurt.

Fehr, H., M. Kalweit and F. Kindermann (2013): Should pensions be progressive? European Economic Review 63, 94-116.

Fehr, H. and F. Kindermann (2018): Introduction to computational economics, Oxford University Press, Oxford.

Feng, Z. and K. Zhao (2018): Employment-based health insurance and aggregate labor supply, Journal of Economic Behavior and Organisation 154, 156-174.

Frankovic, I. and M. Kuhn (2019): Access to health care, medical progress and the emergence of the longevity gap: A general equilibrium analysis, Journal of the Economics of Ageing 14, Article 100188.

Grabka, M.M. and J. Goebel (2020) : Real incomes increasing, low-income rate decreasing in individual age groups, DIW Weekly Report 10, Issue 17/18, 231-239.

Grossman, M. (1972): On the concept of health capital and the demand for health, Journal of Political Economy 80(2), 223-255.

Haliday, T.J., H. He, L. Ning and H. Zhang (2019): Health investment over the life cycle, Macroeconomic Dynamics 23, 178-215.

Hall, R.E. and C.I. Jones (2007): The value of life and the rise in health expenditures, Quarterly Journal of Economics 122(1), 39-72.

Hansen, G.D., M. Hsu, and J. Lee (2014): Health insurance reform: The impact of a Medicare buy-in, Journal of Economic Dynamics & Control 45, 315-329.

Heathcote, J., K. Storeletten and G.L. Violante (2008): Insurance and opportunities: A welfare analysis of labor market risk, Journal of Monetary Economics 55, 501-525.

Hsu, M. and J. Lee (2013): The provision of public universal health insurance: Impacts on private insurance, asset holdings, and welfare, Macroeconomic Dynamics 17, 1252-1280.

Jeske, K. and S. Kitao (2009): U.S. tax policy and health insurance demand: Can regressive policy improve welfare? Journal of Monetary Economics 56, 210-221.

Jung, J., and C. Tran (2016): Market inefficiency, insurance mandate and welfare: U.S. health care reform 2010, Review of Economic Dynamics 20, 132-159.

Jung, J., C. Tran, and M. Chambers (2017): Aging and health financing in the U.S.: A general equilibrium analysis, European Economic Review 100, 428-462.

Karlsson, M., T.J. Klein and N.R. Ziebarth (2016): Skewed, persistent and high before death: Medical spending in Germany, Fiscal Studies 37(3-4), 527-559.

Kifmann, M. and M. Nell (2014): Fairer Wettbewerb zwischen gesetzlicher und privater Krankenversicherung, Perspektiven der Wirtschaftspolitik 15(1), 75-87.

OECD (2019): Health at a Glance 2019: OECD Indicators, OECD Publishing, Paris.

Ozkan, S. (2017): Preventive vs. curative medicine: A macroeconomic analysis of health care over the life cycle, Mimeo.

Palumbo, M. G. (1999): Uncertain medical expenses and precautionary saving near the end of the life cycle, Review of Economic Studies 66, 395-421.

Pashchenko, S. and P. Porapakkarm (2013): Quantitative analysis of health insurance reform: Separating regulation from redistribution, Review of Economic Dynamics 16, 383-404.

Picone, G., M. Uribe and R.M. Wilson (1998): The effect of uncertainty on the demand for medical care, health capital and wealth, Journal of Health Economics 17, 171-185.

Rosen, S. (1988): The value of changes in life expectancy, Journal of Risk and Uncertainty 1, 285-304.

Storesletten, K., C.I. Telmer and A. Yaron (2004): Consumption and risk sharing over the life cycle, Journal of Monetary Economics 51, 609-633.

Wasem, J., F. Buchner, G. Lux and S. Schillo (2018): Health plan payment in Germany, in: T.G. McGuire and R.C. van Kleef (eds.): Risk adjustment, risk sharing and premium regulation in health insurance markets, Academic Press, 295-329.

Zhao, K. (2014): Social security and the rise in health spending, Journal of Monetary Economics 64, 21-37.

Zhao, K. (2017): Social insurance, private health insurance and individual welfare, Journal of Economic Dynamics & Control 78, 102-117.

Appendix A: The household's optimization problem

At any state $z = (j, a, h, ep, \theta, \eta, \zeta)$, households have to decide how much to work on the market and how to split up their current resources into consumption expenditures pc, health investment pm and financial assets a^+.

In recursive form the household's optimization problem is given by

$$V(z) = \max_{c,\ell,a^+,m} \left\{ u(c,\ell,h)^{1-\frac{1}{\gamma}} + \beta\psi_{j+1}(h)\, E[V(z^+|\eta,\zeta)^{1-\epsilon}]^{\frac{1-\frac{1}{\gamma}}{1-\epsilon}} \right\}^{\frac{1}{1-\frac{1}{\gamma}}}$$

subject to

$$\begin{aligned} a^+ &= (1+r)a + y + pen + b + tr - T_p(y) - T_h(y, pen) - T(\tilde{y}) - q^{ip} - \vartheta hc - p(c+m) \\ h^+ &= (1-\delta_h)h + g(m, hc) + \zeta \\ ep^+ &= ep + \min[y/\bar{y}; 2] \\ & \quad c > 0,\ \ell + l + s(h) = 1,\ a^+ \geq 0,\ m = 0 \text{ or } m \geq \underline{m}. \end{aligned}$$

The expectation operators E are defined with respect to the stochastic labor productivity process η and the health shocks ζ in (4) and (8). The current resources on the right hand side of the periodic budget constraint are represented by the sum of financial assets (including interest), gross labor and pension income, bequest, net of payroll taxes, health premiums, income taxes, not-insured health costs, consumption, and health investment.

The optimization problems defined above can be solved in two steps:

1. *Health investment:* Given a current state $\tilde{z} = (j, \tilde{a}^+, h, ep^+, \theta, \eta, \zeta)$, we need to split total investment $\tilde{a}^+$ between health investment $pm = \omega^+\tilde{a}^+$ and financial investment $a^+ = (1-\omega^+)\tilde{a}^+$. This procedure yields to $\omega^+ = \omega(\tilde{z})$.

   In order to distinguish the case without any health investment we first compute the welfare level
   $$Q(\tilde{z}, \omega^+ = 0) = E\left[\ V(z^+|\eta,\zeta)^{1-\epsilon}\ \right]^{\frac{1}{1-\epsilon}},$$
   where we need to make sure that
   $$\begin{aligned} a^+ &= \tilde{a}^+ \geq 0 \\ h^+ &= (1-\delta_h)h + g(0, hc) + \zeta. \end{aligned}$$
   holds as well as (4) and (8).

   Households who want to invest in their health (i.e. $m \geq \underline{m}$) need to split their total investment $\tilde{a}^+$ into health investment, making sure that the minimum requirement is fulfilled, and liquid assets. The sub-optimization problem is now
   $$Q(\tilde{z}, \omega^+ > 0) = \max_{\underline{\omega}(\tilde{a}^+) \leq \omega^+ \leq 1} E\left[\ V(z^+|\eta,\zeta)^{1-\epsilon}\ \right]^{\frac{1}{1-\epsilon}}$$
   subject to
   $$a^+ = (1-\omega^+)\tilde{a}^+$$

$$h^+ \quad = \quad (1-\delta_h)h + g(\omega^+ \tilde{a}^+, hc) + \zeta$$

where $\underline{\omega}(\tilde{a}^+) = p\underline{m}/\tilde{a}^+$ and again (4) and (8) apply.

Given the two welfare levels with and without health investment we derive

$$Q(\tilde{z}) = \max[Q(\tilde{z}, \omega^+ = 0), Q(\tilde{z}, \omega^+ > 0)]$$

from which we get $\omega(\tilde{z})$.

2. *The consumption-labor supply-savings decision:* Given a current state z and the optimal split between financial and health investment $\omega(\tilde{z})$, we can solve the consumption-labor-savings decision in order to get $c(z)$, $\ell(z)$ and $\tilde{a}^+(z)$.

   Given $Q(\tilde{z})$, we can set up the optimization problem as follows

$$\begin{aligned}
V(z) &= \max_{c,\ell,\tilde{a}^+} \left\{ u(c,\ell,h)^{1-\frac{1}{\gamma}} + \beta\psi_{j+1}(h) Q(\tilde{z})^{1-\frac{1}{\gamma}} \right\}^{\frac{1}{1-\frac{1}{\gamma}}} \\
\text{s.t. } \tilde{a}^+ &= (1+r)a + y + pen + b + tr - T_p(y) - T_h(y, pen) - T(\tilde{y}) - q^{ip} - \vartheta hc - pc \\
ep^+ &= ep + \min[y/\bar{y}; 2]
\end{aligned}$$

   where $y = w(1-\ell-s(h)) = wl$.

   The first-order conditions of consumption and leisure supply yield to the following optimality condition

$$pc = \frac{\mu}{1-\mu} w^m (1-l-s(h)) \quad \text{where} \quad w^m = w(1-T'(y)-T'_p(y)-T'_h(y))$$

   is the marginal wage rate and $T'_i(y), i = p, h$ define the *marginal* contribution rates

$$T'_i(y) = \begin{cases} 0.5\tau^i & \text{if } y < \hat{y}^i \qquad i = p, h \\ 0 & \text{otherwise.} \end{cases}$$

   Substituting this into the budget constraint (during employment periods) we get

$$w^n l + \frac{\mu}{1-\mu} w^m l = \tilde{a}^+ - \left[\, (1+r)a + b - q^{ip} - \vartheta hc \,\right] + \frac{\mu}{1-\mu} w^m (1-s(h))$$

   where $w^n = w(1 - T(y)/y - T_p(y)/y - T_h(y)/y)$ defines the net wage.

   Labor supply is therefore computed from

$$l = \min\left[\max\left[\frac{(1-\mu)[\tilde{a}^+ - [(1+r)a + b - q^{ip} - \vartheta hc] + \mu w^m (1-s(h))}{(1-\mu)w^n + \mu w^m}; 0\right]; 1-s(h)\right]$$

Appendix B: Calibration targets for Germany 2018

GDP and health care data

In 2018 total health expenditures in Germany amounted to 390 bn. € or about 11.7 percent of GDP. Table 6 shows the different institutions that spent these outlays. The statutory health insurance system provides by far the most health care services amounting to roughly 57 percent of total outlays. Quite surprisingly, private households bear about 13 percent of all expenditures. These expenditures mainly include out-of pocket payments for non-covered costs and self medication. The private health insurance only spend about 8.5 percent of total cost, which includes (fairly small) outlays for private long-term care (LTC). The rest is spent by the statutory LTC system, other public institutions and employers. In the following, the statutory LTC system and other funding institutions are omitted with focus on the public and private insurance system as well as private expenditures on health care.

Table 6: Health expenditure by funding institutions in Germany in 2018*

Institution	in € bn	in %
Statutory health insurance (GKV)	222.1	56.9
Households and private non-profit institutions	52.1	13.3
Private health insurance (PKV)[1]	33.3	8.5
Statutory long-term care insurance	39.5	10.1
Other funding sources[2]	43.7	11.2
Total	390.7	100.0

*Source: Statistisches Bundesamt (2020): Genesis-Online.

[1] Including private LTC.

[2] Government, employers, pension and accident insurance.

For our purpose it is important to isolate these expenditures in the national accounting statistics. If not stated otherwise, the following data is based on StaBu (2019a). Table 7 reports the official national income accounting data for Germany in 2018.

Table 7: National accounting in Germany 2018 (in € bn)*

Output measure		Expenditure measure		Distribution measure	
Gross value added	3.012	Private consumption	1.693	Labor cost	1.771
Goods taxes ($\tau^c C$)	332	health care	87	Capital income	732
		Private NPOs	51	Aggregate income	2.503
		Government consumption	665	Production taxes	326
		social in-kind	211	NNI	2.829
		Gross investment	729	Depreciation	609
		Trade balance	206	GNI	3.438
				Primary income RoW	-94
GDP	3.344		3.344		3.344

*Source: StaBu (2019a).

Private consumption includes health care consumption which amounts in 2018 to roughly 87 bn €.[24] This amount covers the expenditures of the PKV (i.e. 33 bn €) and voluntary private expenditures of 54 bn €. Consequently, this last figure fits quite well with the private expenditures reported in Table 6 above. However, our measure of private health investment is much broader defined and also includes consumption of healthy food, sport activities, body care etc. Some of these voluntary private health expenditures are included in consumption of private non-profit organisations (NPOs). The latter produces services which are mainly provided to private households and are financed by voluntary contributions or donations. These organisations include churches, charitable, cultural or scientific organisations, political parties and trade unions. Health services by such organisations are provided for example by the Red Cross and charitable organisations. In our broad definition, also sport clubs provide such services. In addition, households spent their leisure time in fitness clubs and buy sports equipment. Total consumption expenditures on such hobbies and leisure activities amount to 38 bn €. Finally, households spend money on body care (35 bn €) and for other social services (37 bn €).[25] Therefore we estimate that up to 80 bn € in total are spent on private health investment (M). Note that in contrast to the health expenditure of the insurance systems these consumption outlays are assessed with consumption taxes. Finally, government consumption includes the social in-kind transfers of the GKV ("Soziale Sachleistungen") which amount to 211 bn € in 2018 (p. 289). The difference between this figure and the GKV expenditures in Table 6 is mainly due to sickness benefits (Krankengeld) which is paid as a monetary transfer directly to private households and neglected in the following.

Before we reconcile the GDP data with the restrictions of the model we need to compute the capital stock employed in production in Germany in 2018. The data for asset values and capital stock is derived from StaBu (2019b). This data set has two advantages. First, all values are reported net of depreciation at current market prices which gives exactly the current value. Second, detailed wealth accounts are compiled not only for the whole economy but also for four institutional sectors: Non-financial corporations, financial corporations (banks), the government and private households. In order to derive the capital stock of production we need to subtract the owner occupied property from total tangible assets. Table 8 provides the original figures from the data.

Table 8: Wealth in Germany 2018 (in bn €)*

	Aggregate economy
Tangible assets	15.897
of which	
household residential buildings	-4.735
Capital stock (K)	11.162

*Source: StaBu (2019b).

According to this data set, total tangible assets in 2018 amount to 15.897 bn €. Subtracting from that figure the value of residential buildings held by the household sector of 4.735 bn € leads to our

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[24] Here we refer to "Gesundheitspflege" which amounts to 86,879 bn € in 2018 (p. 256).

[25] Here we refer to "Andere Geräte und Artikel für Freizeitgestaltung (Sportgeräte)" 38.315 bn €, "Körperpflege" 35.436 bn € and "Dienstleistungen sozialer Einrichtungen" 37.291 bn € in 2018 (p. 257).

estimate for the capital stock employed in production.

In order to reconcile the data from Table 7 with the restriction of a closed economy and the valuation at producer prices we add the trade balance and private NPOs to private consumption. From the sum of 1.950 bn € we subtract goods taxes (332 bn €), private health investment (80 bn €) and private health insurance expenditures (33 bn €) to compute at a consumption value of 1.505 bn €. Similarly, government consumption in Table 7 is reduced statutory health care cost (i.e. social in-kind) and amount to 454 bn €. In the left part we add self employed income of 230 bn € from capital income to labor income and derive capital income endogenously. Our adjusted figures are shown in Table 9.

Table 9: Adjusted national accounts (in € bn)

Output measure		Expenditure measure		in %	Distribution measure	
Output (Y)	3.012	Private consumption (C)	1.505	50.0	Labor income (wL)	2.001
		Statutory hc (SHC)	211	7.0	Capital income (rK)	402
		Private hc (PHC)	33	1.1	Depreciation (δK)	609
		Health investment (M)	80	2.7		
		Public consumption (G)	454	15.0		
		Gross investment ($(n+\delta)K$)	729	24.2		
GVA	3.012		3.012	100.0		3.012

Public debt (B_G) in 2018 amounts to 2.060 bn €, see Deutsche Bundesbank (2019, 58*). Related to GDP at market prices from Table 7 this would be roughly 60 percent. In our model we need to relate this figure to output evaluated at producer prices so that we get

$$\frac{B_G}{Y} = 0.68 \quad \text{and} \quad \frac{K}{Y} = 3.70.$$

The right part of Table 9 shows the values for primary incomes and allows to compute the capital share in the Cobb-Douglas function α since in equilibrium we have $\alpha = \frac{F_K K}{K}$ and $F_K = r + \delta$. The annual interest rate compiled with our data would amount to 3.6 percent. The annual depreciation rate is calculated by subtracting nK from gross investment and has a value of 6 percent.

$$\alpha = \frac{F_K K}{Y} = 0.34 \qquad r = \frac{rK}{K} = 0.036 \qquad \text{and} \qquad \delta = \frac{\delta K}{K} = 0.06.$$

Next we quantify the adjusted sectoral balances for the closed economy in Table 10. The production sector in the left column first derives net value added, which can be seen in the previous Table 9. This value is split up in labor income and net business surplus which together with asset income from the government bonds sum up to aggregate income (Volkseinkommen) of households. Interest cost of the government are computed as follows: Assuming a slightly lower interest rate on public debt of 3 percent yields for rB an amount of roughly € 60 bn. This figure seems too high since the official interest payments of the government amounted to roughly € 40 bn in 2018, see Deutsche Bundesbank (2019, 59*). However, we also exclude households asset income from abroad so that € 60 bn is reasonable. In addition, the resulting aggregate income of € 2.463 bn is only slightly below the respective figure of € 2.503 bn in Table 7.

Aggregate income of households is reduced by labor taxes and SHI contributions, while pension contributions are redistributed within the household sector. Labor income and assessed income tax (for

Table 10: Transactions and sectoral balances in the model (in € bn)*

	Production	Government	Households	reporting
Gross value added	3.012			
Depreciation	609			
Net value added	2.403			
Labor cost	-2.001		2.001	
Net business surplus	-402		402	€
Asset income		-60	60	2.0 % of Y
Aggregate income			2.463	
Labor income tax		280	-280	9.2% of Y
Pension contrib.			-300	10.0 % of Y
Pension benefits			300	
SHI contrib.		211	-211	
Available income			1.972	
VAT		235	-235	7.8% of Y
SHI benefits		-211		
Consumption		-454	-1.618	
Savings/Investment	-120	1	119	

Own calculations.

self employed) revenues in 2018 amounted to 247 bn € and 60 bn €, respectively (p. 303). The target of 280 bn € therefore is only slightly below the realistic level. With respect to pension benefits we need to exclude non-contribution related benefits (such as child rearing, etc.) and included pension benefits of civil servants. The former are financed by taxes and amount to almost one third of total benefits. We therefore add pension contribution revenues of 222 bn € (p. 308) and benefits of civil servants of 70 bn € (p. 305) to arrive at the figure of 300 bn €. Households SHI contributions which were already derived above are close to total contributions to public health care of 224 bn € (p. 308). From the resulting available income we subtract value added tax revenues of 235 bn € (p. 303) and the private consumption expenditures at producer prices of 1.618 bn € from Table 9. Private consumption at market prices then amounts to 1853 bn € which is fairly close to the value of 1.744 bn € in Table 7. The resulting household and government savings figures are much lower than the actual levels of 214 bn € (p. 50) and 62 bn € (p. 55) in 2018. However, the positive government savings in this year were unusual and the household figure reflects the closed economy.

Individual income and health data

StaBu (2019a, 52) reports an average annual gross income of all employees of 35922 € and an average annual gross income of 40677 € for not-marginally employed.[26]. The respective monthly gross labor earnings are at 2.994 € and 3.390 €. Our guess for average monthly labor income in 2018 is therefore 3.200 €, which yields to an annual value of 38.400 € that corresponds to average annual gross income of employed workers reported in Deutsche Rentenversicherung Bund (2020, 258). The

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[26] Marginally employment amounts to 5.28 mio employees out of 40.63 total employees (p. 52) and includes mainly mini and midi jobs. Note that this figure does not include employers social security contributions which is neglected in the following.

monthly contribution ceiling for the pension system was at 6.500 € in West Germany and at 5.800 € in East Germany. On average, a contribution ceiling of 6.400 €, which yields to 2 earning points is realistic. The monthly contribution ceiling for the statutory health care system was the same in East and West Germany at 4.425 € (Deutsche Rentenversicherung Bund, 2020, 262) so that it is roughly 40 percent above the average income. Although it is not required for the simulation model, Table 11 also reports the opt-out threshold from the statutory health insurance system, which was in 2018 about 55 percent above average income.

Table 11: Income and health cost per capita (in €) in 2018

	Month	Year	in %
Labor income	3.200	38.400	
Pension contribution ceiling	6.400	76.800	200.0
SHI contribution ceiling	4.425	53.100	140.0
Opt-out threshold		59.400	154.7
Health cost			
GKV		3.000	7.8
PKV		3.800	
Premiums (p.m.)	250-280	3.000	8.0

According to Hagermeister and Wild (2020) about 8.74 mio out of the total population of 83.16 mio. were insured in the private system in 2018. This is about 10.5 %. The average age of privately insured is 45.26 years and therefore about 1.5 years higher than the average age of those insured in the statutory insurance. Dividing the total expenditures of the two insurance systems from Table 6 by the number of insured, we arrive at the average figures reported in the lower part of Table 11. Premiums in the private health insurance depend on age, gender and the record of previous health problems. On average a 25-30 year old has to pay about 250-280 € per month which amounts to roughly 8 percent of average income. Finally, according to the PHI data base (see https://www.pkv-zahlenportal.de/werte/2008/2018/12/kap-anlagen/basket/result), the total assets accumulated in 2018 amounted to 289 bn € or 8.6 percent of GDP.

As cab be seen in the latest life tables 2017/2019 published by StaBu (2020), women reach an average age of 83.4 years and men 78.1 years. However, life expectancy will differ quite significantly across specific subgroups of a cohort. In Germany the PHI uses specific life tables since the PHI members (i.e. civil servants, academics, self employed, etc.) have a significantly higher life expectancy than the average population. Using these tables it turns out that privately insured agents live on average up to five years longer than the average population, see Table 12.[27] Such morbidity differentials between members of the private health insurance and the statutory health insurance in Germany are also documented, among others, by Hajek et al. (2018). Since they can only partially be explained by income differences (which determine individual health investment), they must reflect better health service access and/or provision.

Next we compute average age-related expenditure profiles for men and women for German sickness funds in the year 2018 from Bundesversicherungsamt (2020). Table 13 shows in the left part the

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[27] Of course, PHI companies have an incentive to use high survival rates in their cost calculations. But at the same time competition in the insurance market restricts this effect.

Table 12: Life expectancy in Germany

	Life tables 2017/2019			PHI Life tables 2020		
	women	men	average	women	men	average
Age 0	83.4	78.1	81.1	87.8	84.8	86.3
Age 65	21.1	17.9	19.6	24.4	22.0	23.2

Source: StaBu (2020), BaFin (2020).

absolute annual figures and in percent of annual income within a five-year period. Health care cost of young people are low at about 3-5 percent of average income. They rise sharply in middle ages before and after retirement to roughly 15 percent of average income. At old ages they remain fairly constant at about 20 percent of average income. We try to match these figures in our model. In addition, we also report the average annual cost in the PHI system derived from Hagermeister and Wild (2020).[28] As discussed in the paper we will not use these figures in our calibration, but they explain a large part of the difference between our model solution and the PHI data.

Table 13: Age-expenditure profiles and illness per cohort

Age	SHI expenditures		PHI expenditures	Sickness fraction
	in €	in % of income	in €	per cohort
20-24	1.236	3.2	1.830	11.2
25-29	1.460	3.8	2.001	13.1
30-34	1.729	4.5	2.645	13.6
35-39	1.788	4.7	2.570	13.6
40-44	1.825	4.8	2.495	13.7
45-49	2.070	5.4	2.785	13.8
50-54	2.473	6.4	3.318	15.6
55-59	3.034	7.9	4.125	17.3
60-64	3.694	9.6	5.196	17.9
65-69	4.415	11.5	6.408	16.0
70-74	5.358	14.0	7.960	19.1
75-79	6.345	16.5	9.430	25.5
80-84	7.286	19.0	10.483	25.5
85-89	8.006	20.8	10.892	25.5
90-94	8.063	21.0	–	25.5
95-99	7.845	20.4	–	25.5
average	3.000		3.800	15.3

Source: BVA(2020), Hagermeister and Wild (2020), BMG (2020, 40).

The right column of Table 13 shows the fractions of ill people in the different cohorts from the Microcensus 2017 reported in BMG (2020, 40). This fraction remains at roughly 13 percent until age 50 and then rises up to 25 percent. Note that the data reported for high age are averages. In the aggregate about 15 percent of the total population were ill.

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[28] We would like to thank Frank Wild for providing the original figures in the respective publication.

In order to calibrate a realistic figure of sickness days we compile the sick days in Germany in year 2018 reported by Institut der Deutschen Wirtschaft (2020). Table 12 shows the absolute days and then as a fraction of working days which are assumed to be 230. Sick days therefore rise on average from 5 percent to almost 15 percent of total working time. On average, employees stayed 18.5 days at home with a medical certificate.

Table 14: Sick time in 2018

Age	Average sick time in days	in %
25-29	11.8	5.1
30-34	12.1	5.3
35-39	13.6	5.9
40-44	15.9	6.9
45-49	18.6	8.0
50-54	22.4	9.7
55-59	28.3	12.3
60-64	33.4	14.5
average	18.5	8.0

Source: IdW (2020).

References

Bundesamt für Finanzdienstleistungsaufsicht (BaFin) (2020): PKV Sterbetafel 2021, https://www.bafin.de/SharedDocs/Downloads/DE/Statistik/PKV/dl_st_2021_pkv_sterbetafel_va.html?nn=9021442.

Bundesministerium für Gesundheit (BMG) (2020): Daten des Gesundheitswesens, Berlin.

Bundesversicherungsamt (2018): GKV-Ausgabenprofile nach Alter, Geschlecht und Hauptleistungsbereichen, 1996-2017 (07.11.2018), URL: https://www.bundesversicherungsamt.de/fileadmin/redaktion/Risikostrukturausgleich/Info-Dateien%20und%20Auswertungen/20181108GKV_Altersausgabenprofile_1996-2017.xlsx (download 29.11.2020).

Institut der Deutschen Wirtschaft (2020): Der Krankenstand in Deutschland steigt, Köln.

Deutsche Bundesbank (2019): Monatsbericht, September 2019.

Deutscher Bundestag (2017): Dritter Bericht der Bundesregierung über die Wohnungs- und Immobilienwirtschaft in Deutschland und Wohngeld- und Mietenbericht 2016, Drucksache 18/13120, Berlin.

Deutsche Rentenversicherung Bund (2020): Rentenversicherung in Zeitreihen, DRV-Schriften Band 22, Berlin.

Hagemeister, S. and F. Wild (2020): Mehrumsatz und Leistungsausgaben von PKV-Versicherten, Jahresbericht 2020, WIP-Analyse 4/2020, Köln.

Hajek, A., J-O. Bock, K.-U. Saum, B. Schötter, H. Brenner, D. Heider and H.H. König (2018): Unterschiede in der Morbidität nach Krankenversichertenstatus im Altrer, Gesundheitswesen 80, 551-556.

Statistisches Bundesamt (StaBu)(2019a): Volkswirtschaftliche Gesamtrechnungen, Inlandsproduktberechnung, Detaillierte Jahresergebnisse 2018, Fachserie 18 Reihe 1.4, Wiesbaden.

Statistisches Bundesamt (StaBu)(2019b): Vermögensbilanzen, Sektorale und gesamtwirtschaftliche Vermögensbilanzen 1999-2018, Wiesbaden.

Statistisches Bundesamt (StaBu)(2020): Sterbetafel 2017/2019, Wiesbaden.