Financing Universal Health Care: Premiums or Payroll Taxes?

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Abstract

This paper presents a stochastic overlapping generations model with endogenous health investment to study the transition from the existing hybrid health insurance system in Germany towards a uniform system, financed by either funded or unfunded premiums or payroll taxes.

Our simulation results highlight the insurance properties of payroll taxes, but also their cost in terms of labor supply distortions and moral hazard. We find that compulsory deductibles decrease aggregate welfare in Germany, although they reduce moral hazard and increase private health investment. Reform models with premiums also induce precautionary behaviour and increase labor supply, but at the same time increase exposure to productivity risk. Since the introduction of a funded system is costly for transitional cohorts, unfunded premiums provide the highest efficiency gains in our framework.

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1 Introduction

Developed countries of the Western world spend a substantial amount of their income and wealth on health care. Health expenditure is projected to outpace GDP growth in the future due to demographic pressures, medical progress, changes in morbidity, and individual health demand. The need to address these increasing costs has led to a growing debate about the reform and financing of the health care system in many countries.

Levels of cost coverage and financing methods of health care differ a lot even among Western countries. On the one hand, the U.S., Switzerland, and the Netherlands mainly rely on private health care financed by individual premiums, either funded or unfunded. On the other hand, most other European countries have adopted payroll taxes as the main financing source for their health care expenditures. Payroll taxes are considered to be more equitable, as they spread the financial burden across all working individuals. However, this method also distorts the labor-leisure choice, putting pressure on the ageing workforce. Individual premiums do not distort labor supply, but instead increase the labor income risk exposure of the insured. This trade-off between risk sharing and distortive effects is a key issue in the debate over health care financing. In addition to the financing methods, the share of health care cost that is covered by the government varies considerably among countries. This leads to an ongoing debate about how much should be financed by whom and how.

This paper develops a dynamic stochastic equilibrium model with overlapping generations where households choose their optimal labor supply, ordinary consumption, health investment, and savings facing productivity, health, and longevity risks along their life cycle. While productivity shocks reduce income from work, health shocks reduce the work capacity and induce costs that are at least partly borne by public and/or private health care. Households may invest in health capital (Grossman, 1972) to benefit from increased future health, time endowment, and longevity. This allows us to quantify moral hazard problems related to insurance provision and to generate differences in life expectancy across and within cohorts.

The model is applied to analyze reforms in the German health care system. Germany has one of the highest total health expenditures among OECD countries, accounting for 11.7 percent of GDP in 2019. The current system is characterized by the coexistence of public statutory health insurance (SHI) and private health insurance (PHI). Employees with earnings below the income threshold are compulsorily insured in the public system, while self-employed, civil servants, and high-income employees are privately insured. The SHI is financed through a payroll tax and offers a standard treatment quality, the PHI is funded by risk-related premiums and offers higher treatment quality at higher cost. The system therefore favors specific employment types and high-income households leading to proposals for establishing a uniform health care system financed either by premiums or payroll taxes.

The present paper aims to evaluate these reform proposals concerning their induced intra- and intergenerational income redistribution, as well as the implied overall efficiency effects. Starting from an initial long-run equilibrium that features the existing health care system, reforms are introduced without announcement and the full transition path to the new steady state is computed together with the individual welfare changes and an aggregated welfare measure. Our simulation results indicate that universal payroll financing provides insurance against productivity and health shocks, which may even compensate for the induced labor supply distortions. However, this comes at the expense of higher moral hazard costs and a loss in life expectancy for those previously privately insured due to the lower treatment quality. The latter also applies to universal premium financing, although it would induce greater individual health investment. Universal funded private insurance provides better treatment quality, which leads to higher life expectancies, but the higher costs induce an overall welfare loss. Finally, we find that compulsory deductibles would reduce aggregate welfare in Germany, although they increase private health investment. Overall, the results of the model provide valuable insights into the trade-off's as well as the potential distributional and welfare consequences of various health care reform proposals.

Our study is related to the extensive literature which allows for heterogeneity in income and health shocks over the life cycle. Mostly this literature focuses on the situation in the U.S., where some public health care is provided to retirees, additional private health care is not mandatory for all, and health costs 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 in the pure life-cycle model allows us to explain the observed consumption and savings behavior of the 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 discuss more channels (besides medical expenses) through which the health status affects individuals. An extended version 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 Medicare and private health care 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 heterogeneous agents that analyze the impact of health care reforms on the macro-economy and household welfare. Later studies highlight the individual health care 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 care when a universal health care 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 private U.S. health care system. Feng and Zhao (2018) even argue that differences in the health care systems may explain part of the observed differences in employment rates between the U.S. and European countries. Like our paper, Conesa et al. (2018) distinguish between short-run and long-run effects by considering the transition between steady states. They also derive an aggregate welfare measure to evaluate each reform proposal.

Our approach is related to all these studies, but due to the institutional setting of the German health care system all households are compulsory insured and cost coverage is much higher than in the U.S. Consequently, the policy debate focuses more on labor supply distortions and moral hazard problems. Therefore, we follow recent work by Jung and Tran (2016), Jung et al. (2017), Halliday et al. (2019) as well as He et al. (2021) and model the individual health investment decision that determines life expectancy and improves productivity. Health care provision may distort such investments similar to labor supply. Similar to Frankovic and Kuhn (2019) we assume that households differ in their ability to produce health to generate different life expectancies. This is especially important in Germany, where privately insured people are healthier than those covered by public insurance.

The next section describes the main characteristics of the German health care system. Then 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 conclusions.

2 The German health care system

In contrast to most European countries, Germany features not a uniform but a dual health insurance system, distinguishing between statutory health insurance and private health insurance. Health coverage is compulsory for everyone in Germany. In 2021, approximately 88 percent of the population was covered under statutory health insurance, roughly 10.5 percent were privately insured and the remaining fraction received health care through specific governmental schemes.

Individuals with an income below the insurance threshold of € 62,550 per year (2020), along with their non-working family members, as well as recipients of social assistance, are members of the SHI system. Self-employed and individuals with an annual income above that threshold can keep SHI voluntarily. While those without income do not contribute to health insurance, employed individuals contribute 14.6 percent of their income up to a contribution ceiling of € 56,224 per year (2020), plus an additional premium of approximately 1 percent of their income. These contributions are paid into a health insurance fund together with tax-financed federal subsidies. Then the fund redistributed resources to health insurance companies depending on the number and health profile of their insured members. The insurance providers operate on a pay-as-you-go basis, meaning that currently received contributions are used for immediate cost coverage. The SHI provides basic benefits that are regulated by law, but many additional services (i.e. dental cleaning, ultrasound, etc.) have to be paid out-of-pocket. When billing a benefit funded by SHI, the value of the services is expressed in points. The monetary value of these points is determined quarterly, based on the total amount of services provided during the quarter and the available funds. This leads to income uncertainty for providers, who do not bill the patient, but the respective health insurance company.

Individuals with income above the insurance threshold are eligible to join private health insurance. PHI benefits are also regulated by law but are more flexible than in the SHI. Individuals can be rejected, and different deductibles can be offered in this context. After the contract is signed, the insured individual is entitled to the agreed-upon benefits during the working phase as long as his earnings are above the threshold, and during retirement. If the income falls below the threshold, the insured person must rejoin the SHI but can retain the entitlement in case of a later return to the PHI. In contrast to SHI, PHI premiums are calculated individually and risk-based. Factors such as age and pre-existing conditions are taken into account to assess individual risks. The PHI operates a funded system, where each generation finances its expected lifetime costs. This means that premiums at younger ages are typically higher than the realized costs while the rising costs at older ages are financed by premiums and the reserves accumulated before. In 2019 the capital stock of private insurers amounted to roughly € 303 bn or (roughly) 9 percent of GDP, see Appendix B.

The pricing of services in the PHI is also based on point values, but the monetary value of points is predetermined. The service fee is then calculated by multiplying the point value with an adjustment factor, which can rise to 3.5, reflecting the effort of the doctor. For that reason, providing medical services to privately insured is more attractive than to SHI insured. In contrast to the SHI, the billing is directly issued to the patient, who initially covers the costs and then seeks reimbursement from his PHI provider. Individuals with private health insurance therefore typically receive faster and better medical care than those covered by the SHI, which also partly explains why they are healthier than the latter ones.[1]

This should suffice to explain the institutional structure of public and private health care in Germany.

3 The model economy

This section describes our simulation model which tries to capture the central elements of the above-described system. To reduce the complexity of the model, we do not allow for an individual insurance choice for those employees above the opt-out threshold, since this would require considering dependent household members in our model. Instead, we distinguish two subgroups within a cohort that are covered either by the SHI or the PHI. PHI members are typically above the income threshold, but even in case they fall temporarily below the threshold they would retain the PHI. Our simplification may be justified by the fact that we focus on the consequences of financing systems.

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 an education level. This assignment determines their skill class for labor productivity and their health care system in the benchmark. In addition to the skill level, all households receive an identical initial endowment of health capital $\bar{h} \in \mathcal{H} = [0, \infty]$.[2] The latter will either depreciate due to health shocks $\zeta \in \mathcal{F} = \{0, -v\}$ and regular age-dependent depreciation δ_j^h or improve due to individual health investments m during the lifetime. The health capital stock h_j at age j determines the conditional survival probability $\psi(h_j)$ from age j to age $j+1$ with the property $\psi(h_J) = 0$. In addition to health shocks, households also start with initial labor productivity $\bar{\eta} \in \mathcal{E}$ and then receive transitory labor productivity shocks 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.

1 Treatment differences between the private and the public health insurance and their consequences are analyzed by Kriwy and Mielck (2006), Schneider and Schneider (2012) or Stauder and Kossov (2017). A more detailed description of the German health care system is provided by Karlsson et al. (2016) or Wasem et al. (2018).

2 De Nardi et al. (2023) argue that mainly the innate heterogeneity in health types explains differences in health outcomes over the life cycle in the U.S. Our assumption may be justified by the fact that German men aged 18-29 rate their health very similar independent of their educational background, see Appendix B. Despite that, we also report model results with different initial health capital in Appendix D, which generates different health transitions. Our main qualitative results remain valid in such a model with heterogeneous health types.

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. 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 that 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.

In each period t the population cohort is then 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

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

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

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

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 behaviour

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

$$\mathbb{E}\left[\sum_{j=1}^{J} \beta^{j-1} \left(\Pi_{i=1}^{j-1} \psi(h_i)\right) u(c_j, \ell_j, h_j)\right] \quad \text{with} \quad \psi(h_j) = 1 - \exp(\omega_1 h_j^{\omega_2}), \tag{3}$$

where β denotes the subjective discount factor. The age-specific survival function $\psi(h_j)$ depends on health capital and the values of ω_1 and ω_2 determine the respective impact. With $\omega_1 < 0$ the choice of $\omega_2 \in [0; 1]$ determines how strong the survival probability decreases with decreasing health capital. Since the health stock h_j typically decreases with age, the probability of dying increases with age. If the health capital is completely depleted at $h_j = 0$, the individual will surely die, i.e. $\psi(0) = 0$. A higher health capital increases the probability of survival, i.e. $\psi(\infty) = 1$.

The preference function is based on Halliday et al. (2019), who assume a Cobb-Douglas specification for consumption and leisure and a CES specification between the consumption-leisure aggregate and health:

$$u(c_j, \ell_j, h_j) = \left[\chi[c_j^{\mu}\ell_j^{1-\mu}]^{1-\frac{1}{\nu}} + (1-\chi)h_j^{1-\frac{1}{\nu}}\right]^{\frac{1}{1-\frac{1}{\nu}}}. \tag{4}$$

Each period, the total time endowment of unity is split between leisure, working (l_j) and sick time $s(h_j)$

$$\ell_j + l_j + s(h_j) = 1 \quad \text{with} \quad s(h_j) = \exp(-\xi h_j), \tag{5}$$

i.e. sick time increases over the life cycle, when health capital decreases.[3]

During their working periods, labor productivity depends on a deterministic age profile of earnings ς_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.

$$\eta_{j+1} = \rho\eta_j + \epsilon_{j+1} \quad \text{with} \quad \epsilon_{j+1} \sim N(0;\sigma_\epsilon^2) \quad \text{and } \eta_1 = \bar{\eta}. \tag{6}$$

Given that, an individual's gross labor income y_j is defined by the wage rate w and the individual's productivity $e_j := \varsigma_j \cdot \exp(\theta + \eta_j)$ for effective hours worked multiplied by the hours effectively worked, i.e.

$$y_j = \begin{cases} we_j l_j & \text{if} \quad j < j_R \quad \text{and} \\ 0 & \text{if} \quad j \geq j_R. \end{cases}$$

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 $\hat{y}^p/\bar{y} = 2$, i.e.

$$ep_{j+1} = ep_j + \min[y_j/\bar{y}; 2]. \tag{7}$$

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 modeled as a fraction κ of average income:[4]

$$pen_j = ep_{j_R} \times \kappa\bar{y} \qquad \forall \quad j \geq j_R. \tag{8}$$

Consequently, the pension system in Germany is closely linked to taxes and benefits, so that labor market shocks during employment are fully transmitted into retirement. This induces precautionary behavior and health investments in later ages.[5]

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[3] 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).

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

[5] See Schneider and Winkler (2021) for a recent analysis of moral-hazard effects with annuitized retirement wealth and Zhao (2014) for possible spill-overs between pensions and health care in the US.

Health capital accumulation is given by

$$h_{j+1} = (1 - \delta_j^h)h_j + g(m_j, hc_j) + \zeta_j \qquad \text{with} \quad \frac{\partial g}{\partial m_j} > 0, \frac{\partial g}{\partial hc_j} > 0. \tag{9}$$

Individual health capital depreciates at the age-specific rate δ_j^h and may decrease due to a shock ζ_j (see equation 10). 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. Following Picone et al. (1998, 177), the health shock takes the following distribution

$$\zeta_{j+1} = \begin{cases} 0 & \text{with prob. } \pi^h(h_j, \zeta_j) \\ -v & \text{with prob. } 1 - \pi^h(h_j, \zeta_j). \end{cases} \tag{10}$$

The probability $\pi^h(h_j, \zeta_j)$ of experiencing a shock in the future increases with declining health and in the presence of an existing shock. This relationship, similar to the one in Picone et al. (1998), is described by the following function:

$$\pi^h(h_j, \zeta_j) = \frac{\exp(1 + d_0 h_j + d_1 \zeta_j)}{1 + \exp(1 + d_0 h_j + d_1 \zeta_j)}, \tag{11}$$

Next, the health production function $g(\cdot)$, which generates the heterogeneity in health behavior and health accumulation between the two insurance types needs to be specified. As in Jung et al. (2017) or Halliday et al. (2019) it is assumed that the health status could be improved by private health investment m_j and insurance-financed health care hc_j.[6] To make sure that both effects are independent we set

$$g(m_j, hc_j(u)) = \lambda_3(\theta)(\lambda_1 - \lambda_2\zeta_j)m_j^{\varepsilon_j} + \lambda_4(u)\sqrt{hc_j(u)} \quad \text{where} \quad \lambda_i > 0, \text{ and} \quad u = SHI, PHI,$$

so that the marginal products of both expenditures are 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 $\zeta_j = -v$), see Picone et al. (1998).

Agents may increase their health capital by (mostly preventive) health investments m_j. These contain expenditures that may improve health but are usually not a direct response to health deterioration, i.e. not prescribed curative care, infrequent vaccinations and screening, costs of sports activities, and healthy food consumption. The effectiveness of m_j on the health production function depends on various factors. High-skilled individuals are more productive in this regard, as they generally have more knowledge how to apply the medical products. We represent this relationship through the skill-class-specific parameter λ_3. This parameter is higher for high-skilled individuals compared to low-skilled individuals, so that $\lambda_3(\theta_1) < \lambda_3(\theta_2)$.

In contrast, health care costs hc_j are direct responses to a health shock that causes a specific, immediate need. If an agent is hit by a shock, the (curative) health costs are defined by

$$hc_j(u) = \Lambda(u)(\varphi_0 + \varphi_1 j + \varphi_2 j^2), \tag{12}$$

[6] In the U.S. models a fraction of total health care demand is typically covered by the insurance system. But this does not reflect the German insurance system that provides basic benefits after a health shock. Individual health investment in our model represents all additional health care expenditures that have to be paid out-of-pocket.

which are (at least in the initial equilibrium) fully reimbursed by the insurance. The function hc_j depends on the age of individuals since treatments become more complex and expensive with increasing age. In addition, the cost function is multiplied by $\Lambda(u), u = SHI, PHI$ which reflects the cost difference between statutory and private health insurance. As explained in section 2, privately insured will typically receive more treatments that are billed at higher rates than those under the SHI. The last parameter $\lambda_4(u)$ depends on the health care provider and reflects the fact that the PHI offers a better treatment quality (i.e. faster access to health care services, etc.) in case of illness, i.e. $\lambda_4(PHI) > \lambda_4(SHI)$.

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

$$\begin{aligned} V(z_j) &= \max_{c_j,\ell_j,m_j,a_{j+1}} \left\{ u(c_j,\ell_j,h_j)^{1-\frac{1}{\gamma}} + \beta\psi(h_j)\mathbb{E}_j\left[V(z_{j+1}|\eta_j,\zeta_j)^{1-\varrho}\right]^{\frac{1-\frac{1}{\gamma}}{1-\varrho}} \right\}^{\frac{1}{1-\frac{1}{\gamma}}} \quad \text{s.t.} \qquad (13) \\ a_{j+1} &= (1+r)a_j + y_j + b_j - T_p(y_j) - T_h(y_j) - T(\tilde{y}_j) - \vartheta hc_j - p(m_j + c_j) \\ & \quad c_j \geq 0,\ m_j, a_{j+1} \geq 0, \end{aligned}$$

together with the constraints (5), (6), (7), (9) and (10). The expectation operator $\mathbb{E}_j$ in equation (13) 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. 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 $\underline{c}$.

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 care costs ϑhc_j and expenditures for health investment and ordinary consumption.[7] Consumer prices include consumption taxes, so that $p = 1 + \tau^c$ with τ^c denoting the respective tax rate. Expenditures must be non-negative and the borrowing constraint must hold. 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,

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

[7] Note that in Germany the same VAT rate is applied to medical and non-medical goods and we abstract from different production technologies.

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.

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

where N denotes the number of all working agents.

3.3 The production sector

The production sector is populated by large firms that hire capital K and effective labor L on perfectly competitive factor markets 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.

$$w_t = (1-\alpha)\Phi \left(\frac{K_t}{L_t}\right)^{\alpha} \tag{14}$$

$$r_t = \alpha\Phi \left(\frac{L_t}{K_t}\right)^{1-\alpha} - \delta. \tag{15}$$

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 to finance public consumption G, transfers Tr_t as well as interest payments on its debt, i.e.

$$(1+n)B_{G,t+1} - B_{G,t} + T_{y,t} + \tau_t^c(C_t + M_t) = G + Tr_t + r_t B_{G,t}, \tag{16}$$

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.

Concerning 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.[8] The resulting income

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

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 2020 (including the solidarity surcharge τ^z of 5.5 percent), so that

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

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

$$\tau_t^p PCB_t = PB_t, \tag{17}$$

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

$$\tau_t^h HCB_t = SHC_t \tag{18}$$

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 (social) health costs 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 balances the expected present value of their lifetime health costs. Therefore we need to distinguish between the *aggregate* private health costs in period t PHC_t and the present value of expected *individual* health costs 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

$$q_t^{ip} ICB_t = IHC_t \quad \text{where} \quad ICB_t = \int_{\mathcal{Z}_2} R_{jt}\mathrm{d}X_{t+j-1}(z_2) \tag{19}$$

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

$$(1+n)A_{p,t+1} = (1+r_t)A_{p,t} + \int_{\mathcal{Z}_2} q_{t-j+1}^{ip}\mathrm{d}X_t(z_2) - PHC_t. \tag{20}$$

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

3.5 Individual and aggregate welfare calculation

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. 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 $v_1(z)$ 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. We convert the aggregate transfers of a specific cohort (and insurance type) into a constant consumption stream $\bar{c}_{ji}$ for the remaining lifetime:

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

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[9]

$$W = \int_{\mathcal{Z}} v_1(z) \mathrm{d}X_1(z) + \sum_{t=2}^{\infty} \left(\frac{1+n}{1+r_0}\right)^{t-1} \int_{\mathcal{S}\times\mathcal{E}} v_t(z_{1i}) \mathrm{d}X_t(z_{1i}),$$

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 $\{\vartheta, q^{ip}\} \quad \forall\ t$, 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 (13) subject to the respective constraints;

2. factor prices are competitive, i.e. (14) and (15) hold;

[9] For simplicity we describe here the situation in the small open economy, although the benchmark calculations are in a closed economy.

3. individual and aggregate behavior are consistent:

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

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

5. unintended bequests satisfy

$$\int_{\mathcal{Z}} b(z)\mathrm{d}X_{t+1}(z) = \int_{\mathcal{Z}} (1-\psi(h(z)))(1+r_{t+1})a^+(z)\mathrm{d}X_t(z); \tag{21}$$

6. the budgets of the general government (16), the public pension and the health care systems (17) and (18) are balanced;

7. private insurance contributions are equal to expected costs (19) and the private health care budget (20) 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 describes the parametrization of the model. This is a two-stage process, where we first specify specific parameter values estimated outside the model and then calibrate further parameters by matching the moments of our model to the data. Our SMM solution algorithm is presented in Appendix C. The aim is to match the German economy in the year 2019/20 with the 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 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.

Model period and time endowments: 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

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	Calibrated
Household preferences			
γ	Intertemporal elasticity of substitution	0.5	Halliday et al. (2019)
ϱ	Risk aversion coefficient	2.0	Common value
ν	Intratemporal elasticity of substitution	0.1	Halliday et al. (2019)
μ	Consumption coefficient	0.4	Halliday et al. (2019)
χ	Weight of consumption/leisure utility	0.65	Calibrated
β	Time discount factor (annual)	0.98	Calibrated
Labor productivity			
$\{\varsigma\}_{j=1}^{j_R-1}$	Age-efficiency profile		Fehr et al. (2013)
ρ	AR(1) correlation	0.96	Fehr et al. (2013)
σ_ϵ^2	Transitory variance	0.03	Calibrated
σ_θ^2	Skill variance	0.8	Calibrated
Health stock accumulation and health costs			
δ_j^h	Depreciation rate (annual)	$[0.0025 - 0.035]$	Jung et al. (2017)
v	Health shock value	2.0	Picone et al. (1998)
d_0, d_1	Health shock probability (h_j, ζ_j)	0.1, 0.4	Calibrated (SMM)
φ_0, φ_1	Health costs coefficients	0.04, 0.034	Calibrated
φ_2		-0.0011	
$\Lambda(u)$	Health expenditures parameter (SHI, PHI)	1.05, 1.34	Calibrated (SMM)
ξ	Sick time coefficient	0.61	Calibrated (SMM)
ω_1, ω_2	Survival probability	-0.77, 0.89	Calibrated (SMM)
λ_1, λ_2	Health production	2.9, 2.4	Calibrated (SMM)
$\lambda_3(\theta)$	Health production (low/high skilled)	(0.9, 1.1)	Calibrated (SMM)
$\lambda_4(u)$	Health production (SHI/PHI insured)	(0.1, 0.7)	Calibrated (SMM)
ε_j	Health production elasticity	$[0.5, .., 2.0, .., 0.3]$	Hall and Jones (2007)
Production sector			
α	Capital share	0.34	see Appendix B
δ	Capital depreciation rate (annual)	0.053	see Appendix B
Policy parameters			
ϑ	Co-insurance rate	0.00	specified
G/Y	Public consumption-to-output ratio	0.172	see Appendix B
B_G/Y	Debt-to-output ratio	0.75	see Appendix B
κ	Pension accrual rate	0.061	see text
$\underline{c}$	Consumption floor	$0.1\bar{y}$	see text

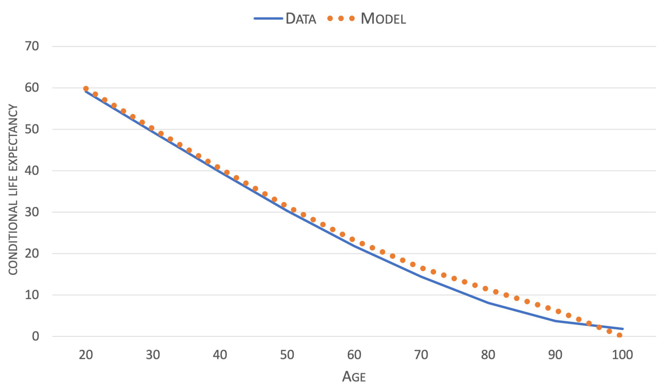
age $J = 16$ corresponds to ages 95-99. Mandatory retirement at model period $j_R = 10$ is therefore at age 65-69. As already discussed above, about 10 percent of the population in Germany are members of private health care. Consequently, the fraction of those insured in the public system ϖ is set to 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 dependency ratio (see Table 2).

Sick time: The health status affects the time available for work, leisure, and lifespan. Hereby ξ is specified to generate an average working time in total time endowment of a third. Note that Table 2 reports that the resulting average sick days in the model are much higher than those in the data. However, this seems to be justified since the data only accounts for those sick days when visiting a doctor during working time.

Utility: In our benchmark calibration of the utility function (4) 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 by Halliday et al. (2019) and are widely used as a starting point in the literature. The intratemporal elasticity ν is used by Halliday et al. (2019) and also helps to match a realistic level of health investments. Similarly, the consumption weight μ is similar to the value used by Halliday et al. (2019) and helps to match an average fraction of working time (see below). The weight χ of the consumption-leisure aggregate is calibrated to match the consumption share in output. Finally, the time discount factor β is calibrated to generate a realistic capital-to-output ratio. Due to the preference formulation from Epstein and Zin (1991), utility is positive, so households always want to live longer, see Rosen (1988).

Life expectancy: The ω_i's in the survival function (3) are calibrated to match a realistic life expectancy at birth and retirement. Figure 1 below compares the resulting conditional life expectancy in the model with those from the German mortality Table 2018/2020.

Figure 1: Conditional LE in the model and in the data



Productivity: Individual labor productivity is determined by the deterministic age-efficiency profile ς_j, the skill level $\theta_i = \pm\sigma_\theta$, and the idiosyncratic productivity shock η. The age-efficiency profile for Germany was estimated by 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 2: Variance of logs over the life cycle

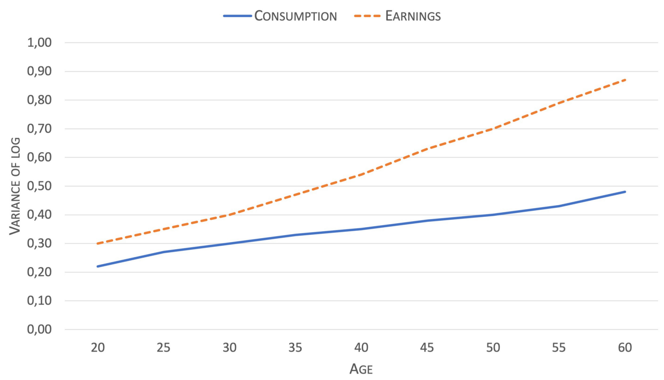


Figure 2 shows the variance of the logarithm of labor earnings and consumption over the working period in the initial equilibrium. The income variance rises from 0.3 to 0.9 and the consumption variance from 0.25 to 0.45. As shown in Table 2, our approach generates the Gini-coefficient and realistic pre-tax income shares for 2020.

Health capital: With respect to the health accumulation process we need to pin down first the initial health capital $\bar{h}$ and the depreciation rate δ_j^h. We normalize the initial health status to $\bar{h} = 10.0$ and assume an (inverse) exponential relationship $\delta_j^h = 1 - \exp(-0.012j)$ to arrive at the (annual) depreciation rates reported in Table 1 above, which are roughly in line with those derived in Picone et al. (1998) or those computed with U.S. health data reported in Jung et al. (2017).[10] The parameters d_0, d_1 in the health shock function (11) are calibrated to generate realistic fractions of ill agents over the life cycle, see Table 2. 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. The value of the shock at $v = 2$ is taken from Picone et al. (1998) and generates a realistic trajectory of health depreciation in terms of survival probabilities and health care costs.

Health production: 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 calibration of the λ_i's can be found in Appendix C.

Health costs: The three free parameters φ_i in the health cost function 12 are calibrated to match the profile of SHI health costs relative to average income as reported in Appendix B. To capture the difference in cost structures between the two health care types reported in Appendix B and to match the health care expenditures relative to GDP we multiply the cost profile by $\Lambda(u)$ which is 1.05 and 1.34 for the SHI and PHI, respectively. Table 2 shows that we match the average health costs to income ratio almost perfectly. The resulting *expected* per-capita cost profiles are displayed in Figure 3, where

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

the difference in the two profiles reflects the PHI markup and the reduced sickness probability of the privately insured.

Figure 3: Average expected health costs over the life cycle

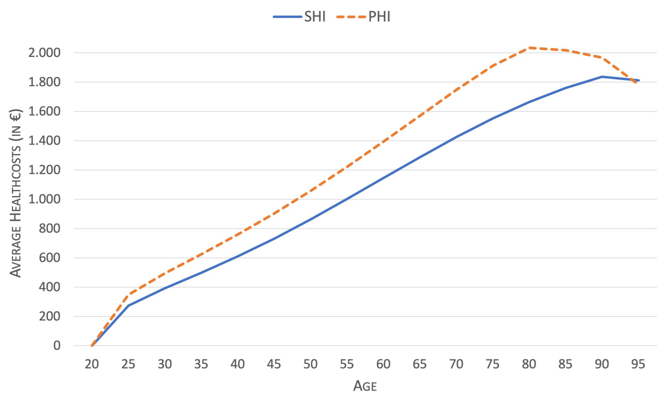


Figure 4: Health investment over the life cycle

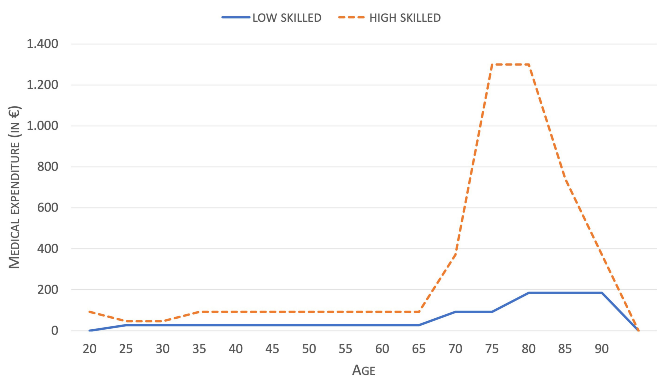


Figure 4 shows the private health investment over the life cycle for the two skill types. At young ages, households invest in health to reduce sick time and to work more. At older ages, they invest to increase utility and extend their life span. As it turns out, both skill types invest very little in health during their employment years since they first build up savings to self-insure against income shocks. After retirement especially the high-skilled increase health investment since better health generates utility and extends their life span. This is consistent with the investment motives discussed by Grossman (1972) and Halliday et al. (2019). It is consistent with the data which shows much higher expenditures in rehabilitation facilities at older ages, see Appendix B. The resulting difference in life expectancy of the two insurance types reported in Table 2 matches the data reported in Appendix B quite well.

Turning to the production parameters and the government policy, the capital share as well as the depreciation rate are computed from 2020 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 48 percent. This is roughly in line with the current practice, it also generates a realistic benefit to GDP ratio and contribution rate (see

Table 2: Model solution and targets for Germany 2020 (in % of GDP)

Variable	Model	Target*
Demographics		
Dependency ratio (65+/20-64)	0.35	0.37
Life expectancy at birth	79.4/84.0	79.1/84.8
at retirement	19.3/23.1	19.6/23.2
Expenditures on GDP		
Private consumption	50.5	49.2
Government consumption	17.2	17.2
Gross investment	23.2	23.4
SHI/PHI health spending	7.0/1.1	7.5/1.1
Private health investment	1.1	1.6
Capital stock, labor market and income		
Capital-output ratio	435.3	380.0
PHI capital-output ratio	11.0	10.0
Working time (in %)	31.5	33.0
Gini (gross labor income)	0.46	0.46
Top 10 % share (in %)	42.4	37.1
Bottom 50 % share (in %)	19.5	19.0
Interest rate p.a. (in %)	2.9	2.6
Health indicators (in %)		
Fraction of sick 20-24	11.3	11.2
Fraction of sick 55-59	17.7	17.3
Fraction of sick average	17.0	15.3
Sick time 25-29	12.1	4.0
Sick time 55-59	30.0	10.6
Sick time average	19.7	7.2
Health costs - income ratio	8.9	8.2
Government indicators		
Labor income tax revenue	10.3	10.2
Consumption tax revenue	8.7	10.4
Consumption tax rate (in %)	16.9	–
Interest costs	1.7	2.0
Pension benefits	8.9	10.2
Pension contribution rate (in %)	17.4	18.6
SHI contribution rate (in %)	15.9	15.6
PHI premium (in € p.m.)	268	300

* See the documentation and calculations in Appendix B.

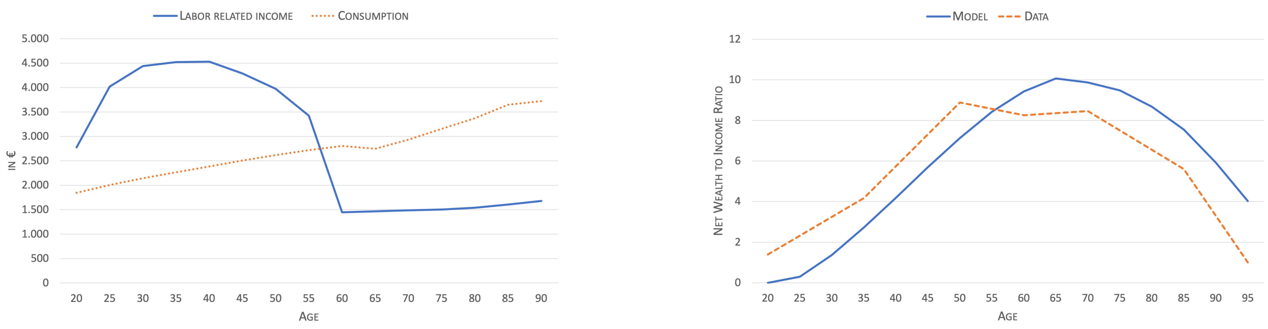
lower part of Table 2). We apply the German income tax code of the year 2020 to labor and pension income, i.e. the marginal tax rate schedule rises after a basic allowance from 14 to 42 (or 45) percent plus the solidarity surcharge. To generate a realistic income tax revenue, income net of insurance 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.[11] The consumption tax rate is then used to balance the budget. While we abstract from any redistributive transfers and neglect other tax revenues, the resulting revenue and consumption tax rate is quite realistic, see the discussion in Appendix B. Even more important in the present context is the fact that the modeling of health care shocks and costs yields a quite realistic SHI contribution rate and PHI premium.

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 to compute equilibrium prices and quantities. For more information on the computational approach see Fehr and Kindermann (2018, 505f.). Figure 5 shows the dynamics over the life cycle of labor income and consumption in Figure 5a and the relation between assets and average income in Figure 5b. The consumption and income profiles are very consistent with the data reported by Fehr et al. (2013, 99) while the asset profile on the right is close to the German profile for 2017 reported by ECB (2020, 6).

Figure 5: Labor income, consumption and assets over the life cycle



(a) Labor income and consumption

(b) Assets in Model and Data

5 Simulating policy reforms

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 contribution 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 this section, we will focus on the following reforms:[12]

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

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

- The *self insurance (SI)* model, where households insured in SHI and PHI have to bear a co-insurance burden of 10 percent (i.e. $\vartheta = 0.1$) of their health costs ($hc_j(u)$).[13]

- The *citizen insurance (CI) model*, where the PHI scheme is phased out for current members and the SHI scheme becomes universal for all households in the long run.

- The *social premium (SP) model*, where the current SHI/PHI membership structure is retained, but SHI contributions are turned into premiums q_t^{sp}, which are independent of labor income and balance
$$q_t^{sp} \int_{\mathcal{Z}_1} \mathrm{d}X_t(z_1) = SHC_t.$$

- The *citizen premium (CP) model*, where the PHI scheme is phased out for current members and premiums q_t^{cp} with universal coverage are introduced successively. The long-run budget balance is therefore
$$q_t^{cp} \int_{\mathcal{Z}} \mathrm{d}X_t(z) = SHC_t + PHC_t.$$

- The *private premium (PP) model*, where the SHI scheme is phased out for current members and the health care system is completely privatized (i.e. funded premiums plus better treatment efficiency) in the long run. In this case, we distinguish two cost scenarios: a) in the PP(h.c.) simulation we assume that all members of the future private system incur the high costs of the current PHI system; b) in the PP(l.c.) scenario we assume that all members of the future private system incur the low costs of the previous SHI scheme.

Consequently, all reforms retain the existing PHI insurance for high-skilled already alive in the reform period. Those households are only indirectly affected by changes in tax rates and factor prices, which of course may also affect their premiums.[14]

In the following, the macroeconomic consequences of the different simulations are discussed first. Then the respective welfare effects for specific cohorts and households as well as in the aggregate are compared. In all these simulations we start from the benchmark equilibrium described in Table 2 above. The third subsection presents sensitivity analysis with respect to preference parameters and institutional arrangements. These simulations are performed in a small open economy setting where factor prices are exogenously set so that the initial equilibrium differs only slightly from the benchmark equilibrium.

5.1 Macroeconomic effects

Before going into the details, it is useful to highlight a general adjustment mechanism of the considered reform scenarios. They all reduce the marginal tax burden on labor for SHI-insured employees, either by reducing their contribution level or by introducing premiums. The resulting increase in labor supply and employment typically induces more savings and higher capital stock, leading further to higher wages, consumption, and output. Higher income tax revenues then allow for a reduction in consumption taxation. Despite these similarities in the adjustment to the new long-run equilibrium,

[13] Such a co-insurance level for the German health system was proposed – among others – by Drabinski (2018).

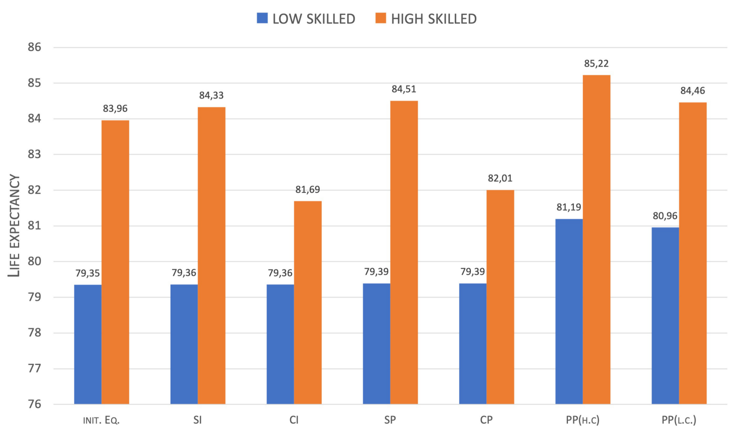
[14] This modeling assumption requires a long phase-out period of the existing system, but it is the most intuitive approach to deal with the existing PHI capital stock.

Table 3 displays significant differences in the magnitudes and pace of the macroeconomic changes on the transition path.

When the co-insurance rate is increased to 10 percent of health costs in the SI simulation, the SHI contribution rate falls by 1.7 percentage points. The PHI premium for new entrants is reduced from 268 to 243 € 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 on impact by roughly 0.6 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 3 percent much stronger than long-run output, which only increases by about 1.5 percent. Non-medical consumption is also rising by about 1.5 percent. However, private health investment increases stronger with almost 3.8 percent in the long run, which indicates the moral hazard costs of the insurance system. Closer inspection reveals that PHI policyholders want to counteract the high costs of sickness. Their medical investment rises by roughly 7 percent, while those insured under the SHI scheme react less.[15] As shown in Figure 6 below, this adjustment slightly increases the gap in life expectancy. Finally, the higher long-run capital stock increases wages, so that the average income and pensions also rise. As a consequence, the consumption tax rate falls and the pension contribution rate has to increase by about 0.3 percentage points in the long run.

The CI model forces high-skilled households into the SHI system. Due to their higher incomes, the CI contribution rate falls during the transition until finally all high-skilled are members of the new system. Consequently, labor supply distortions fall slightly for former SHI members, but they rise strongly for former PHI members who now join the CI system. This explains the rising decline in employment on the transition path. Lower incomes reduce medical and non-medical consumption and private savings. Lower savings and the elimination of PHI assets reduce the capital stock during the transition. Output therefore declines by 1.5 percent in the long run, while wages decline much less. The consumption tax rate steadily increases during the transition. Overall the CI system provides better protection against health shocks but this comes at the expense of higher moral hazard costs and a loss in life expectancy for those previously privately insured, see Figure 6.

Figure 6: Health care system and life expectancy



15 If we allow for different health shocks and more uncertainty regarding the cost, precautionary behavior would further rise.

Table 3: Macroeconomic and welfare effects of the reform models[a]

	SI	CI	SP	CP	PP (h.c.)	PP (l.c.)
Employment						
2020-24	0.59	-0.11	4.08	4.02	-0.04	-0.13
2030-34	0.59	-0.02	3.77	3.74	1.54	0.94
2040-44	0.64	-0.15	3.83	3.57	2.78	1.78
∞	0.75	-1.42	4.11	2.29	6.65	4.31
Capital stock						
2025-29	0.72	-0.21	2.61	2.50	-0.39	-0.44
030-34	1.27	-0.37	4.49	4.28	-0.35	-0.57
2040-44	2.02	-0.58	6.90	6.58	0.70	-0.05
∞	2.86	-1.67	8.72	7.12	16.69	13.75
Output						
2020-24	0.39	-0.07	2.68	2.64	-0.03	-0.09
2030-34	0.81	-0.15	4.05	3.92	0.53	0.18
2040-44	1.09	-0.24	4.83	4.58	1.64	0.87
∞	1.47	-1.50	5.65	3.91	9.96	7.43
Consumption						
2020-24	-0.49	0.25	0.72	0.84	0.62	0.60
2030-34	0.26	0.20	3.41	3.47	0.27	0.41
2040-44	0.77	0.23	4.93	4.98	0.54	0.75
∞	1.49	-0.86	6.86	5.57	6.71	7.71
Health investment						
2020-24	-0.67	-1.10	-2.43	-2.60	0.66	0.38
2030-34	0.25	-1.29	4.64	4.26	-0.65	-0.56
2040-44	1.32	-2.54	8.27	2.80	1.41	0.13
∞	3.77	-0.77	13.24	9.46	-0.81	-3.00
Wage rate						
2020-24	-0.20	0.04	-1.35	-1.33	0.01	0.05
2030-34	0.23	-0.12	0.22	0.18	-0.45	-0.39
2040-44	0.47	-0.18	1.01	0.98	-0.48	-0.47
∞	0.71	-0.09	1.48	1.58	3.11	2.99
Contribution rate/Premiums						
2020-24	-1.73	-0.38	264/275	272	271/268	212/210
2030-34	-1.76	-1.04	263/272	265	273/270	214/212
2040-44	-1.77	-1.56	262/270	260	276/273	216/214
∞	-1.80	-2.28	273/267	259	285/279	223/220
Consumption tax rate						
2020-24	-0.22	-0.03	-0.52	-0.56	0.08	0.04
2030-34	-0.61	0.06	-1.85	-1.89	0.50	0.36
2040-44	-0.86	0.12	-2.53	-2.54	0.39	0.25
∞	-1.12	0.57	-3.07	-2.60	-3.42	-3.63
Pension contribution rate						
2020-24	-0.07	0.01	-0.42	-0.41	0.01	0.01
2030-34	0.00	0.02	-0.16	-0.13	-0.13	-0.09
2040-44	0.08	0.03	0.13	0.14	-0.25	-0.20
∞	0.29	-0.64	1.04	0.31	2.94	2.23
CEV	-0.31	0.65	1.63	2.28	-1.11	0.88

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

When the SP model is introduced in the third column of Table 3, SHI contributions of low-skilled are immediately substituted by premiums. The latter are only slightly lower than those in the private system since the lower health costs of SHI members are partially neutralized by their higher sickness risk. Premiums reduce labor supply distortions immediately so that employment, output, and savings now increase strongly on impact. Consequently, wages and consumption increase steadily during the transition. Low-skilled households slightly invest more in health, since the premiums provide less insurance. High-skilled benefit from higher wages and lower consumer prices, which increases their health investment strongly. The consequence is a greater gap in high- and low-skilled health investment causing greater inequality as measured via life expectancy, see Figure 6.

The fourth simulation introduces the CP model, where the whole population is finally insured in the unfunded (and uniform) premium system. Consequently, impact effects are very similar to the previous SP model, but now the funded system is eliminated during the transition and the formerly privately insured don't receive better health treatment anymore. The latter induces a decline in life expectancy for high-skilled as shown in Figure 6, although they increase their health investment. They also build up more precautionary savings which compensates the phased-out savings from the private fund. Compared to the previous simulation, capital accumulation is dampened, so that long-run employment, output, and consumption are reduced.

In the next simulation with the PP(h.c.) model, it is assumed that all agents in the new insurance system face higher health costs and better treatment of the private system.[16] Low-skilled households, who enter the labor market are now forced to pay into a health fund which finances their health costs later in life. Note that premiums for low-skilled are now slightly higher than those of high-skilled due to higher health investment and the resulting better health of the latter. Low-skilled cohorts in the PHI are also forced to pay contributions to finance those who remain in the SHI system. These contributions decline to zero during the transition. While their labor supply distortions hardly fall initially, they reduce savings 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 premiums are significantly higher than in the CP model, which reflects the higher health care costs in the private system. However, labor distortions are reduced during the transition, and employment, capital stock, output, wages, and consumption rise in the long run. The higher capital stock is mainly due to the accumulated assets of the private insurance. Since PHI offers better treatment than SHI, the life expectancy of low-skilled increases by almost two years in the long run, although their health investment slightly decreases (not shown). High-skilled, however, significantly increase their health investment in this scenario, due to higher incomes. As shown in Figure 6, long-run life expectancy is now 81.2 and 85.2 years for low- and high-skilled, respectively.

The last simulation combines the funded premium insurance with higher treatment efficiency and the lower health costs of the former public system. Now the premiums are significantly lower than in the previous simulation so that households can afford to consume more and work less than before in the long run. This, however, does not apply to private health investment, which now decreases compared to the previous simulation. Lower health investments and lower health costs explain why life expectancy in Figure 6 declines for both skill types compared to the previous simulation.

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[16] Implicitly it is assumed here that the higher demand for better treatment induces a higher supply of medical providers.

5.2 Welfare effects

Figure 7 compares the welfare effects of the different reforms discussed above for specific cohorts and skill 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 other precautionary behavior against health shocks as well as the implied insurance provision. While the premium models reduce labor supply distortions and the insurance provision against productivity shocks, the opposite applies to the CI model.

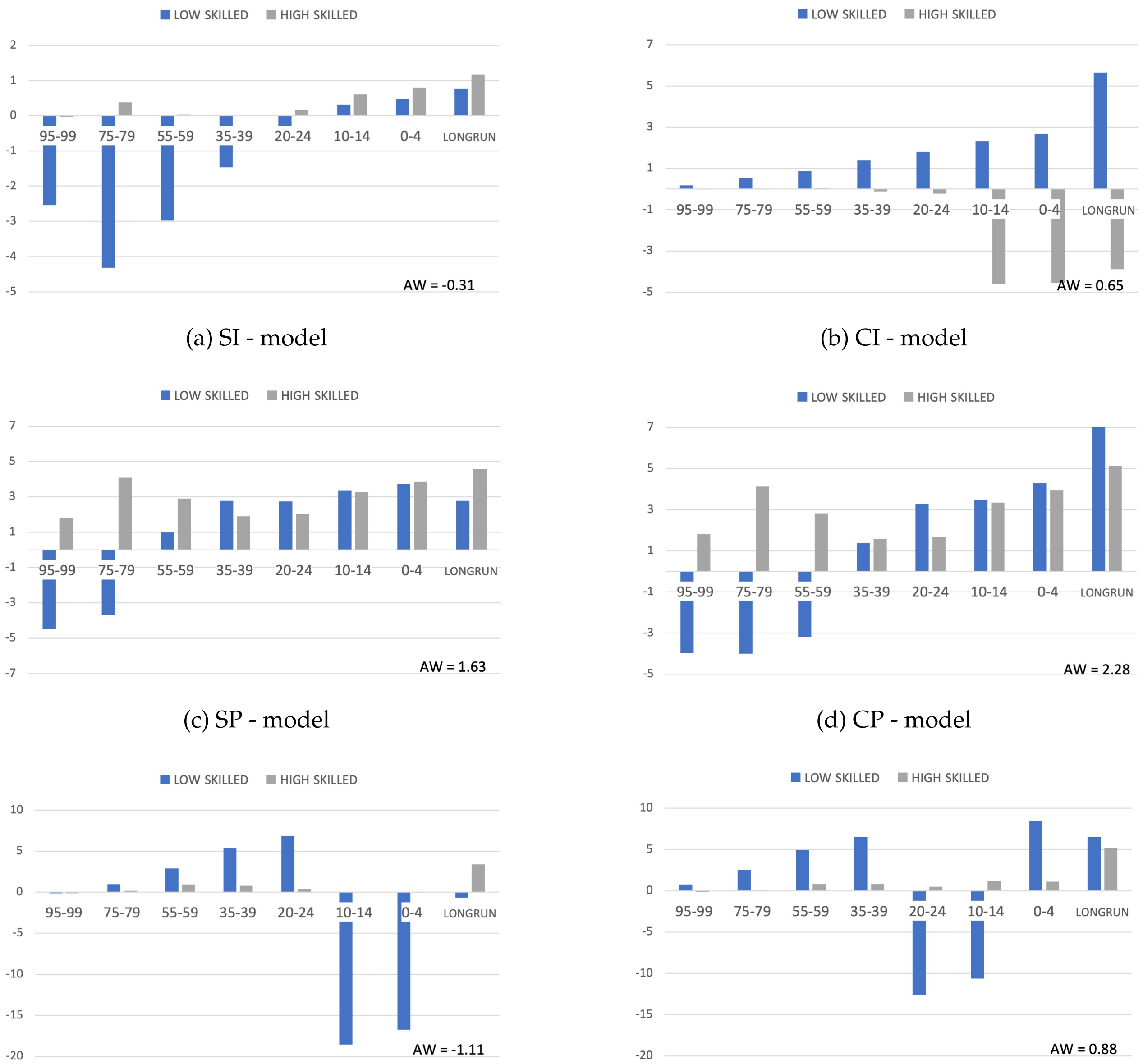
The increase in the share of co-payments in health care costs primarily harms the older pensioner cohorts in the SHI system. They have high costs and at the same time often low savings so that they are extremely exposed to health shocks. The retired cohorts in the PHI system are less affected because on the one hand, their premiums are reduced much stronger due to the accumulated PHI assets and on the other hand, they have typically higher additional savings. During the transition, younger and future cohorts can self-insure their health risk and benefit from higher wages, lower contributions, and consumption taxes. Hence, younger and future cohorts realize a significant welfare increase. Overall, the future welfare gains cannot fully compensate for the welfare losses of the initial elderly, so the aggregate welfare measure reported in the last line of Table 3 indicates a loss of 0.3 percent of initial consumption. Consequently, despite the reduced moral hazard, a health care system with deductibles reduces efficiency in our model.

The welfare effects of the CI model in Figure 7b are quite different. On the one side, all low-skilled benefit, since their health insurance contributions are sequentially reduced throughout the transition. In the long run their welfare increase corresponds to an almost six percent rise in initial consumption. The remaining PHI-insured high-skilled realize hardly any welfare changes since they are only slightly affected by changes in consumption taxes and factor prices. On the other side, high-skilled labor market entrants who are now forced into the public system are much worse off than before. Their labor supply distortions rise significantly and the health treatment they receive when sick has deteriorated. They benefit from the lower cost of the public system, but they have to co-finance the higher health costs of low-skilled. The latter generate higher costs due to their lower health investment shown in Figure 4. Overall, contribution financing of health care improves the insurance provision even for high-skilled. This seems to dominate the increased labor supply distortions of high-skilled, so that this reform increases aggregate welfare by 0.65 percent of initial consumption, see the last line in Table 3.

The social premium model in Figure 7c clearly hurts the low-skilled pensioners of the initial reform periods. They now have to bear on average much higher insurance costs than before. The retired high-skilled, however, benefit from lower consumption taxes and higher interest rates. Elderly low-skilled employees of the reform period experience a significant welfare increase because their financing burden decreases. Younger and future cohorts benefit from higher wages and lower consumption taxes. The overall welfare change in Table 3 is now significantly positive, amounting to 1.63 percent of aggregate consumption.

As shown in Figure 7d, when the high-skilled are forced into the unfunded public premium system, low-skilled are better off in the long run than in the previous simulation due to the improved cost sharing. High-skilled benefit from the lower health costs, but are hurt due to redistribution and the lower treatment quality. These latter effects are clearly dominated by the former. The overall welfare

Figure 7: Welfare consequences of the considered reform models



(a) SI - model

(b) CI - model

(c) SP - model

(d) CP - model

(e) PP(h.c.) - model

(f) PP(l.c.) - model

increase is now even 2.3 percent of initial aggregate consumption. All in all, financial health costs are lower and more equally distributed within the society which implicitly improves the insurance provision and explains the resulting aggregate welfare increase. When comparing the CP and the CI model, one can see that young and future high-skilled are worse off compared to respective low-skilled due to the higher health care contributions.

The welfare effects in the two PP models in Figures 7e and 7f are quite different compared to the SP and CP models. The oldest cohorts are hardly affected by these reforms because factor prices and consumption taxes remain initially fairly stable. The middle-aged low-skilled, who remain in the SHI system, benefit significantly since their contributions decline when the system is phased out. At the same time, younger low-skilled cohorts who enter the labor market are dramatically hurt because they have to co-finance the health bills of the elderly in the SHI system and are forced to build up PHI assets at the same time. During the transition, this double burden falls and turns eventually positive in the long run.[17] Note that the welfare losses for some cohorts amount to roughly 20 percent of initial consumption. As a consequence, the society realizes an overall welfare loss amounting to 1.11 percent of initial consumption. This welfare loss, despite many positive aspects and higher life expectancy, can be attributed to the fact that the costs of private insurance are much higher than those of public health care.

Figure 7f shows, that younger and future cohorts would benefit if the introduction of the privately funded insurance system is accompanied by a reduction in health costs. The dramatic welfare losses from the last simulation are then significantly reduced and the future welfare increases are much higher than before. Overall welfare is now even increasing at 0.88 percent of aggregate initial consumption. Compared to the CP model, the aggregate welfare gain of the PP(l.c.) model is lower, despite the improved treatment quality and lower premiums. This reflects the higher labor supply distortions during transitional years when the savings of the funded system have to be built up and two systems have to be financed.

5.3 Sensitivity analysis

Welfare effects reported in the previous subsection are strongly dependent on the assumptions made about preferences and the institutional setting of the public system. With respect to household choice modeling, we would like to quantify the impact of health investment options as well as the elasticity 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, where we exogenously specify the interest rate of Table 2. With this specification, the initial equilibrium is close to the one reported in Table 2. Table 4 shows the impact of alternative assumption on the aggregate welfare effects when we simulate the SI model and three reform models in a small open economy.

In the "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 shows that (except for the SI reform) wages typically decrease initially (so that the interest rate falls), but increase significantly 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, the described redistribution of resources across and within cohorts hardly changes incentives and insurance provisions. Therefore, the aggregate welfare effects in the first row of Table 4 hardly change compared to those in the respective closed economy case reported in Figure 7. In all following simulations, we change preference or institutional parameters so that the initial equilibrium will be (slightly) different from the one shown in Table 2.

In the second line, a model is shown in which private investment in health has no impact on health.

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

Table 4: Sensitivity analysis: Aggregate welfare effects in a small open economy[a]

	SI model	CI model	CP model	PP(h.c.) model
Benchmark	-0.30	0.64	2.23	-0.98
No health investment $\lambda_3 = 0$	-0.33	0.31	2.00	-0.77
Fixed labor supply $l = \max[0.37; 1 - s(h)]$	-1.36	0.80	-1.21	-2.16
Higher risk aversion $\varrho = 6.0$	-0.64	-0.04	-0.20	-2.70

[a] CEV measured in percent of initial consumption.

Accordingly, differences in life expectancy arise exclusively from different treatments and costs by different health insurers. Now (high-skilled) households can only react with their labor supply and savings to self-insure. As a consequence insurance provision is lower, which in turn reduces the aggregate welfare effects of the considered policies. The constant wage rate also dampens the redistribution towards the high-skilled at least in the CP and the PP(h.c.) models. The latter will improve aggregate welfare. The lower aggregate welfare loss in the PP(h.c.) model might be because the wage effect dominates the insurance effect.

When the policy reform is simulated with a fixed labor supply, households cannot self-insure by working more. To be able to insure oneself against health shocks, people in all four considered scenarios invest more in health, which leads to higher life expectancy. As they do not benefit from reduced distortions of labor supply, aggregate welfare losses are much higher in the SI model and the PP(h.c.) model, and formerly welfare gains turn into significant losses in the CP model. In all these reforms households 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), aggregated welfare even slightly increases compared to the benchmark simulation, reflecting better risk allocation compared to the other models.

Since more risk-averse households build higher precautionary savings, the reduction in insurance protection in the SI and the two premium models reduces aggregate welfare compared to the respective benchmark situation.[18] The premium models especially reduce insurance protection of low-skilled households, so that higher risk aversion intensifies this effect. This mainly explains the significant fall in aggregate welfare reported in Table 4 above. Aggregate welfare also is reduced in the CI model, but much less than in the two premium models. This reflects the fact that the CI model provides more insurance than the two premium models. Now the CI model performs best relative to all other models.

[18] Since we are unsure about the exact value of ϱ, we assume same value as Palumbo (1999), so that $\varrho = 6$. Asset pricing studies such as Heathcote et al. (2008) simulate with $\varrho \in [1; 10]$.

6 Conclusion

This paper develops a stochastic overlapping generations model that accounts for endogenous health and survival, differences in individual health ability as well as cost and quality differences between private and public health insurance. The model is simulated to quantify the impact of alternative financing and coverage schemes for the German health insurance system. Our simulations highlight three major results. First, while premiums entail lower labor supply distortions, contribution-financed health care has better insurance properties. If the latter dominates the former, then contribution-financed health care is preferred from a welfare point of view. In our benchmark calibration, however, the citizen premium model dominates all other reform models in terms of welfare. Second, despite significant moral hazard costs in the existing system, compulsory deductibles would reduce aggregate welfare in Germany. Third, the transition towards the private system is more expensive than the immediate introduction of a public premium system. In addition, although private insurance provides a better treatment quality which leads to higher life expectancies, the higher cost induces a welfare loss. This poses the question, of whether we should consider not only life expectancy but also healthy life expectancy as an indicator in future work.

The sensitivity analysis reveals that the economic benefits of the premium system are fairly robust. Contribution-financed health care is only preferred with very low labor supply elasticities and/or very risk-averse households. We also show that private health investment may significantly affect the welfare of individuals. While complete insurance only finances the direct monetary costs of health problems, households still bear indirect costs of sick time and lower life span which can be reduced by individual behavior. Finally, we highlight different causes for the observed (and growing) gap in intra-generational life expectancy. Not only individual monetary investment but also individual ability and better behaviors and genetics play a role as well as differences in treatment quality of the health care system. All these channels are present in our model and have a significant impact.

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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

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

subject to

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

The expectation operators $\mathbb{E}$ are defined with respect to the stochastic labor productivity process η and the health shocks ζ in (6) and (10). 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 $\omega^+ = \omega(\tilde{z})$.

   Households who optimize investment in their health need to split their total investment $\tilde{a}^+$ into health investment and liquid assets. The sub-optimization problem is

   $$Q(\tilde{z}) = \max_{0\leq\omega^+\leq 1} \mathbb{E}\left[\, V(z^+|\eta,\zeta)^{1-\varrho}\,\right]^{\frac{1}{1-\varrho}}$$

   subject to

   $$\begin{aligned} a^+ &= (1-\omega^+)\tilde{a}^+ \\ h^+ &= (1-\delta^h)h + g(\omega^+\tilde{a}^+, hc) + \zeta \end{aligned}$$

   where again (6) and (10) apply.

   This gives $Q(\tilde{z})$ as well as $\omega(\tilde{z})$.

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 $y = w \cdot e \cdot (1 - \ell - s(h)) = w \cdot e \cdot l$.

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

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

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 $w^n = we(1 - T(y)/y - T_p(y)/y - T_h(y)/y)$ 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 2020

GDP and health care data

In 2020 total health expenditures in Germany amounted to € 440 bn. or about 13 percent of GDP. Table 5 shows the different institutions that spent these outlays. The statutory health care system

Table 5: Health expenditure by funding institutions in Germany in 2020*

Institution	in € bn	in %
Statutory health insurance (SHI)	241.5	55.0
Households and private non-profit institutions	57.1	13.0
Private health insurance (PHI)[1]	35.4	8.0
Statutory long-term care insurance	47.1	10.7
Other funding sources[2]	58.2	13.3
Total	439.3	100.0

*Source: Statistisches Bundesamt (2022): Genesis-Online.
[1] Including private LTC.
[2] Government, employers, pension and accident insurance.

provides by far the most health care services amounting to 55 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. Private health care only spends about 8 percent of total costs, 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.

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 (2021a). Table 6 reports the official national income accounting data for Germany in 2020.

Table 6: National accounting in Germany 2020 (in € bn)*

Output measure		Expenditure measure		Distribution measure	
Gross value added	3,050	Private consumption	1,656	Labor costs	1,852
Goods taxes ($\tau^c C$)	317	health care	87	Capital income	676
		Private NPOs	53	Aggregate income	2,528
		Government consumption	754	Production taxes	274
		social in-kind	230	NNI	2,802
		Gross investment	711	Depreciation	659
		Trade balance	193	GNI	3,461
				Primary income RoW	-94
GDP	3,367		3,367		3,367

*Source: StaBu (2021a).

Private consumption includes health care consumption which amounts in 2020 to roughly € 87 bn.[19] This amount covers the expenditures of the PKV (i.e. € 35 bn) and voluntary private expenditures of € 57 bn. Consequently, this last figure fits quite well with the private expenditures reported in Table 5 above. However, our measure of private health investment is differently defined and includes the consumption of healthy food, sports activities, body care, etc. Some of these activities are included in the consumption of private non-profit organizations (NPOs). The latter produce services that are mainly provided to private households and are financed by voluntary contributions or donations. Total consumption expenditures on such hobbies and leisure activities amount to € 41 bn. Finally, households spend money on body care (€ 34 bn) and for other social services (€ 44 bn).[20] We assume that roughly € 50 bn in total is spent on private health activities (or investments) (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 amounted to € 230 bn in 2020 (p. 289). The difference between this figure and the GKV expenditures in Table 5 is mainly due to sickness benefits (Krankengeld) which are 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 2020. The data for asset values and capital stock is derived from StaBu (2021b). 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 (Wohnbauten) from total tangible assets (Sachvermögen). Table 7 provides the original figures from the data.

Table 7: Wealth in Germany 2020 (in € bn)*

	Aggregate economy
Tangible assets	17,528
of which	
residential buildings	-5,907
Capital stock (K)	11,621

*Source: StaBu (2021b).

According to this data set, total tangible assets in 2020 amount to € 17,528 bn. Subtracting from that figure the value of residential buildings held by the household sector of € 5,907 bn leads to our estimate for the capital stock employed in production.

In order to reconcile the data from Table 6 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

[19] Here we refer to "Gesundheitspflege" which amounts to € 87,445 bn in 2020 (p. 256).

[20] Here we refer to "Andere Geräte und Artikel für Freizeitgestaltung (Sportgeräte)" € 40,988 bn, "Körperpflege" € 33,909 bn and "Dienstleistungen sozialer Einrichtungen" € 44,202 bn in 2020 (p. 257).

sum of € 1,902 bn, we subtract goods taxes (€ 317 bn), private health investment (€ 50 bn), and private health care expenditures (€ 35 bn) to compute a consumption value of € 1,500 bn. Similarly, government consumption in Table 6 is reduced by statutory health care costs (i.e. social in-kind) and amounts to € 524 bn. In the left part, we add self-employed income of € 230 bn to labor income and derive capital income endogenously.[21] Our adjusted figures are shown in Table 8.

Table 8: Adjusted national accounts (in € bn)

Output measure		Expenditure measure		in %	Distribution measure	
Output (Y)	3,050	Private consumption (C)	1,500	49.2	Labor income (wL)	2,082
		Statutory hc (SHC)	230	7.5	Capital income (rK)	309
		Private hc (PHC)	35	1.1	Depreciation (δK)	659
		Health investment (M)	50	1.6		
		Public consumption (G)	524	17.2		
		Gross investment ($(n+\delta)K$)	711	23.4		
GVA	3,050		3,050	100.0		3,050

We use the expenditure composition in the middle part of Table 8 as calibration targets or exogenous public consumption share. In addition, we can now compute the parameters

$$\alpha = \frac{F_K K}{Y} = \frac{(r+\delta)K}{Y} = 0.32, \qquad r = \frac{rK}{K} = 0.026, \qquad \delta = \frac{\delta K}{K} = 0.057 \quad \text{and} \quad n = \frac{nK}{K} = 0.0045.$$

Consequently, compiled with our data the annual interest and depreciation rates amount to 2.6 and 5.3 percent, respectively and the annual population growth rate is 0.55 percent.

Public debt (B_G) in 2020 amounts to € 2,314 bn, see Deutsche Bundesbank (2022, 58*). Related to GDP at market prices from Table 6 this would be roughly 68 percent. In our model we need to relate the stock values to output evaluated at producer prices so that we get

$$\frac{B_G}{Y} = 0.75, \qquad \frac{rB_G}{Y} = 0.02 \qquad \text{and} \qquad \frac{K}{Y} = 3.80.$$

Next, we quantify the adjusted sectoral balances for the closed economy in Table 9. The production sector in the left column first derives net value added, which can be seen in the previous Table 8. This value is split up into labor income and net business surplus which together with asset income from the government bonds sum up to the aggregate income (Volkseinkommen) of households. Interest costs of the government are computed as follows: Using the above interest rate on public debt yields for rB_G an amount of roughly € 60 bn. This figure seems too high since the official interest payments of the government amounted to roughly € 23 bn in 2020, see Deutsche Bundesbank (2022). However, we also exclude household asset income from abroad so that € 60 bn is reasonable. In addition, the resulting aggregate income of € 2,451 bn is only slightly below the respective figure of € 2,528 bn in Table 6.

The 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

[21] A rough measure for self employed income is "Ausschüttungen und Gewinnentnahmen" at p. 304.

Table 9: Transactions and sectoral balances in the model (in € bn)*

	Production	Government	Households	reporting in % of Y
Gross value added	3,050			
Depreciation	659			
Net value added	2,391			
Labor income	-2,082		2,082	
Capital income	-309		309	
Asset income		-60	60	2.0
Aggregate income			2,451	
Labor income tax		311	-311	10.2
Pension contrib.			-313	10.2
Pension benefits			313	
SHI contrib.		230	-230	
Available income			1,910	
Goods taxes		317	-317	10.4
SHI benefits		-230		
Consumption		-524	-1,585	
Savings/Investment	-52	44	8	

Own calculations.

(for self-employed) revenues in 2020 amounted to € 254 bn and € 57 bn, respectively (StaBu, 2021a, p. 303). The value of € 311 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 include pension benefits of civil servants. The former are financed by taxes and amount to almost a third of total benefits. Therefore, we add pension contribution revenues of € 237 bn (p. 308) and benefits of civil servants of € 76 bn (p. 305) to arrive at the figure of € 313 bn. Household's SHI contributions which were already derived above are close to total contributions to public health care of € 237 bn (p. 308). From the resulting available income, we subtract goods taxes of € 317 bn and the private consumption expenditures at producer prices of 1,585 bn € from Table 8. Private consumption at market prices then amounts to € 1,806 bn, which is fairly close to the value of € 1,708 bn in Table 6. The resulting household and government savings figures are much lower than the actual levels of € 327 bn (p. 50) and € 51 bn (p. 55) in 2019.[22] However, positive government savings were normal until the pandemic and the household figure reflects the closed economy.

Individual income and health data

StaBu (2021a, 52) reports in the year 2020 the average annual gross income of all employees of € 36,951 and average annual gross income of € 41,400 for not-marginally employed.[23] The respective

22 The figure for the government surplus is for 2019 since in 2020 the COVID-19 pandemic increased the deficit dramatically up to € 145 bn.

23 Marginally employment amounts to 4,85 mio employees out of 40,86 mio 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 gross labor earnings are at € 3,079 and € 3,450. Our guess for average monthly labor income in 2020 is therefore € 3,250, which yields an annual value of € 39,000 that corresponds to the average annual gross income of employed workers reported in Deutsche Rentenversicherung Bund (2021, 258). The monthly contribution ceiling for the pension system was € 6,900 in West Germany and € 6,450 in East Germany. On average, a contribution ceiling of 6,500 €, which yields a maximum of 2 earning points, is realistic. The monthly contribution ceiling for the statutory health care system was the same in East and West Germany at € 4,687 (Deutsche Rentenversicherung Bund, 2021, 262) so it is roughly 40 percent above the average income. Although it is not required for the simulation model, Table 10 also reports the opt-out threshold from the statutory health care system, which was 2020 about 60 percent above average income.

Table 10: Income and health costs per capita in 2020 (in €)

	Month	Year	in % of av. income
Labor income	3,250	39,000	
Pension contribution ceiling	6,500	78,000	200.0
SHI contribution ceiling	4,687	56,244	144.0
Opt-out threshold		62,550	160.0
Health costs			
SHI		3,200	8.2
PHI		4,000	
SHI Contribution rate			15.6
PHI Premiums	300	3,600	–
Pension contribution rate			18.6

Source: StaBu (2021a), DRV (2021).

With respect to the distribution of incomes, Grabka and Goebel (2020, 235) find that the Gini index of household market income roughly stayed constant at 0.46 since 2002. The World Income Database (http://wid.world/country/germany/) reveals that in 2020 the top percentile of households in Germany held 37.1 percent of incomes while the bottom half of households only held 19 percent of incomes.

According to Hagermeister and Wild (2021, p.4) about 8,73 mio out of the total population of 83,17 mio were insured in the private system in 2019, which is about 10.5 %. The average age of privately insured is 45.6 years and therefore about 1.6 years higher than the average age of those insured in the statutory insurance. Dividing the total expenditures of the two insurance systems from Table 5 by the number of insured, we arrive at the average per-capita figures reported in the middle part of Table 10. Premiums in private health care depend on age, gender, and the record of previous health problems. On average, a 25-30 year-old has to pay about 300 € premium per month in the private system. The contribution rates to the SHI and the public pension system in 2020 were 15.6 and 18.6 percent, respectively, see DRV (2021, p.260). Finally, according to the PHI data base[24], the total assets accumulated in 2019 amounted to 303 bn €. Assuming a slightly higher rate in 2020 we arrive at 10 percent of GVA.

24 See https://www.pkv-zahlenportal.de/werte/2008/2018/12/kap-anlagen/basket/result

As can be seen in the latest life tables 2018/2020 published by StaBu (2021d), men reach an average age of 79.1 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 11.[25]

Table 11: Remaining life expectancy in Germany

Age	20	30	40	50	60	70	80	90
Life tables 2018/2020	59.1	49.3	39.7	30.3	21.8	14.4	8.1	3.7
PHI Life tables 2020	64.8	55.1	45.3	35.6	26.3	17.7	10.1	4.7

Quelle: StaBu (2021d), BaFin (2020).

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 also reflect better health service access and/or provision.

In 2020 the dependency ratio of those 65 years old and older relative to the population group with ages between 20 and 64 years is 36.9 percent (see StaBu, 2021c).

Next, we compute average age-related expenditure profiles for men and women for German sickness funds in the year 2020 from Bundesamt für Soziale Sicherung (2021). Table 12 shows in the left part the absolute annual figures and in percent of annual income within a five-year period. Health care costs of young people are low at about 3-5 percent of average income. They rise sharply in the middle ages before and after retirement to roughly 15 percent of average income. In old age, they remain fairly constant at about 20 percent of the 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 (2021).[26] 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. The right column of Table 12 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.

To calibrate a realistic figure of sickness days we compile the sick days in Germany in the year 2020 reported by Institut der Deutschen Wirtschaft (2022). Table 11 shows the absolute days and then as a fraction of working days which are assumed to be 253. Sick days therefore rise on average from 4 percent to almost 14 percent of total working time. On average, employees stayed 18.2 days at home with a medical certificate.

[25] 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.

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

Table 12: Health costs profiles and illness per cohort

Age	hc (SHI) in €	in % of income	hc (PHI) in €	Sickness fraction per cohort
20-24	1,089	2.8	1,830	11.2
25-29	1,142	2.9	2,001	13.1
30-34	1,272	3.3	2,645	13.6
35-39	1,467	3.8	2,570	13.6
40-44	1,709	4.4	2,495	13.7
45-49	2,060	5.3	2,785	13.8
50-54	2,565	6.6	3,318	15.6
55-59	3,330	8.5	4,125	17.3
60-64	4,329	11.1	5,196	17.9
65-69	4,374	11.2	6,408	16.0
70-74	6,492	16.6	7,960	19.1
75-79	7,647	19.6	9,430	25.5
80-84	8,458	21.7	10,483	25.5
85-89	9,156	23.5	10,892	25.5
90-94	9,201	23.6	–	25.5
95-99	8,916	22.9	–	25.5
average	3,200	8.2	4,000	15.3

Source: BfSS(2021), Hagermeister and Wild (2021), BMG (2020, 40).

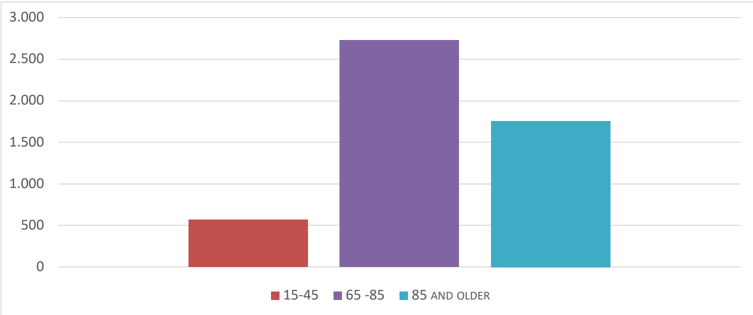
Table 13: Sick time in 2018

Age	Average sick time in days	in %
25-29	10.3	4.0
30-34	10.6	4.1
35-39	12.0	4.7
40-44	14.0	5.5
45-49	16.6	6.5
50-54	20.2	8.0
55-59	26.9	10.6
60-64	33.9	13.4
average	18.2	7.2

Source: Idw (2022).

The following Figure 8 shows the number of cases in preventive care and rehabilitation facilities in Germany for the year 2020. Of course, health cures in Germany are usually financed by the insurance system, but typically there are some deductibles which have to be financed out-of-pocket. In addition, people often spent time at such a facility without prescription, i.e. they pay all cost out-of-pocket. As can be seen, people aged 65-85 years have the highest demand across considered age. At least this indicates that these groups have the highest private medical investment.

Figure 8: Number of cases in preventive care and rehabilitation facilities in Germany (2020)



Source: https://tinyurl.com/StaBu-Reha.

Finally, Table 14 shows the distribution of self-assessed health of German men in the age bins 18-29 in 2009. Importantly, the study distinguishes different education/skill classes. As shown, high-skilled are more optimistic with regard to their health but the differences especially to middle-skilled are fairly small. This might justify our choice of a uniform initial health stock for our skill types in the benchmark model. Nevertheless, we also provide simulations below where we assume heterogeneity in initial health.

Table 14: Health of German men, age 18-29 in 2009

Skill type	Self assessed health condition		
	Good/very good	middle	Bad/very bad
Low	81.0	16.7	2.3
Middle	88.7	10.1	1.2
High	93.3	5.9	0.9

Source: https://tinyurl.com/RKIStudy2009.

Appendix C: Calibration process

In our model calibration, we employ the Simulated Method of Moments (SMM) technique, a widely used econometric method. Consequently, we select the following moments $m(x)$ from the data described in Appendix B:

- Dependency ratio (DR) as the proportion of the population age 65+ relative to those at age 20-64.
- Life expectancy at 20 of low- and high-skilled (LE20_L, LE20_H).
- Public and private health care spending relative to GDP ($SHC/Y, PHC/Y$).
- Life expectancy at 60 of low-skilled (LE60_L).
- Average normalized working time ($\bar{l}$).
- Aggregated private health expenditures relative to GDP (M/Y).
- Fraction of individuals with health shock (sick individuals, SI).
- Difference in life expectancy between high and low skilled (Δ LE60).
- Contribution rate for SHI budget (τ_h).
- Monthly PHI premium (q^{ip}).

The values of these target moments are normalized to lie in the interval $[0, 1]$. Then we define an array of uncertain parameters as

$$\Theta = (\xi, d_0, d_1, \omega_1, \omega_2, \lambda_1, \lambda_2, \lambda_3(1), \lambda_3(2), \lambda_4(SHI), \lambda_4(PHI), \Lambda(PHI))$$

The parameter values of Θ are adjusted to minimize the difference between the target moments and their counterparts $\hat{m}(\hat{x}|\Theta)$ computed from the simulated data $\hat{x}$ of the initial model equilibrium, i.e.

$$\hat{\Theta} = \min_{\Theta} \sum_i \Gamma_i \left(\hat{m}_i(\hat{x}|\Theta) - m_i(x)\right)^2 ,$$

where Γ_i is a weighting factor of the moment m_i. With the exception of $\Lambda(SHI)$, which is set at 1.05, the parameter values are initially guessed together with intervals within which our algorithm searches for an optimal solution. Due to complications during the calibration process, we give greater weight to the target value for aggregated health care expenditures, all other weights are set to unity. The problem is solved using the *fminsearch* subroutine from the FORTRAN library. The resulting parameter values are reported in Table 1.

Appendix D: Simulation with different health endowments, categorized by skill type

In this simulation, we consider a model in which the initial health endowment $\bar{h}$ differs between the two skill types. In addition to the skill-specific $\bar{h}$, we now neglect differences in individual health abilities. Since high-skilled individuals start now with better conditions, such as better environmental conditions, better-educated parents, etc., their initial health endowment is 10% higher than that of low-skilled individuals, where the latter remains at the benchmark level. Since the heterogeneity of health endowments already accounts for health variations, there is no need to introduce additional differences in abilities related to health. Therefore, the parameter $\lambda_3(\theta)$ now has the same fitted value for both skill types. To facilitate comparisons between the models, we refrain from re-calibrating any other parameters.

Table 15 compares the new equilibrium with the benchmark model, along with the target values. It should be noted that the changes compared to the initial equilibrium are mostly negligible. The main difference between the benchmark model from the main section and the present exercise is the increased life expectancy of high-skilled individuals from 84 years to 86.5 years (see Figure 9). The reason for this is that with better health endowments, the probability of falling ill decreases. As a result, health capital depletes more slowly, leading to a higher life expectancy. This reduces the PHI premiums from € 268 to € 250. As life expectancy increases, so do the pension contributions, as a longer payout period is now anticipated. These are the most significant changes to the initial equilibrium, as can be seen in Table 15.

The reform simulations with the new results are presented in Table 16. Given that the primary objective of this experiment is to demonstrate that the effects are similar to those of the main model, we opt not to simulate the PHI with lower costs. When we compare the results of the deductible simulation (SI) in Tables 3 and 16, we observe that both the short-term and long-term effects of these simulations are quite similar. However, in the simulation with heterogeneous initial health, the effects are somewhat dampened since now 10% of the population, namely the high-skilled individuals, start with better health endowments in the economy.

More interesting is the comparison of the switch to citizen insurance (CI). In the present simulation, the labor supply decreases less, leading to a smaller decline in output, capital stock, and consumption (both medical and non-medical). In this regard, we observe a contrasting development, particularly in private health investments. While in the benchmark model private health investments decrease in the long term, we now observe a positive increase of 2% which reflects lower prices and higher incomes. High-skilled individuals now start investing in their health later in life, but they invest more compared to the respective benchmark simulation. When considering the social premium (SP) and the citizen premium (CP) reform, we once again find that the results are very similar to those in Table 3.

Examining the last reform, in which all insured individuals are privately insured in the long term, we note that the directions of change remain the same, but are more pronounced. For instance, output and capital stock increase much more significantly, while private health investments decrease much more. The more significant reduction in private health investments can be explained by the fact that in the benchmark mainly high-skilled individuals had invested heavily in health. In the present model calibration, private health investments are less efficient in producing health. Therefore, individuals resort to precautionary savings and invest less in health for precautionary reasons. This also explains the delayed start of health investments in previous simulations.

Figure 9 reports the changes in life expectancy. The old equilibrium is also depicted for reference. As we can see, there is a similar trend. Among low-skilled individuals, there is a significant increase in life expectancy in the model with private health insurance, while other changes are relatively small. However, among high-skilled individuals, a decrease in life expectancy can be observed in the CI and CP models, as the superior treatment provided by the PHI system is no longer guaranteed. In the other simulations, high-skilled individuals benefit from the reform and can expect a higher life

Table 15: Initial equilibrium (in % of GDP)

Variable	New model	Benchmark model	Target
Demographics			
Dependency ratio (65+/20-64)	0.35	0.35	0.37
Life expectancy at birth	79.4/86.5	79.4/84.0	79.1/84.8
at retirement	19.3/24.4	19.3/23.1	19.6/23.2
Expenditures on GDP			
Private consumption	50.7	50.5	49.2
Government consumption	17.2	17.2	17.2
Gross investment	23.2	23.2	23.4
SHI/PHI health spending	6.9/1.1	7.0/1.1	7.5/1.1
Private health investment	1.1	1.1	1.6
Capital stock, labor market and income			
Capital-output ratio	435.1	435.3	380.0
PHI capital-output ratio	11.3	11.0	10.0
Working time (in %)	31.8	31.5	33.0
Gini (gross labor income)	0.47	0.46	0.46
Top 10 % share (in %)	43.2	42.4	37.1
Bottom 50 % share (in %)	19.1	19.5	19.0
Interest rate p.a. (in %)	2.9	2.9	2.6
Health indicators (in %)			
Fraction of sick 20-24	11.2	11.3	11.2
Fraction of sick 55-59	17.6	17.7	17.3
Fraction of sick average	16.9	17.0	15.3
Sick time 25-29	11.9	12.1	4.0
Sick time 55-59	29.9	30.0	10.6
Sick time average	19.4	19.7	7.2
Health costs - income ratio	8.6	8.9	8.2
Government indicators			
Labor income tax revenue	10.4	10.3	10.2
Consumption tax revenue	8.6	8.7	10.4
Consumption tax rate (in %)	16.6	16.9	–
Interest costs	1.7	1.7	2.0
Pension benefits	9.1	8.9	10.2
Pension contribution rate (in %)	17.8	17.4	18.6
SHI contribution rate (in %)	15.8	15.9	15.6
PHI premium (in € p.m.)	250	268	300

Table 16: Macroeconomic consequences of the reform models

	SI	CI	SP	CP	PP
Employment					
2020-24	0.57	-0.08	3.96	3.91	-0.01
2030-34	0.51	0.04	3.62	3.62	1.56
2040-44	0.52	-0.01	3.62	3.46	2.77
∞	0.53	-1.10	3.65	2.38	5.56
Capital stock					
2025-29	0.71	-0.21	2.52	2.42	-0.36
2030-34	1.25	-0.37	4.35	4.16	-0.32
2040-44	1.98	-0.58	6.69	6.37	0.73
∞	2.69	-1.44	8.29	7.01	16.01
Output					
2020-24	0.37	-0.05	2.60	2.57	-0.01
2030-34	0.77	-0.11	3.91	3.80	0.57
2040-44	1.01	-0.17	4.65	4.44	1.66
∞	1.26	-1.21	5.20	3.93	9.00
Consumption					
2020-24	-0.48	0.26	0.69	0.81	0.62
2030-34	0.22	0.23	3.26	3.35	0.30
2040-44	0.68	0.29	4.75	4.82	0.58
∞	1.23	-0.50	6.25	5.58	5.47
Health Investment					
2020-24	-1.16	0.21	-0.20	-0.22	0.74
2030-34	-0.09	-0.07	3.58	3.58	1.19
2040-44	0.41	-0.06	5.93	4.68	1.74
∞	1.12	2.07	9.79	11.46	-10.24
Wage rate					
2020-24	-0.19	0.03	-1.31	-1.30	0.00
2030-34	0.25	-0.13	0.22	0.18	-0.46
2040-44	0.49	-0.21	1.00	0.94	-0.47
∞	0.73	-0.12	1.50	1.52	3.26
Contribution rate/Premiums					
2020-24	-1.72	-0.38	270/248	267	265/250
2030-34	-1.74	-1.06	266/247	259	267/250
2040-44	-1.75	-1.60	264/246	254	270/249
∞	-1.78	-2.39	263/258	252	279/266
Consumption tax rate					
2020-24	-0.21	-0.04	-0.48	-0.53	0.07
2030-34	-0.58	0.05	-1.75	-1.80	0.47
2040-44	-0.79	0.09	-2.40	-2.44	0.36
∞	-0.99	0.43	-2.82	-2.56	-2.93
Pension contribution rate					
2020-24	-0.08	0.02	-0.44	-0.42	0.01
2030-34	-0.01	0.03	-0.17	-0.14	-0.13
2040-44	0.06	0.04	0.11	0.13	-0.25
∞	0.20	-0.54	0.88	0.33	2.55

expectancy.

Figure 9: Health care system and life expectancy

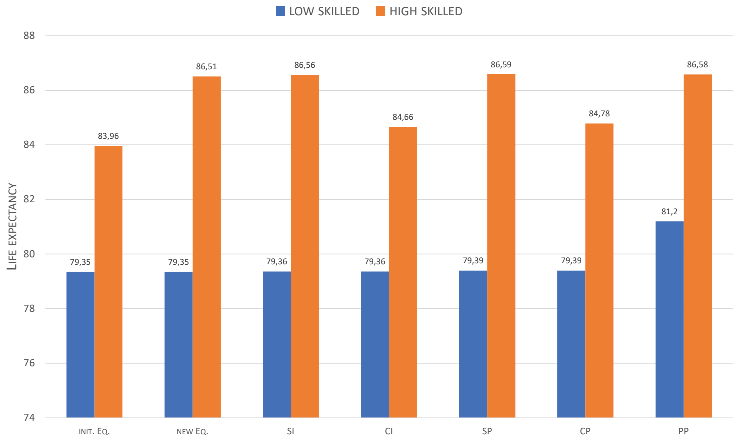


Table 17 reports the welfare effects for specific households and in the aggregate. In comparison to the benchmark model, the central qualitative results remain valid.

Now young low-skilled individuals benefit more from the SI model than before. While their aggregated long-run welfare was at 0.77, it is now at 1.42. A positive increase is also observed in the age groups of 20-24 and 10-14 years. Consequently, aggregate welfare decreases less than before, as the negative effects of the older generations are offset by the positive effects of the younger ones.

In the transition to the CI model, older high-skilled individuals now benefit from their better health, resulting in positive changes in welfare. However, younger high-skilled individuals are more negatively affected by this reform. This is because their expected health care costs are lower than those of low-skilled individuals, and the redistribution is unfavorable for them. On the other hand, low-skilled individuals benefit more from the reduced health care contributions than before. As a result, the overall welfare in this simulation is higher than in the respective benchmark simulation.

The SP model favours younger low-skilled individuals more strongly than before. Hence, aggregate welfare further increases compared to the benchmark, even though high-skilled young individuals are worse off. The same applies to the CP model, where in addition to the SP model, low-skilled individuals benefit from a greater redistribution from the healthier high-skilled individuals. The transition to the PHI is now less negative because low- skilled are less hurt and even experience welfare gains in the long run.

Table 17: Welfare consequences of the considered reform models

	SI		CI		SP		CP		PP	
age	LS	HS	LS	HS	LS	HS	LS	HS	LS	HS
95-99	-2.55	-0.05	0.20	0.00	-4.66	1.69	-4.00	1.72	-0.11	-0.10
75-79	-4.38	0.32	0.61	0.05	-3.89	4.01	-4.14	4.07	1.02	0.25
55-59	-3.08	-0.03	0.99	0.17	0.75	2.77	-3.26	2.80	2.92	1.05
35-39	-1.56	-0.08	1.59	0.04	2.51	1.70	1.42	1.57	5.34	0.81
20-24	-0.53	0.12	2.01	-0.09	4.30	1.87	3.29	1.69	6.83	0.37
10-14	0.80	0.58	2.63	-5.02	4.97	3.20	5.22	2.99	-17.61	-0.03
0-4	0.97	0.77	2.99	-4.96	5.64	3.80	6.05	3.59	-15.63	-0.09
Longrun	1.42	1.17	6.11	-4.26	2.51	4.54	8.98	4.79	1.78	3.19
$\sum$	-0.19		0.7		2.02		2.68		-0.7	

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