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Sick Pay Policies and the Socioeconomic Gradient in Health and Welfare

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November 13, 2025

Abstract. Sick pay compensates for income loss during illness. However, it may distort labor supply by affecting gross wages if paid by employers and net wages if financed by social insurance contributions. We develop a dynamic general equilibrium model with endogenous, biologically founded health and aging in an education-stratified society to study how the level and financing of sick pay affect the socioeconomic health gradient, income inequality, life expectancy, and welfare. Our analysis shows that reducing the sick pay replacement rate would significantly raise distributional disparities in income and health in Germany. We also show that the individually preferred sick pay replacement rate decreases with the level of educational attainment and that most individuals prefer employer-funded sick pay over public financing.

Keywords: Health deficit accumulation; Sick pay; Social insurance; Socioeconomic health gradient; Welfare.

JEL: H51, I14, I18.

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1. INTRODUCTION

Sick pay is income provided to employees who are unable to work due to illness or injury that impairs the ability to work. It is a standard component of labor protection in most OECD and G20 countries, provided either as employer-paid sick leave or through publicly funded social insurance schemes (Raub et al., 2018).¹ Both the amount of sick pay and the way it is financed are subjects of intensive policy debates. For instance, the employers’ association in Germany recently launched a widely received campaign to limit the sick pay replacement rate and the weight of employer-based sick pay finance.²

A well-known fact from the health economic literature is that there are substantial differences in morbidity and therefore in the frequency and duration of illness when people are grouped by education (e.g. Case and Deaton, 2017; Murtin et al. 2022), occupation (e.g. Banks et al., 2006), or income (e.g. Chetty et al., 2016). Sick pay can therefore fulfill a redistributive function – for instance, when it is publicly financed with income-based contributions. It can also influence individuals’ health-related spending behavior, thereby affecting overall health inequality.

To date, no systematic research has examined how sick pay institutions affect income inequality, the socioeconomic health gradient, life expectancy, or overall welfare. This paper aims to fill this gap. We set up a multi-period overlapping generations model of an educationally stratified society, in which the educational groups differ in their ability to earn income and in their health risk to examine the heterogeneous income, health, and welfare effects of sick pay policies in general equilibrium.

Importantly, we distinguish between chronic health deficits and events of acute illness. Illness leads to absenteeism from work and reduces enjoyable leisure time. As described in the medical and gerontological literature, individuals develop chronic health deficits in a self-productive way, which means that existing health deficits are conducive to the development of further deficits. We analyze the dynamic interaction between health conditions: on the one hand, severe illness leads to the development of further health deficits, for instance, capturing inflammatory responses in vascular, molecular, and neural systems (“inflammaging”); on the other hand, the number of existing health deficits influences the probability that health shocks – such as infections – lead to severe illness, capturing aging of the immune system (“immunosenescence”). This means that the duration of

¹One exception is South Korea. Also in Japan, sick pay is not obligatory, although some firms are granting it. In the United States, sick pay has been introduced some years ago in several states and cities but is far from being universal (Pichler and Ziebarth, 2024).

²See BDA (2025) for the position of the employers’ association in Germany.

illness per time unit—for example, the number of sick days per year—depends positively on the number of pre-existing health deficits. Mortality risk depends on accumulated health deficits rather than chronological age.

Health care spending can shorten the duration of illness and therewith the development of new chronic health deficits. Health care is covered to some degree by the public health care system and can be supplemented by private health expenditure. Sick pay is either financed by the public health care system or by private employers. Individual contributions to the public health care system are proportional to gross earnings. Thus, if sick pay is financed by the public health care system, more generous sick pay increases the health insurance contribution rate and distorts labor supply beyond the already existing distortions caused by public health care finance, the public pension system, and progressive income taxation. Alternatively to publicly financed sick pay, we consider employer-paid sick leave, which distorts marginal production costs and therefore affects gross equilibrium wages. It thus impacts labor supply and welfare differently than publicly financed sick pay.

Under both forms of financing, sick pay leads to an equity-efficiency trade-off. On the one hand, sick pay has a redistributive effect due to socioeconomic differences in health status. On the other hand, sick pay finance distorts labor supply. In addition, however, sick pay increases sick people's disposable income, which they can use for health investments that supplement public health care. These intricate interactions and countervailing mechanisms imply that the distributional outcomes and welfare effects of sick pay are generally complex and *a priori* unknown. Here, we estimate them using a calibrated dynamic equilibrium model.

We calibrate our model to Germany. Germany is an interesting case because it has a comprehensive social security system that includes a publicly financed pay-as-you-go system, the possibility of private annuity savings, a compulsory health care system, and sick pay institutions. Employers pay 100% of earnings during sick leave for the first six weeks of illness (from day one) before the public health care system takes over and compensates 70% of earnings.³ Only about 5% of workers are absent from work for more than six weeks annually (i.e. sick pay is financed by employers for 95%) and less than 2% for more than 100 days (Puhani and Sonderhof, 2010). We examine the effects of reducing employer-based sick pay generosity on the net wage rate, life expectancy, as well as the average level and distribution of labor supply, income, health spending, sick time, and welfare. We also show how the results change when sick pay is (at least partially) financed by the public health care system and derive the consequences for the health contribution rate. Finally, we

³The maximum duration of sick pay is 78 weeks within three years for the same illness. See <https://www.bundesgesundheitsministerium.de/krankengeld.html>, retrieved on April 22, 2025.

examine the sensitivity of results when there is a cap on reimbursed income while sick and when low-skilled workers are hand-to-mouth consumers who do not save. We also examine the role of the generosity of public health care coverage and disability benefits.

Our analysis shows that reducing the sick pay replacement rate in Germany would significantly raise distributional disparities in income and health. Moreover, it raises private health expenditure, particularly of high-skilled individuals, and thus slightly increases average life expectancy. If financed by employers, lowering sick pay generosity also raises the equilibrium wage rate.

Our results reveal an important distributional conflict: while low-income workers prefer full sick pay under both financing schemes, high-income workers wish to abandon sick pay. Middle-income workers prefer at least partial compensation for the labor income lost during illness.

Moreover, we find that the financing scheme of sick pay in Germany, which basically is employer-based, is largely optimal for most households, conditional on the existence of full sick pay. A cap on sick payments that is binding for high-skilled individuals would be preferred by low- and middle-income workers, whereas high-income earners would lose. With such a sick pay cap, middle-income earners would prefer a higher sick pay replacement rate than without, as wage distortions would be lower, and they would still prefer an employer-based financing scheme.

Finally, we show that particularly hand-to-mouth consumers at mid-life would suffer from reduced sick pay generosity and that lower public health care spending would raise the loss for low-skilled workers of abandoning sick pay. Our results are robust to introducing disability benefits.

The paper is structured as follows. Section 2 presents related literature. Section 3 sets up the model and discusses its features. Section 4 lays out the calibration strategy. Section 5 provides the numerical analysis of our research questions. Section 6 discusses the main results by introducing a cap on sick pay, low-skilled hand-to-mouth consumers, and lower public health care spending compared to the benchmark model. The last section concludes.

2. RELATED LITERATURE

In terms of modeling, we build on Cropper's (1977) idea that the likelihood of acute illness depends on an individual's current health status. In addition, we also capture the feedback effect of illness on health status. In contrast to Cropper (1977), who measures health status by a latent health capital stock, as in Grossman (1972), we measure health status by observable health deficits, as in Dalggaard and Strulik (2014). More precisely, we capture the health status using the frailty index, which is a person's relative number of aging-related illnesses and functional limitations from a large number of potential health deficits. The frailty index was developed by Mitnitski et al. (2001)

and has since been used in countless studies in medical science, gerontology, and, more recently, in economics (see Searle et al., 2008, for a methodological foundation; Howlett et al., 2021, for a recent survey of applications; and Strulik, 2023, for an introduction for economists). The frailty index predicts mortality at the individual level well, outperforming not only chronological age as a predictor but also other measures of health and aging such as biomarkers and biological clocks constructed from epigenetic information (Kim et al., 2017; Ji, Jazwinski, and Kim, 2021) and self-reported health status (Hosseini et al., 2022). Moreover, the literature has established as a robust result an exponential increase of the frailty index with age at a rate of 2 to 4 percent per year (e.g. Mitnitski et al., 2002a; Mitnitski and Rockwood, 2016; Abeliansky and Strulik, 2018; Abeliansky et al., 2020). Hosseini et al. (2022) highlight that the health deficit accumulation process depends on socioeconomic background. Russo et al. (2014) document large differences in the frailty index at age 55 according to race and ethnicity in the U.S. that explain a considerable share of life expectancy gaps.

The health deficit model of Dalgaard and Strulik (2014) integrated the frailty index as an endogenous measure of individual health status into life cycle economics by allowing the process of health deficit accumulation to depend on health spending decisions. This framework has now been used to discuss various problems in health economics. Recently, Strulik and Grossmann (2024, 2025) extended the model to examine the interaction between chronic health deficits and infections. Here we integrate and adapt the interaction process between acute diseases and chronic health deficits, for the first time, in a macroeconomic context. The health deficit approach has mostly been applied to single-agent frameworks (see Grossmann, 2023, for a brief overview). An exception is Grossmann et al. (2024) who studied the role of occupational health differences for the public pension system; however, without allowing for health investments, sick pay, and infections. Here, we examine for the first time the role of illness in labor supply decisions and the institution of sick pay in the health deficit framework.

Our paper is also related to a small but growing literature that uses calibrated, intertemporal models to investigate the relationship between health inequality and other socioeconomic indicators (e.g. De Nardi et al., 2010; Hugonnier et al., 2013; Capatina, 2015; Mahler and Yum, 2024; Hosseini et al., 2025; Ozkan, 2025). Our paper differs from previous contributions in several important ways.

First, the previous macro-health literature has not considered sick pay policies. Second, much of the existing literature introduces or amplifies heterogeneity through exogenous health shocks. While this approach is well-suited to the questions those studies address, our analysis centers on

educational differences, abstracting from within-group heterogeneity. This focus allows us to investigate the fundamental distributional effects of behavioral responses to sick pay policies, driven by productivity differences across workers and systematic health disparities arising from endogenous, path-dependent accumulation of health deficits rather than by exogenous shocks.⁴ Methodologically closer to our study, Frankovic and Kuhn (2019) analyze life expectancy gaps across education groups within an overlapping-generations framework, where individual income positively influences healthcare utilization and education shapes the effectiveness of medical advancements in reducing mortality. Although mortality risk also depends on health investments, their analysis abstracts from the path-dependence of health status and does not account for sick pay policies.

Third, we advance the macro-health literature by distinguishing and linking health deficits and illnesses, a distinction that is particularly relevant for examining the long-term health impacts of sick pay.

The previous, mostly empirical and microeconomic sick pay literature has focused on the short-run effects of sick pay reforms on absenteeism from work and “contagious presenteeism”—workers showing up sick and potentially infecting others (e.g. Gilleskie, 1998; Henrekson and Persson, 2004; Puhani and Sonderhof, 2010; Ziebarth and Karlsson, 2010, 2014; Ahn and Yelowitz, 2015; Pichler and Ziebarth, 2017; Callison and Pesko, 2022). By contrast, we examine the effects of sick pay on the evolution of individual health deficits over time, which is endogenous to sick time and thus endogenous to both public and private health spending. We take into account that, on the one hand, more generous sick pay can weaken the incentives for private health spending because it reduces the loss of income due to illness, but, on the other hand, it plays a redistributive role. Our quantitative framework abstracts, however, from intentional non-medical absenteeism (fraudulent sick leave) and contagious presenteeism. We do so for two reasons. First, the empirical literature finds at most moderate and heterogeneous moral-hazard responses to paid sick-leave reforms, with effects concentrated in short spells. For instance, the high-quality study for Germany by Pichler and Ziebarth (2017) shows that the annual aggregated labor supply elasticity for contagious diseases is close to zero, due to counteracting micro effects. Second, our focus is on the long-term, general equilibrium effects of behavioral responses from sick pay reform that drive distributional outcomes

⁴Hosseini et al. (2025) also use the frailty index for measuring health status, but do not model health investment decisions. They gauge the role of health inequality for the variance of lifetime earnings. Mahler and Yum (2024) allow for preventive health spending decisions, but treat health as a binary variable rather than modeling the accumulation of health deficits. Their model explains the substantial wealth gap between healthy and unhealthy individuals for all age groups in the U.S. and Germany.

by education; these channels are likely to be first order for long-term health, while dishonesty or contagious presenteeism in the case of mild infections are second order.

3. THE MODEL

The model features stochastic and health-dependent mortality of heterogeneous individuals in multi-period overlapping generations. Time is discrete and indexed by t . Each period, a unit mass of newly born individuals enters the labor market. There are J groups of individuals that are indexed by j and differ with respect to their human capital endowment in increasing order. The population share of education group j is denoted by θ^j , with $\sum_{j=1}^J \theta^j = 1$.

The public health care system finances health care expenditures for sick individuals; the reimbursed amount depends on the severity of the illness. Individuals may supplement public health spending by private health expenditure. Importantly, individuals receive sick pay, i.e. continued payment of wages while absent from work, which is either paid by employers or the public health care system. Because sick pay is mostly relevant at working age, we also model a retirement period where individuals receive income from a public pay-as-you-go pension system. Additionally, individuals save in actuarially fair annuities (Yaari, 1965).

Labor supply is endogenous and distorted by redistributive earnings taxation, as well as by the contributions to public health insurance and the public pension system.

3.1. Illness and Sick Time. Individuals experience health shocks. These shocks happen permanently and come in different sizes. Following Mitnitski et al. (2013), who provide a biological foundation on health deficit accumulation, we can think of these shocks as “environmental challenges imposed by stresses on the organism”, like “individual exposures to perturbations in the climate, solar activity, weather, pollution, stressful social events, disease outbreaks, etc.” (p. 711). Most of these shocks are so small that the body takes care of them immediately. Only if shocks are large enough, they affect the individual perceptibly and the individual feels sick. To fix ideas, suppose that, at any instant, individuals are hit by a health shock of a certain size. The size of a shock is denoted by \mathfrak{s} and Pareto-distributed in $[1, \infty)$; that is, the probability density function of \mathfrak{s} is $f(\mathfrak{s}) = \gamma \cdot \mathfrak{s}^{-(\gamma+1)}$, $\gamma > 0$. Thus, the probability that \mathfrak{s} exceeds some threshold level $\bar{\mathfrak{s}}$ is given by $\mathcal{P}(\bar{\mathfrak{s}}) = \int_{\bar{\mathfrak{s}}}^{\infty} f(\mathfrak{s})d\mathfrak{s} = \bar{\mathfrak{s}}^{-\gamma}$, which is the probability that an individual becomes sick.

The threshold at which the shocks cause illness depends on health status (Cropper, 1977) which in our model is conceptualized by the frailty of the body. For example, a person with pre-conditions is more likely to develop severe illness after exposure to the influenza virus or SARS-CoV-2 (leading

to COVID-19). More health deficits also raise the likelihood of experiencing a health shock leading to a stroke or heart attack. Moreover, frail persons are more likely to have a severe accident at home (e.g. falling down the stairs). As explained in the introduction, the frailty index is a well-established metric in medical science that calculates the proportion of bodily impairments out of a long list of potential health deficits. The list of potential health deficits in gerontological studies on frailty typically includes, for instance, the difficulty of performing daily routines (e.g. preparing meals, housework, walking in the house, bathing, lifting, shopping), high blood pressure, limited grip and shoulder strength, high body mass index, and chronic health conditions (e.g. congestive heart failure, diabetes, chronic lung disease). Health deficits are also closely related to immunosenescence, i.e. the aging of the immune system (e.g. Santoro, Bientinesi, and Monti, 2021).

Formally, we assume that the threshold health shock level of education group j is decreasing in the frailty index $d \in [0, 1]$, $\bar{\mathfrak{s}}^j = \tilde{\mathfrak{s}}^j(d)$, with $(\tilde{\mathfrak{s}}^j)'(d) < 0$ and $\tilde{\mathfrak{s}}^j(0) = \infty$. This means that individuals without any health deficits ($d = 0$) never become sick. We rule out this case by assuming that health deficits are non-zero in the beginning of economic life. By allowing $\tilde{\mathfrak{s}}^j(d)$ to be group-specific, we capture socioeconomic differences in preventive behavior. For instance, vaccination rates strongly differ between education groups (e.g. Endrich, Blank and Szucs, 2009; Bartig et al., 2023) which means that for given pre-existing health deficits, more educated individuals have a lower probability of getting a severe infection.

Cropper (1977) conceptualizes $\mathcal{P}(\bar{\mathfrak{s}})$ as the share of sick time in a period of unit length for a population with threshold shock size $\bar{\mathfrak{s}}$ (without distinguishing groups). We adopt this interpretation and assume that health care spending reduces sick time, which in the absence of health spending is thus given by $z^j(d) \equiv \mathcal{P}(\tilde{\mathfrak{s}}^j(d))$. $z^j(d)$ also measures the severity of illness of a member from education group j with health deficits d in a given period. We measure health expenditure in terms of final goods, which means that the price of health inputs is normalized to one since the final good is the numeraire good. We denote by g^j the health spending covered by public health insurance for members of group j and by h^j the private health spending level (a catch-all variable including private health insurance contributions, co-payments, and other out-of-pocket expenditure). Both forms of health spending are, potentially, imperfectly substitutable such that sick time of an individual from group j , Z^j , is given by:

$$Z^j(g^j, h^j, d^j) = z^j(d^j) - \Gamma(g^j, h^j), \quad (1)$$

with partial derivatives $\Gamma_g > 0$, $\Gamma_h > 0$, $\Gamma_{gg} \leq 0$, $\Gamma_{hh} \leq 0$, $\Gamma_{gh} \geq 0$, and $\Gamma(0,0) = 0$; thus, $Z^j(0,0,d) = z^j(d)$.

3.2. Illness and Health Deficit Accumulation. Illness influences the further development of health deficits and the course of aging. For example, health shocks leading to cardiovascular illness remain lifelong conditions with potentially increasing complications even after treatment (e.g. insertion of stents into affected coronary arteries to treat atherosclerosis). The link from sick time to health deficits is also evident from virus infections like COVID-19 that could lead to prolonged fatigue states, among many other Long Covid symptoms (Bowe et al., 2023), potentially associated with an increase in blood pressure and body mass index due to reduced activity. Moreover, recent evidence strongly suggests that COVID-19 can accelerate biological aging in vascular, molecular, and neural systems.⁵ More generally, infections can lead to inflammaging, i.e. permanent organ damage or the development of persistent inflammatory conditions, which can cause a variety of chronic diseases. For example, inflammaging and immunosenescence are suspected to be related to cardiovascular disease, lung and kidney disease, some cancers, rheumatoid arthritis, cognitive disability, chronic obstructive pulmonary disease (COPD), osteoporosis, periodontitis, sarcopenia, type 2 diabetes, as well as Alzheimer and Parkinson disease (e.g. Franceschi and Campisi, 2014; Bektas et al., 2018; Franceschi et al., 2018). As a final example for the link from sick time to health deficits as measured by the frailty index, the remaining pain after orthopedic leg surgeries may reduce the motivation or ability to walk, limiting physical strength in the long term.

These features are formally represented by the law of motion for health deficits. For individuals from group j born in period v , i.e. from cohort (vintage) v , it is given by:

$$d_{v,t+1}^j - d_{v,t}^j = \mu d_{v,t}^j + \varsigma \cdot Z^j(g_{v,t}^j, h_{v,t}^j, d_{v,t}^j), \quad (2)$$

with initial condition $d_{v,v}^j = \underline{d} > 0$ for all cohorts v and all educational groups $j \in \{1, \dots, J\}$. The parameter $\mu > 0$ reflects the rate of biological aging, measured by health deficit accumulation, that occurs even in the absence of illness. For instance, people develop high blood pressure without feeling ill. As another example, diabetes promotes new chronic diseases, despite insulin treatment. In other words, health deficits are self-productive such that existing health deficits lead to the development of further deficits (Mitnitski et al., 2002a), irrespective of acute illness. The parameter

⁵For instance, COVID-19 has been associated with increased arterial stiffness post-infection, particularly for women, increasing the likelihood of heart attacks and strokes (Bruno et al., 2025), faster epigenetic aging of cells, tissues, and organs, as measured by DNA methylation clocks (Calzari, 2024), and accelerated brain changes and measurable deficits in memory and attention (Hampshire et al., 2024; Mohammadi-Nejad et al., 2025).

$\varsigma > 0$ determines how sick time due to acute illness affects health deficit accumulation. Illness reinforces the self-productive nature of health deficits such that treatments that reduce sick time also slow down health deficit accumulation. Eqs. (1) and (2) capture the two-sided interaction of acute illnesses and chronic conditions: greater frailty leads to more severe illness, which in turn promotes the accumulation of health deficits.

3.3. Health Deficits and Mortality. As explained in the Introduction, the frailty index has high predictive power for the event of death at the individual level and for mortality at the group level. Specifically, it has been shown that there exists a power law association between the frailty index and the mortality rate with a precisely estimated frailty elasticity of mortality (Mitnitski et al., 2002b; Dalgaard, Hansen, and Strulik, 2022). In our notation, this means that the mortality rate of an individual from group j and cohort v at age $t - v$, $m_{v,t}^j$, is an increasing and convex function of the frailty index $d_{v,t}^j$ of the individual at that age, $m_{v,t}^j = \tilde{m}(d_{v,t}^j)$ and given by

$$\tilde{m}(d_{v,t}^j) = \begin{cases} \kappa(d_{v,t}^j)^\psi & \text{for } d_{v,t}^j < (1/\kappa)^{1/\psi}, \\ 1 & \text{otherwise,} \end{cases} \quad (3)$$

$\kappa > 0$, $\psi > 0$. In regression analysis, Dalgaard et al. (2022) find a high coefficient of determination for this functional form ($R^2 = 0.98$). Let $S_{v,t}^j$ be the unconditional survival probability of an individual from group j and cohort v at time t , where $S_{v,v}^j = 1$ for all v . As $m_{v,t}^j = -\frac{S_{v,t+1}^j - S_{v,t}^j}{S_{v,t}^j}$ by definition, the survival probability evolves as

$$S_{v,t+1}^j = (1 - \tilde{m}(d_{v,t}^j))S_{v,t}^j. \quad (4)$$

3.4. Preferences and Endowments. Normalizing utility when dead to zero, individuals from cohort v face expected lifetime utility

$$U_v^j = \sum_{t=v}^{v+T-1} \beta^{t-v} S_{v,t}^j u(c_{v,t}^j, l_{v,t}^j), \quad (5)$$

where u is the instantaneous utility function, $c_{v,t}^j$ is consumption of a homogeneous (numeraire) good, $l_{v,t}^j$ is leisure time, $T > 0$ is the maximum length of life, and $\beta \in (0, 1]$ is the discount factor of future utility. Similarly to French (2005), we specify:

$$u(c, l) = \frac{c^{1-\sigma} - 1}{1 - \sigma} + \varrho \frac{l^{1-\eta} - 1}{1 - \eta} + \bar{u}, \quad (6)$$

where $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution (IES), $\eta > 0$ determines the elasticity of labor supply, and $\varrho > 0$ determines the marginal rate of substitution between consumption and leisure. The term $\bar{u} > 0$ follows Hall and Jones (2007) and ensures that instantaneous utility is for all individuals and all times positive in the calibrated model. We calibrate \bar{u} to a widely accepted value of life.

In each period, individuals have one unit of time available, which can be assigned to labor supply and leisure time. Illness shortens the effective time for both activities. By reducing leisure time, illness has a direct impact on utility.⁶ Denoting the contractually fixed labor supply by ℓ and recalling that sick time is denoted by Z , enjoyable leisure time is given by $l = (1 - \ell)(1 - Z)$ and effective working hours are $(1 - Z)\ell$. As an illustrative example (that roughly matches recent data for Germany), suppose the unit time endowment is 6000 hours per year (roughly equivalent to 16 hours per day), which a fully healthy person can assign for labor supply and leisure. Let us also assume that the contractually agreed working time (actual work plus sick time) is 1500 hours ($\ell = 0.25$) and the individual is sick 10% of the time ($Z = 0.1$). Then, on average, the individual works $6000(1 - Z)\ell = 1350$ hours per year, is absent from work for $6000Z\ell = 150$ hours, and enjoys leisure time of $6000(1 - \ell)(1 - Z) = 4050$ hours.

Illness can also have an indirect impact on utility by reducing effective working hours for a given contractually fixed labor supply and therewith earnings and consumption. Individuals from group j are endowed with human capital a^j , which means that they supply $a^j \cdot (1 - Z^j(g_{v,t}^j, h_{v,t}^j, d_{v,t}^j))\ell_{v,t}^j$ efficiency units of labor and receive earnings $W_t^j = w_t a^j$ per unit of labor worked in period t (“hourly wage”), where w_t is the wage per unit of human capital in period t . We order $a^1 < \dots < a^J$. As described next, employers or the public health care system may compensate part of the contractual earnings during sick leave.

3.5. Policy Instruments. We assume that labor earnings, including sick payments, are taxed for redistributive purposes and for financing the health and pension system. The three activities are governed by three separate budgets, which are balanced each period. Retirees also contribute to the public health care system. For simplicity, capital income is not taxed. The government budget constraints are derived in Online Appendix A.1.2.

3.5.1. Health System. The public health care system covers health care expenditure and some fraction $1 - \phi$ of sick pay, whereas a fraction $\phi \in [0, 1]$ of sick pay is paid by employers. Public

⁶This reasoning is similar to French (2005) who posits that there are two states of health, good and bad, and that bad health reduces leisure time. In our framework, health status is not binary but measured by two continuous and interrelated variables, sick time and the frailty index.

health care spent on an individual from group j , g^j , is an increasing and strictly concave function \mathfrak{g} of the severity of illness, $z^j(d)$:

$$g^j = \mathfrak{g}(z^j(d)) \equiv \tilde{g}^j(d). \quad (7)$$

Recall that individuals from any group j can supplement public health care with private health care spending, h^j . Individual contributions to the public health care system are proportional to earnings (labor income and pension benefits). The contribution rate, τ_t^g , endogenously adjusts to ensure a balanced government health budget each period.

Gross sick pay per unit of absent time for members of education group j is a time-invariant fraction $s^j \in (0, 1]$ of gross hourly earnings when not being sick (i.e. contractual earnings), which we refer to as “sick pay replacement rate”. For most of the analysis, we assume $s^j = s$ for all j , except for the case where we introduce a maximum amount of sick pay that constrains sick payments of the most productive education group (“sick pay cap”).⁷ In this case, $s^J < s^{J-1} = \dots = s^1$.

Recalling that an individual works $(1 - Z)\ell$ time units and is absent $Z\ell$ time units per period, gross earnings in period t of a member of group j born in v are given by:

$$\begin{aligned} y_{v,t}^j &= W_t^j \cdot \left(1 - Z^j(g_{v,t}^j, h_{v,t}^j, d_{v,t}^j)\right) \ell_{v,t}^j + s^j W_t^j \cdot Z^j(g_{v,t}^j, h_{v,t}^j, d_{v,t}^j) \ell_{v,t}^j \\ &= \left(1 - \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j)(1 - s^j)\right) w_t a^j \ell_{v,t}^j \equiv \tilde{y}^j(\ell_{v,t}^j, h_{v,t}^j, d_{v,t}^j; w_t, s^j), \end{aligned} \quad (8)$$

where, for the second equation, we used $W_t^j = w_t a^j$ and $g^j = \tilde{g}^j(d)$, and defined $\tilde{Z}^j(h, d) \equiv Z^j(\tilde{g}^j(d), h, d)$. For given labor supply, gross earnings rise with the level of private health spending due to reduced sick time ($\tilde{Z}_h^j < 0$). Also noteworthy, our calibrated model implies that $\tilde{Z}_d^j = Z_g^j(\tilde{g}^j)' + Z_d^j > 0$, such that gross earnings decrease with higher frailty despite the positive relationship between public health spending and health deficits, $g^j = \tilde{g}^j(d)$. In sum, we have $\tilde{y}_h^j > 0$ and $\tilde{y}_d^j < 0$. For given labor supply, also leisure time,

$$l_{v,t}^j = (1 - \ell_{v,t}^j)(1 - \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j)), \quad (9)$$

is increasing in private health spending and decreasing in frailty.

3.5.2. Pension System. The government runs a pay-as-you-go (PAYG) pension system that is financed by proportional contributions on earnings of employees, including sick pay benefits. Annual pension benefits for retirees are proportional to their contributions during working life, where the

⁷For simplicity, as it is not relevant for our calibrated model that captures group-averages, we do not model a maximum duration of sick payment (typically, 6 months or more in OECD countries; see Raub et al., 2018).

factor of proportionality (the “conversion rate”) is not differentiated across groups. This characteristic feature of the German pension system is usually referred to as “equivalence principle” (Eggert, 2021).⁸

For simplicity, we assume that all individuals retire at a statutory retirement age \bar{R} . After retirement, pension benefits of members from cohort v in group j are given by

$$B_{v,t}^j = \tilde{B}(P_{v,t}^j) \equiv \begin{cases} 0 & \text{for } v \leq t \leq v + \bar{R} - 1, \\ b_v P_{v,t}^j & \text{for } v + \bar{R} \leq t \leq v + T - 1, \end{cases} \quad (10)$$

where $P_{v,t}^j$ is the sum of the contributions (“pension wealth”) of a member of cohort v up to period t and b_v is the conversion rate for cohort v ; that is, we assume that conversion rates are not age-dependent, capturing political constraints preventing that demographic change leads to cutting pension benefits of already retired workers (Grossmann et al., 2024). Recall that retirees have to contribute to the health system, i.e. pension benefits in period t are taxed at rate τ_t^g .

The PAYG pension budget is balanced in each period. For concreteness, we assume that the pension contribution rate is time-invariant and denoted by $\tau^P \in (0, 1)$. That is, any changes in earnings and life expectancy in response to changes in sick pay replacement rates and the employer share of sick pay finance impact the conversion rate(s). Given the initial condition $P_{v,v}^j = 0$, pension wealth accumulates according to

$$P_{v,t+1}^j = P_{v,t}^j + \tau^P \tilde{y}^j(\ell_{v,t}^j, h_{v,t}^j, d_{v,t}^j; w_t, s^j). \quad (11)$$

3.5.3. Earnings Taxation. For a meaningful welfare analysis of the social insurance system, it is important to capture that contributions to the public pension system and the public health care system distort labor supply decisions beyond general taxes on earnings. We therefore assume that gross earnings, including sick pay, are taxed at a constant marginal tax rate $\tau^w \in (0, 1)$, in addition to social security contributions.⁹

The tax revenue is used exclusively for redistributive purposes, i.e. to finance a uniform lump sum transfer \mathcal{T} to the workers in the same period (“earned income tax credit”). The average tax rate is thus increasing in earnings. This affine-linear tax schedule is a simple device to capture the

⁸The term is misleading, however, since life expectancy and thus the duration of benefit payments differ across occupational groups. For empirical evidence, see Haan and Prowse (2014), and Haan, Kemptner, and Luthen (2020). Also see Grossmann et al. (2024), for an analysis of distributional implications of a reform towards a fair pension system.

⁹We implicitly assume that social security contributions are not deducted from the tax base. This enables us to use the tax wedge data of the OECD (<https://www.oecd.org/tax/tax-policy/taxing-wages-germany.pdf>) to calibrate the behaviorally relevant marginal tax rate, following Grossmann and Strulik (2019).

progressivity of income taxation. We refrain from modeling taxation for other purposes, such as public goods provision. Moreover, we assume that pension benefits are not taxed, in order to avoid that our results are contaminated by second-order effects: taxation of pension benefits would either introduce redistribution within the group of retirees if paid out to retirees or imply a redistribution from old to young if tax revenues were redistributed as earned income tax credit.

3.6. Production Technology and Factor Prices. There is an exogenous world market interest rate, \bar{r} , and a perfect annuity market with group-specific, actuarially fair insurance within a cohort (Yaari, 1965). The interest factor of a group member j of cohort v on financial assets between date t and $t + 1$ then reads as

$$1 + r_{v,t}^j = \frac{1 + \bar{r}}{1 - m_{v,t-1}^j}. \quad (12)$$

Actuarially fair insurance implies that $r_{v,t}^j$ increases in the group-specific mortality rate.

In period t , the final (numeraire) good is produced in perfect competition according to

$$Y_t = (K_t)^\alpha (AL_t)^{1-\alpha}, \quad (13)$$

$\alpha \in (0, 1)$, where K_t denotes the physical capital input, L_t denotes the effective amount of labor used in production, and $A > 0$ is a (time-invariant) productivity parameter (i.e. we abstract from long run economic growth). Physical capital depreciates at a constant rate $\delta > 0$ such that the user costs of capital are $\bar{r} + \delta$. Let $L_t^{C,j}$ denote the total amount of contractually employed labor from education group j , $L_t^{N,j}$ the corresponding amount of labor that is absent from work due to illness, and $\bar{Z}_t^j \equiv L_t^{N,j} / L_t^{C,j}$ the fraction of contractual labor units from group j that is absent in t . The representative firm takes fractions \bar{Z}_t^j , $j \in \{1, \dots, J\}$, as given,¹⁰ thereby accounting for the fact that extending contractual employment $L_t^{C,j}$ proportionally implies additional sick pay costs of the amount $\phi s^j L_t^{N,j} = \phi s^j \bar{Z}_t^j L_t^{C,j}$. (Recall that gross sick pay per unit of absent time for members of group j equals a fraction s^j of earnings when not being sick and employers cover a fraction ϕ of total sick pay as paid sick leave.) By definition, the effective employment level is $L_t = \sum_j (L_t^{C,j} - L_t^{N,j})$.

In Online Appendix A.1.1, we show that the (perfect foresight) equilibrium wage rate is given by

$$w_t = \Psi \cdot \left(1 + \frac{\phi}{L_t} \sum_{j=1}^J s^j L_t^{N,j} \right)^{-1}, \quad \text{where } \Psi \equiv (1 - \alpha) \left(\frac{\alpha}{\bar{r} + \delta} \right)^{\frac{\alpha}{1-\alpha}} A, \quad (14)$$

¹⁰We abstract from competition for healthy workers by assuming that firms cannot observe health status and government regulation rules out discriminating older workers.

$$L_t^{N,j} = \theta^j a^j \sum_{v=t-\bar{R}+1}^t S_{v,t}^j \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j) \ell_{v,t}^j, \quad (15)$$

and

$$L_t = \sum_{j=1}^J \theta^j a^j \sum_{v=t-\bar{R}+1}^t S_{v,t}^j (1 - \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j)) \ell_{v,t}^j. \quad (16)$$

According to (14), when employers do not have sick pay costs ($\phi = 0$), the wage rate is time-invariant and independent of public policy, $w_t = \Psi$. Paid sick leave depresses the wage rate; that is, $w_t < \Psi$ for $\phi > 0$. For given contractual labor inputs and sick times, more generous sick pay for some group (a higher s^j) increases marginal costs of firms whenever $\phi > 0$, in turn, depressing the wage rate. The effect is higher, the higher the share of sick pay borne by firms, ϕ . This potentially distorts labor supply as well. Finally, with paid sick leave ($\phi > 0$), health investments positively affect the equilibrium wage rate for given contractual labor supply, according to (14)–(16). This is because a healthier workforce lowers marginal production costs by reducing sick time, if there is paid sick leave.

3.7. Individual Budget Constraint. Financial assets of group j and cohort v in period t are denoted by $k_{v,t}^j$ and financial wealth accumulates according to

$$k_{v,t+1}^j - k_{v,t}^j = r_{v,t}^j k_{v,t}^j + (1 - \tau_t) y_{v,t}^j + \mathbf{1}_{v,t}(\bar{R}) \cdot \mathcal{T}_{v,t} + (1 - \tau_t^g) B_{v,t}^j - h_{v,t}^j - c_{v,t}^j, \quad (17)$$

where $\tau_t \equiv \tau^w + \tau^P + \tau_t^g$ is the total tax wedge of workers and $\mathbf{1}_{v,t}(\bar{R})$ is an indicator function that takes the value of one if a member of cohort v has an age lower than \bar{R} in period t (i.e. has not retired and thus is eligible for the earned income tax credit) and zero otherwise. At the beginning of economic life, asset holdings are zero, $k_{v,v}^j = 0$, consistent with the absence of a bequest motive. The standard No Ponzi game condition $k_{v,v+T}^j \geq 0$ applies.

3.8. Utility Maximization Problem. Inserting (6) and (9) into (5), we find that individuals from cohort v and education group j control $\{c_{v,t}^j, \ell_{v,t}^j, h_{v,t}^j\}_{t=v}^{v+T-1}$ to maximize lifetime utility

$$\sum_{t=v}^{v+T-1} \beta^{t-v} S_{v,t}^j \left[\frac{(c_{v,t}^j)^{1-\sigma} - 1}{1-\sigma} + \varrho \frac{((1 - \ell_{v,t}^j)(1 - \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j)))^{1-\eta} - 1}{1-\eta} + \bar{u} \right] \quad (18)$$

$$\text{s.t. (2), (4), (11), (17), } B_{v,t}^j = \tilde{B}(P_{v,t}^j), y_{v,t}^j = \tilde{y}^j(\ell_{v,t}^j, h_{v,t}^j, d_{v,t}^j; w_t, s^j), \quad (19)$$

$$k_{v,v+T}^j \geq 0, \ell_{v,t}^j = 0 \text{ for all } t \geq v + \bar{R}, \quad (20)$$

i.e. subject to the accumulation process of state variables $d_{v,t+1}^j$, $S_{v,t+1}^j$, $P_{v,t+1}^j$, $k_{v,t+1}^j$, the pension benefit function, the gross earnings function, the terminal condition for financial assets, and the simplifying behavioral restriction of zero labor supply after retirement. Notably, individuals understand that higher labor supply will raise both their pension benefits and sick pay, but take factor prices w_t and $r_{v,t}^j$ as given.¹¹

3.9. Equilibrium. An equilibrium is reached when the representative final goods producer chooses factor demand to maximize profits by taking the fraction of contractual labor units from each group that is absent from work and factor prices as given, profits in the private annuity market are zero, households maximize expected lifetime utility by taking the health contribution rate, the pension conversion rate, and factor prices as given, and the labor market clears. Moreover, the government budgets for redistributive income taxation, the health system, and the pension system are balanced. We focus on perfect foresight, long-run equilibria. Online Appendix A.1.4 summarizes the dynamic system.

4. CALIBRATION

In order to quantitatively analyze the economics of sick pay, we calibrate the model to the case of Germany. In order to account for heterogeneity in the population, we distinguish three groups ($J = 3$) according to their highest educational attainment: below upper secondary education (group 1), upper secondary education (group 2), and tertiary education (group 3). We calibrate a representative (male) individual from each of these three groups (representing within-group averages) in terms of their rates of health deficit accumulation, mortality rates, sick days, labor supply and leisure, and consumption as well as health behavior. In line with the measurement of health deficits using the frailty index introduced in Section 1 (a person’s relative number of aging-related illnesses and functional limitations from a large number of potential health deficits), we consider health deficits to be in the range $d \in (0, 1)$. Since the frailty index applies for adults, we assume that life starts at the age of 20 such that the educational decision has already been made. In our calibration strategy, we distinguish between externally set parameters and estimated parameters. Externally set parameter values are taken from other (comparable) studies or can be directly observed in the data. Estimated parameters are simultaneously calibrated to fit the response of endogenous variables to moments observed in the data. We numerically solve the model with the relaxation algorithm by Trimborn, Koch, and Steger (2008).

¹¹The first-order conditions and transversality conditions of the optimization problem are relegated to Online Appendix A.1.3.

4.1. Parametrization. We first introduce functional forms for sick time and public health care. We specify the threshold health shock function as $\bar{s}^j = \tilde{s}^j(d) = (\zeta^j)^{-1/\gamma}/d$. Using $z^j(d) = \mathcal{P}(\tilde{s}^j(d))$ and $\mathcal{P}(\bar{s}) = \bar{s}^{-\gamma}$, we obtain $z^j(d) = \zeta^j \cdot d^\gamma$. Group-specific parameter $\zeta^j > 0$ captures socioeconomic differences in the probability of becoming sick for given health deficits and thus, in our model, differences in sick time by education. To calibrate the sick time function $Z^j(g, h, d) = z^j(d) - \Gamma(g, h)$ in (1), we also parameterize that medical treatment reduces sick time by $\Gamma(g, h) = \xi \cdot (g^\epsilon + h^\epsilon)$, $\epsilon \leq 1$, where $\xi > 0$ captures the efficiency of the health technology and $(1 - \epsilon)^{-1}$ the degree of substitutability between publicly financed health input and private health supplement. That is, $\Gamma(g, h)$ is a CES technology with equal weights and a degree of homogeneity equal to ϵ (thus, for $\epsilon < 1$, there are decreasing returns to scale). Hence, according to (1), sick time after treatment expenses (g^j, h^j) of a member of group j with health deficits d^j can be written as

$$Z^j(g^j, h^j, d^j) = \zeta^j \cdot (d^j)^\gamma - \xi \cdot [(g^j)^\epsilon + (h^j)^\epsilon], \quad (21)$$

Substituting (21) into (2), health deficits in group j evolve according to

$$d_{v,t+1}^j - d_{v,t}^j = \mu d_{v,t}^j + \varsigma \cdot \left(\zeta^j (d_{v,t}^j)^\gamma - \xi [(g_{v,t}^j)^\epsilon + (h_{v,t}^j)^\epsilon] \right). \quad (22)$$

Health deficit accumulation process (22) is a generalized case of the process in Dalgaard and Strulik (2014), who implicitly assume $\zeta^j = 0$ (neither allowing for acute illness to foster health deficits nor for heterogeneity of individuals in the deficit accumulation process) and $g_{v,t}^j = 0$ (no public health spending).¹²

Public healthcare costs as a function of the severity of illness are given by $\mathbf{g}(z) = G \cdot z^v$, where $G > 0$ is a policy parameter measuring the generosity of the public health care system and $v > 0$ is a curvature parameter relating the severity of illness to public health expenditure. Thus, public health cost as a function of individual health deficits is given by

$$g^j = \mathbf{g}(z^j(d^j)) = G \cdot z^j(d^j)^v = G \cdot (\zeta^j)^v \cdot (d^j)^{\gamma v} = \tilde{g}^j(d^j). \quad (23)$$

Our calibrated model ensures that the duration of illness is, also with treatment, longer in people with more health deficits. To see under which parameter configurations this holds, insert (23) into (21) to obtain

$$\tilde{Z}^j(h, d) = Z^j(\tilde{g}^j(d), h, d) = \zeta^j d^\gamma - \xi [(G(\zeta^j)^v d^{\gamma v})^\epsilon + h^\epsilon]. \quad (24)$$

¹²Moreover, Dalgaard and Strulik (2014) consider a single agent life-cycle model in continuous time to explore the nexus between income and life expectancy rather than a discrete-time general equilibrium model with a social welfare system.

From (24), it is easy to show that $\tilde{Z}_d^j > 0$ (i.e. sick time increases with health deficits) if $(\zeta^j d^\gamma)^{1-\nu\epsilon} > \nu\epsilon\xi G^\epsilon$. In the calibrated model, the condition holds for all $d \in (\underline{d}, 1)$ and all j .

4.2. Externally Set Parameters. In Germany, employers compensate 100% of regular earnings during sick leave up to six weeks (Raub et al., 2018). According to Puhani and Sonderhof (2010), about 95% of workers are sick for less than six weeks. Thus, the benchmark calibration assumes $s^j = 1$ for all j and $\phi = 1$.

For the initial frailty index of individuals (at age 20) we set $\underline{d} = 0.0269$, according to Abeliatsky and Strulik (2018) who estimate the frailty index with data from 10 European countries as a function of age. The value is also in line with Mitnitski et al. (2002a) who find that, on average, Canadian men have roughly one deficit out of 38 potential deficits at the age of 20.

At the production side, we set the capital share to $\alpha = 0.37$ (Feenstra, Inklaar, and Timmer, 2015) and the depreciation rate to $\delta = 0.058$ (Davis and Heathcote, 2005). The world market interest rate is $\bar{r} = 0.05$, which is approximately the average return on assets when assets are weighted by the observed fractions of asset categories in large advanced countries (Jorda et al., 2019).

In the German pension system, pension contributions are proportional to labor income and amount to 18.6% of gross earnings (DRV, 2025). Therefore, we set $\tau^P = 0.186$. For the marginal income tax rate, we follow Grossmann and Strulik (2019) and set $\tau^w = 0.25$. Further, we set population shares of workers with below upper secondary education, upper secondary education, and tertiary education to $\theta^1 = 0.173$, $\theta^2 = 0.476$, and $\theta^3 = 0.351$, respectively, according to OECD (2025a). Moreover, we account for differences in labor income by adjusting the group-specific productivity parameters, a^j , to match relative earnings by educational level. According to OECD (2025b), the earnings premium for upper secondary and tertiary education relative to below upper secondary education amounts to 34.6% and 102.5%, respectively, expressed in full-time equivalents. Normalizing $a^1 = 1$, this implies $a^2 = 1.346$ and $a^3 = 2.025$. We further set $\sigma = 1$, consistent with evidence of an intertemporal elasticity of substitution close to unity (Chetty, 2006). Finally, we assume a (statutory) retirement age of 65, a maximum lifespan of 100 years, and normalize the productivity (scale) parameter in the production function of final output (13) by setting $A = 100$.¹³ Table 1 summarizes the externally set parameter values along with the associated source.

¹³We checked that the scale of the economy is inconsequential for the results. We set $A = 100$ for computational convenience.

TABLE 1. Externally Set Parameters

Parameter	Value	Explanation	Source
$s^1 = s^2 = s^3$	1	sick pay replacement rate	Raub et al. (2018)
ϕ	1	employer share of sick pay	Raub et al. (2018)
$\frac{1}{\sigma}$	1	intertemporal elasticity of substitution	Chetty (2006)
\underline{d}	0.0269	initial deficit level	Abeliansky and Strulik (2018)
α	0.37	capital share	Feenstra et al. (2015)
δ	0.058	depreciation rate	Davis and Heathcote (2005)
\bar{r}	0.05	(real) interest rate	Jorda et al. (2019)
τ^p	0.186	pension contribution rate	DRV (2025)
τ^w	0.25	income tax rate	Grossmann and Strulik (2019)
θ^1	0.173	share of low educational group	OECD (2025a)
θ^2	0.476	share of middle educational group	OECD (2025a)
θ^3	0.351	share of high educational group	OECD (2025a)
a^1	1	productivity of low education group	normalization
a^2	1.346	productivity of middle educational group	OECD (2025b)
a^3	2.025	productivity of high educational group	OECD (2025b)
\bar{R}	65	statutory retirement age	OECD (2019)
T	100	maximum life span	convention
A	100	technological (scale) parameter	normalization

4.3. Calibrated Parameters. Treating health-related variables as exogenous, like in standard models and empirical studies in labor economics, with instantaneous utility from equation (6) the Frisch elasticity of labor supply reads as $\eta^{-1}l/\ell$.¹⁴ We assume a ratio between leisure and labor supply of $(1 - \ell)/\ell = 3$. The value is derived from OECD (2024) that reports actual hours worked of 1347 per year in the year 2022. Given that workers miss approximately 10% of working days due to sick leave, this amounts to contractually fixed working hours of 1482. Assuming 16 hours per day that may be allocated to labor and leisure, the total amount of time is 5840 hours per year. Therefore, the fraction of time that is devoted to contractually fixed labor is given by $\ell \approx 0.25$. As explained at the end of this section, we will replicate these stylized facts of the German labor market with our calibrated model. Using evidence from Chetty et al. (2011) suggesting a Frisch elasticity of labor supply of 0.5, this implies $\eta = 6$.

¹⁴The result is easy to show from first-order condition (40). To derive it, we hold fixed the shadow prices of private assets and of pension wealth.

The time preference parameter is set such that individuals perfectly smooth consumption across time. Browning and Ejrnaes (2009) find that the consumption trajectory becomes flat once family size is controlled for. With $\bar{r} = 0.05$, this implies $\beta = (1 + \bar{r})^{-1} = 0.95$.

We use the government balanced budget constraints derived in Online Appendix A.1.2 to match the German contribution rate for the public health care system of $\tau^g = 0.146$ (BfG, 2024). This gives us (along with other parameters) the generosity of financing health treatment costs, G . The exogenous contribution rate for the public pension system, τ^P , is used to calibrate a long-run pension conversion rate that is the same for all cohorts, $b_v = b$. Similarly, the long-run value of the earned income tax credit, \mathcal{T} , follows from the exogenous tax rate on earnings, τ^w .

We then simultaneously calibrate the remaining parameters $\mu, \zeta^1, \zeta^2, \zeta^3, \xi, \epsilon, \gamma, \varsigma, \varrho, \psi, \kappa, A$, and \bar{u} , to match the following calibration targets: (i) the health deficit path at ages 30, 50, 70, and 90, (ii) the life expectancy at ages 20 and 65, (iii) the life expectancy differentials between education groups, (iv) labor supply, (v) sick days at ages 30, 45, and 60, (vi) the sick day differential between the highest and lowest occupational group, (vii) the ratio of average private health care expenditure between the highest and lowest educational group, (viii) the slope of the health care expenditure path for ages 35, 50, 70, and 90, and (ix) the ratio between the empirical value of a statistical life (VSL) and earnings at age 50.

For calibration target (i), we exploit findings from Abeliatsky and Strulik (2018). Using the SHARE data for 10 European countries, the authors estimate the exponential function $d = 0.0269 \cdot \exp(0.026 \cdot age)$ for the health deficit index of males. This allows us to calculate the health deficit index over the life cycle. Data for calibration target (ii) come from DESTATIS (2023) reporting a remaining life expectancy at age 20 of 58.77 years and a remaining life expectancy at age 65 of 17.63 years. For calibration target (iii) we rely on a study by Luy et al. (2015) that finds differences in life expectancy at 40 of 2.0 years between the low education group and the middle education group and 6.30 years between the low and high education group. For calibration target (iv), we match an average labor supply relative to total available time of 0.25, as derived above from OECD (2024). For calibration target (v), we retrieve the number of sick days by age from the German research institute IWD (2024). Since in the data sick time is measured as working days being absent from work per year, we multiply the number of those sick days by $365/220$, assuming 220 regular working days in a year. Calibration target (vi) takes the variation of sick leave between educational groups into account. The data come from BfG (2023) reporting relative differences in sick days by a factor of 2 between the low and the high education group. In other words, individuals with

below upper secondary education experience on average twice as many sick days as individuals with tertiary education. For calibration target (vii), we rely on a study by Bremer (2014) finding that the highest income quintile spends on average twice as much on out-of-pocket expenditure as the lowest income quintile. Although the stratification of the population with respect to income quintiles does not perfectly mimic our educational groups, we consider it a reasonable approximation. Data on life-cycle health expenditure for calibration target (viii) come from DESTATIS (2024). Finally, for calibration target (ix), we exploit the findings from Murphy and Topel (2006) that the ratio between the VSL and earnings at age 50 is equal to 100. Table 2 shows the calibration results.

TABLE 2. Calibration Results

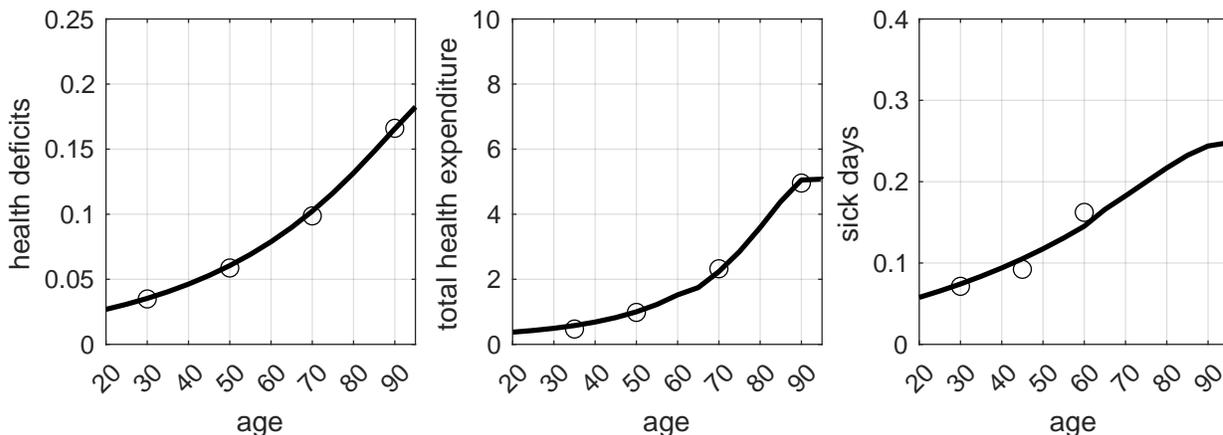
Parameter	Value	Explanation
η	6	elasticity of marginal utility from leisure
β	0.95	time preference
μ	0.021	rate of ageing
ζ^1	1.34	sick time level parameter of low education group
ζ^2	1.20	sick time level parameter of middle education group
ζ^3	0.92	sick time level parameter of high education group
γ	0.62	sick time curvature parameter
G	857.4	level parameter public health care expenditure
v	3.54	curvature parameter public health care expenditure
ξ	0.033	level parameter effectiveness of health care
ϵ	0.27	curvature parameter effectiveness of health care
ς	0.003	effect of sick time on deficit accumulation
ϱ	0.32	preference parameter for leisure
κ	105.4	mortality level parameter
ψ	3.69	mortality curvature parameter
\bar{u}	4.61	utility constant

Our parameter estimate for the aging parameter μ is naturally smaller than those found by Abeliatsky and Strulik (2018) since we add sick time as another component of the deficit accumulation process. The values for the sick time parameters ζ^j suggest that health deficits result in more severe illness (higher sick time) when coming from a lower education group.

4.4. Age Profiles. Figure 1 illustrates age profiles for important observables. The age trajectories are shown as a weighted average of the three education groups, while dots indicate data points. The left panel shows the evolution of health deficits over the life cycle. As the empirical literature

suggests, health deficits correlate exponentially with age. The center panel displays life-cycle health investments as the sum of private and public health expenditure relative to age 50. Total health expenditure increases with age in line with the data. The right panel shows the evolution of sick days as a share of total working days over age. In the course of deficit accumulation, sick days increase with age. In all three cases, the model manages to match the data reasonably well.

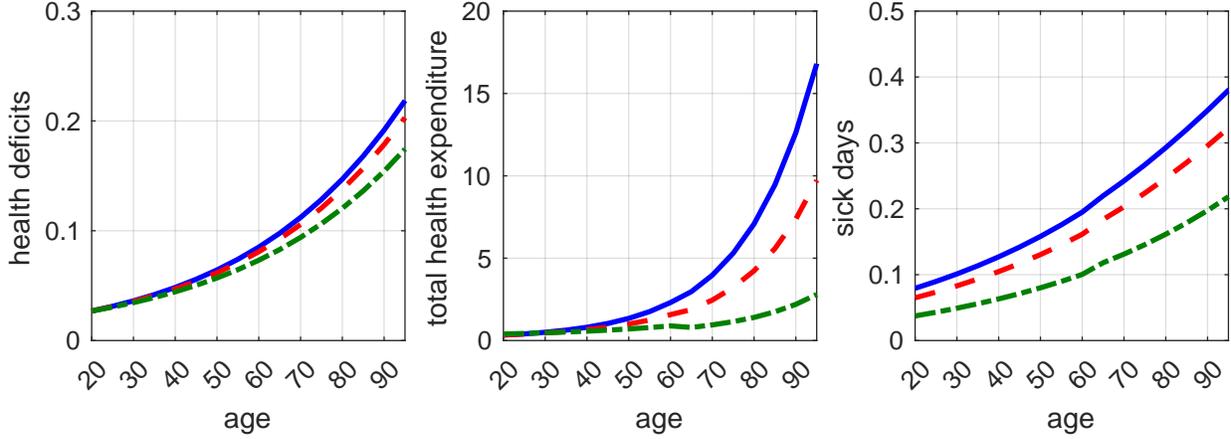
FIGURE 1. Benchmark Run - Average Outcomes



Dots indicate data points. Data for health deficits come from Abeliansky and Strulik (2018), for health expenditure from DESTATIS (2024) and for sick days from IWD (2024).

Figure 2 illustrates model outcomes separately for the three education groups. Blue (solid) lines indicate the low education group, red (dashed) lines indicate the middle education group, and green (dashed-dotted) lines indicate the high education group. The left panel shows that deficits accumulate fastest in the low education group and slowest in the high education group. This translates directly into survival probabilities and eventually into life expectancy differences, which are 2.0 years between the low and middle education groups and 6.3 years between the low and high education groups, as targeted. The feature that health deficits accumulate faster when the education level is lower also implies that public health costs are highest for the low education group. This translates into higher overall health expenditure and a steeper age-expenditure profile, despite private health expenditure increasing with the education level. The right panel of Figure 2 shows significantly higher sick time for lower education groups. This is because lower education groups have more sick days for a given health deficit level than higher education groups and, as a result, display more health deficits at any given age.

FIGURE 2. Model Results: Benchmark Run - Heterogeneous Outcomes



Blue (solid) lines: low education group. Red (dashed) lines: middle education group. Green (dashed-dotted) lines: high education group.

4.5. Non-Targeted Data Moments. In order to further substantiate the validity of our model, we compare model predictions with empirical data moments that are not targeted in the baseline calibration, as summarized in Table 3.

The first measure of interest refers to the income elasticity of life expectancy (i.e. the percentage change of life expectancy in response to a one-percent increase in income). Econometric estimates suggest that this elasticity amounts to 0.024 (Pritchett and Summers, 1996) while theory-based approaches find values of approximately 0.08 (e.g. Dalgaard and Strulik, 2014). Our model predicts, from increasing the exogenous productivity parameter A accordingly, an elasticity of 0.046, which lies well within that range of estimates.

While we match the ratio of sick days between the highest and the lowest education group, the baseline calibration does not target the sick days of the middle education group. BIFG (2023) reports that average sick days of workers with below upper secondary education exceed those of the middle education group by a factor between 1.12 and 1.40. Consistent with this range of values, our model suggests a ratio of 1.21.

In the statutory pension system of Germany, the pension benefit in period t of a member from group j born in v after retirement at or beyond statutory retirement age is given by $B_{v,t}^j = \tilde{b}_t \sum_{t=v}^{v+\bar{R}-1} \frac{y_{v,t}^j}{\bar{y}_t}$ (Seibold, 2021),¹⁵ where \bar{y}_t are average earnings in the economy in t and \tilde{b}_t is the

¹⁵When retiring before the statutory retirement age, the German statutory pension system levies a proportional penalty on pension benefits that linearly depends on the actual retirement age. For simplicity, we abstract from early retirement.

so-called “pension value” (defined as monthly rate). According to (11), pension wealth is given by $P_{v,t}^j = \tau^P \sum_{t=v}^{v+\bar{R}-1} y_{v,t}^j$. Hence, in the long run, where $\bar{y}_t = \bar{y}$, we can insert $\sum_{t=v}^{v+\bar{R}-1} y_{v,t}^j = P_{v,t}^j / \tau^P$ into the German pension formulae and suppress subscripts to obtain $B^j = (\tilde{b}/\bar{y})P^j / \tau^P$. According to (10), in the long run, we have $B^j = bP^j$. Theoretically, for the long run, we thus capture the German statutory pension system with a conversion rate $b = (\tilde{b}/\bar{y}) / \tau^P$. The pension value in 2024–25 equals €39.32 per month, i.e. \tilde{b} equals €471.84 per year. The (estimated) average earnings in the year 2025, \bar{y} , equal €50,493 (DRV, 2025). Using the German pension contribution rate $\tau^P = 0.186$, we thus have $b = 0.0502$. Our calibrated model implies a very close long run conversion rate of 0.0514.

We finally look at the transfer income \mathcal{T} in the calibrated model. Recall that, in our model, the labor income tax burden for earnings y^j is equal to $\tau^w y - \mathcal{T}$ and earnings taxation is purely redistributive (i.e. does not include public good provision etc.). Thus, the average tax rate for a member of education group j reads as $\bar{\tau}^{w,j} \equiv \tau^w - \mathcal{T}/y^j$. For incomes at age 50, in our calibrated model, we find $\mathcal{T}/y^1 = 0.51$, $\mathcal{T}/y^2 = 0.32$, and $\mathcal{T}/y^3 = 0.18$. Thus, the difference in average tax rates between the middle and the low education group is $\bar{\tau}^{w,2} - \bar{\tau}^{w,1} = 0.2$ and between the high and low education group $\bar{\tau}^{w,3} - \bar{\tau}^{w,1} = 0.34$. Unfortunately, we do not have exact corresponding figures from the empirical literature. However, the degree of progressivity implied by the calibrated model seems reasonable for the German income tax system. According to Beznoska (2023), the effective average personal income tax rate in 2019 was (on average) 30.1% for the top-1% of income earners, 24.4% for the top decile, 9.7% for the 4th to 8th decile, and 1.5% for the bottom 30%.¹⁶

TABLE 3. Non-Targeted Data Moments

Data Moment	Model Prediction	Empirical Estimate	Source
income elasticity of life expectancy	0.046	0.024–0.080	Pritchett and Summers (1996) Dalgaard and Strulik (2014)
ratio of sick days between low and middle group	1.21	1.12–1.40	BIFG (2023)
conversion rate b	0.0514	0.0502	DRV (2025)
ratio of earned income tax credit to earnings at age 50 for low/middle/high	0.51/0.32/0.18	Avg. tax rate diff. (see text)	Beznoska (2023)

¹⁶Note that personal income includes capital income that is taxed at a flat rate (of 25%), suggesting that these values underestimate the degree of progressivity of the labor income tax in Germany.

5. NUMERICAL ANALYSIS

We are now ready for the numerical evaluation of key policy experiments.

5.1. Change in the Sick Pay Replacement Rate. As a first experiment, we analyze the effect of gradually lowering the sick pay replacement rate (from its calibrated value $s^j = s = 1$ for all groups) under the status quo employer-based financing scheme ($\phi = 1$). Panel A of Table 4 summarizes the results for this policy experiment. Column (1) shows how the health contribution rate endogenously adjusts to the policy intervention. Columns (2), (3), and (4) display the effect on the net wage rate, $w^{net} \equiv (1 - \tau)w$, average labor supply, and average gross earnings relative to the status quo scenario, respectively. Reducing the sick pay replacement rate leads to a considerable increase in the net wage rate, w^{net} , of 10%. This increase is the result of an increase in gross wages because the health contribution rate changes only mildly. Since firms finance sick pay, a decrease in s reduces their effective marginal labor costs, leading to an increase in the equilibrium gross wage rate, w . Despite lower income when sick, a decrease in s very slightly increases average gross earnings in the economy due to the increase in the wage rate. Therefore, the health contribution rate τ^g decreases slightly from 14.60% to 14.51% for a given generosity of the health care system. Average labor supply remains virtually unchanged because the effect of higher net wages which – taken for itself – leads to higher labor supply is compensated by the effect of lower sick pay which – taken for itself – reduces labor supply.

Columns (5), (6), and (7) show average private health expenditure and average sick time relative to the status quo scenario, and average life expectancy, respectively. When the sick pay replacement rate is reduced from $s = 1$ to $s = 0$, private health expenditure increases, on average, by 19%. The reason is that individuals aim to reduce sick time when sick leave is not compensated. As a consequence, average sick time falls by 4%, which is associated with a slight increase in average life expectancy at 20 from 58.77 to 58.99 years.

TABLE 4. Comparative Dynamics

Case	(1) τ^g	(2) \hat{w}^{net}	(3) $\hat{\ell}$	(4) \hat{y}	(5) \hat{h}	(6) \hat{Z}	(7) LE	(8) ℓ^3/ℓ^1	(9) y^3/y^1	(10) h^3/h^1	(11) Z^3/Z^1	(12) Δ LE
Panel A (for $\phi = 1$)												
Sick pay repl. rate												
$s = 1.0$	14.60	1.00	1.00	1.00	1.00	1.00	58.77	1.32	2.67	2.00	0.50	6.30
$s = 0.8$	14.58	1.02	1.00	1.00	1.03	0.99	58.82	1.32	2.71	2.06	0.50	6.34
$s = 0.6$	14.56	1.04	1.00	1.00	1.07	0.99	58.86	1.33	2.76	2.11	0.49	6.39
$s = 0.4$	14.54	1.06	1.00	1.00	1.11	0.98	58.90	1.33	2.81	2.17	0.49	6.43
$s = 0.2$	14.53	1.08	1.00	1.00	1.15	0.97	58.95	1.34	2.87	2.22	0.48	6.48
$s = 0.0$	14.51	1.10	1.00	1.01	1.19	0.96	58.99	1.35	2.93	2.28	0.48	6.52
Panel B (for $s = 1$)												
Empl. share of sick pay												
$\phi = 1.0$	14.60	1.00	1.00	1.00	1.00	1.00	58.77	1.32	2.67	2.00	0.50	6.30
$\phi = 0.8$	15.95	0.98	1.00	1.01	0.99	1.00	58.76	1.32	2.68	2.00	0.50	6.29
$\phi = 0.6$	17.31	0.97	0.99	1.03	0.98	1.00	58.75	1.33	2.69	1.99	0.50	6.28
$\phi = 0.4$	18.68	0.95	0.99	1.04	0.96	1.00	58.74	1.34	2.70	1.98	0.50	6.27
$\phi = 0.2$	20.07	0.93	0.98	1.06	0.95	1.00	58.72	1.34	2.72	1.97	0.50	6.26
$\phi = 0.0$	21.47	0.92	0.98	1.07	0.94	1.01	58.71	1.35	2.73	1.96	0.50	6.25
Panel C (for $\phi = 0$)												
Sick pay repl. rate												
$s = 1.0$	21.47	0.92	0.98	1.07	0.94	1.01	58.71	1.35	2.73	1.96	0.50	6.25
$s = 0.8$	20.11	0.95	0.98	1.06	0.98	1.00	58.76	1.35	2.76	2.02	0.50	6.30
$s = 0.6$	18.74	0.99	0.99	1.05	1.03	0.99	58.82	1.35	2.80	2.08	0.49	6.36
$s = 0.4$	17.35	1.02	0.99	1.03	1.08	0.98	58.88	1.35	2.84	2.15	0.49	6.41
$s = 0.2$	15.94	1.06	1.00	1.02	1.13	0.97	58.93	1.35	2.88	2.21	0.48	6.47
$s = 0.0$	14.51	1.10	1.00	1.01	1.19	0.96	58.99	1.35	2.93	2.28	0.48	6.52

The table uses the following notation. s : sick pay replacement rate; ϕ : employer share of sick pay; τ_g : contribution rate to the health care system; \hat{w}^{net} : net wage rate relative to the status quo scenario; $\hat{\ell}$: average labor supply relative to the status quo scenario; \hat{y} : average earnings relative to the status quo scenario; \hat{h} : average private health expenditure relative to the status quo scenario; \hat{Z} : average sick time relative to the status quo scenario; LE: average life expectancy at 20; ℓ^3/ℓ^1 : labor supply ratio between high- and low-education group; y^3/y^1 : earnings ratio between high- and low-education group; h^3/h^1 : private health expenditure ratio between high- and low-education group; Z^3/Z^1 : sick time ratio between high- and low-education group; Δ LE: gap in life expectancy at 40 between the high- and the low-education group.

We now turn to the socioeconomic implications of lower sick pay. Column (8) shows the labor supply ratio between the high- and the low-education group. Reducing the sick pay replacement rate from $s = 1$ to $s = 0$ slightly increases the labor supply ratio. Since average labor supply remains virtually unchanged (recall column (3)), this implies that the labor supply of the low-education group (slightly) decreases while the labor supply of the high-education group (slightly) increases. For the low-education group, the positive effect on labor supply of increasing net wages is overcompensated by the effect of lower sick pay because this group suffers a higher number of sick days. For the high-education group, who suffers significantly fewer sick days, the opposite net effect emerges. Column (9) shows the earnings ratio between the high- and low-education group. Reducing the sick pay replacement rate from $s = 1$ to $s = 0$ increases the earnings ratio from 2.67 to 2.93. Although both groups enjoy the same increase in hourly wages, the low-education group suffers more from the cut in employer-financed sick pay because this group faces a higher number of sick days. Columns (8), (9), and (10) display the ratio in private health expenditure, sick time, and the gap in life expectancy between high-skilled and low-skilled individuals, respectively. The divergence in earnings translates into the ratio of private health expenditure, which increases from 2.00 to 2.28. As a result, the ratio of sick time falls from 0.5 to 0.48 and the life expectancy gap increases from 6.30 to 6.52 years. Thus, reducing the sick pay replacement rate raises the inequality of both income and health. Health inequality rises because individuals with higher incomes adjust health spending to a larger extent.

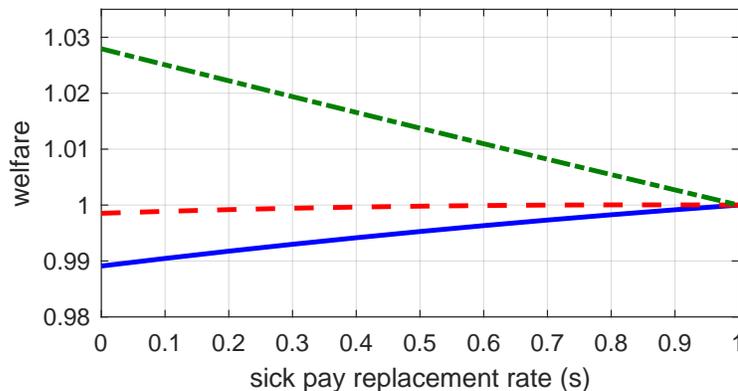
Figure 3 shows the welfare implications. Group-specific welfare is measured as lifetime utility at age 20. The blue (solid) line, red (dashed) line, and green (dash-dotted) line illustrate the welfare level of the low-, middle-, and high-education groups relative to their welfare levels in the status quo scenario ($s = \phi = 1$), respectively, in terms of consumption equivalents as a function of the sick pay replacement rate, s .¹⁷

Welfare of the high-education group increases by lowering the generosity of employer-financed sick pay. For this group, the positive effect on the wage rate more than compensates for the loss of sick pay such that $s = 0$ is optimal, but vice versa for the low-education group, for which $s = 1$ turns out to be optimal. The reason behind this heterogeneous effect is that the low-education group suffers more sick days than the high-education group, leading to a situation in which the positive effect of sick pay outweighs the negative general equilibrium effect on wages for low-skilled individuals. High-skilled individuals would gain 2.79% in welfare when abandoning sick pay, while

¹⁷See Online Appendix A.2 for welfare change measurement.

low-skilled workers would lose 1.09%. For the middle-education group, the increase in wages and the loss of sick pay largely offset each other so that this group is almost indifferent between different replacement rates under employer-paid sick leave. For this group, the optimal sick pay replacement rate is $s = 0.9$.

FIGURE 3. Sick Pay Generosity and Welfare with Employer-Paid Sick Leave



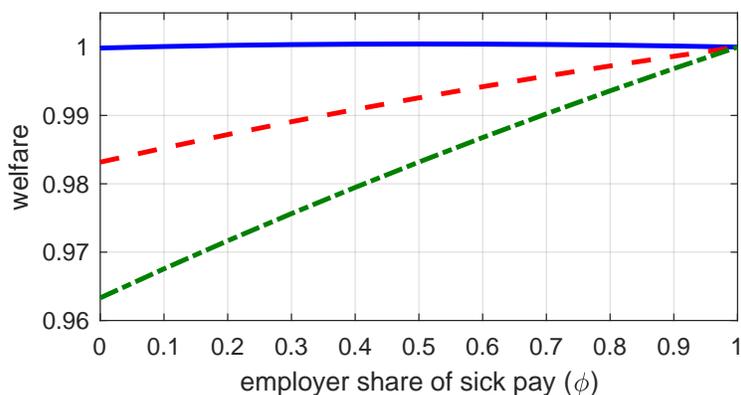
The figure presents welfare deviations from the status quo policy scenario ($s = \phi = 1$), measured in consumption equivalents (see Online Appendix A.2). Blue (solid) lines: low education group. Red (dashed) lines: middle education group. Green (dashed-dotted) lines: high education group.

5.2. Effects of Changes in the Composition of Sick Pay Finance. We now turn to the composition of sick pay finance and gradually reduce the cost share covered by firms from $\phi = 1$ to $\phi = 0$ (i.e. sick pay becomes financed to a larger extent by the public health care system) while keeping the sick pay replacement rate constant at $s = 1$. As shown in Panel B of Table 4, entirely moving to publicly financed sick pay ($\phi = 0$ instead of $\phi = 1$) requires an increase in the health contribution rate, τ^g , from 14.60% to 21.47%. At the same time, the net wage rate, w^{net} , decreases by 8%. Although employers enjoy a reduction in their effective marginal cost leading to an increase in the gross wage rate, w , higher health contributions outweigh this effect, so that individuals face a reduction in w^{net} . This leads to a reduction in average labor supply of 2% while gross earnings increase by 7%. Since the health contribution rate increases, net earnings decrease, such that private health spending in the economy drops by 6%. This also leads to a slight decrease in average life expectancy at 20 from 58.77 to 58.71 years. The ratio between the labor supply of the group with a high level of education and that of the group with a low level of education rises slightly from 1.32 to 1.35, as a result of which the income ratio increases slightly from 2.67 to 2.73. Nevertheless, the health expenditure ratio between the high- and low-education group falls from

2.00 to 1.96, such that the life expectancy gap decreases from 6.30 to 6.25 years and employees from the high education group still has half as many sick days as employees from the low education group.

Figure 4 illustrates the implications for welfare of the three groups as a function of the employer share of sick payments, ϕ , given full sick pay ($s = 1$). Again, welfare of each group is normalized by the respective welfare under the status quo policy ($s = \phi = 1$) and the figure displays welfare deviations in terms of consumption equivalents. As the figure shows, for the low-education group, welfare is almost invariant to the employer share. For them, an employer share of $\phi = 0.5$ is optimal. For both the middle- and the high-education group, the status quo employer share of $\phi = 1$ is optimal. Comparing the two groups, welfare of the high-education group drops more strongly after a decrease in the employer share than for the middle-education group. The reason behind these observations lies in the redistributive nature of earnings taxation. As discussed above, lowering the employer share of sick pay reduces the net wage rate. This effect, taken for itself, reduces the welfare for all groups. Since earnings increase, however, earnings tax revenues and thus the uniform lump-sum transfer component \mathcal{T} increase as well. This is especially favorable for the low-education group who benefits most from redistributive taxation. In fact, for this group, the two effects (almost) balance each other, while for the high-education group the effect of redistributive taxation adds to the already negative effect stemming from the decrease in the net wage rate.

FIGURE 4. Group-Specific Welfare under Full Sick Pay as a Function of the Employer Share

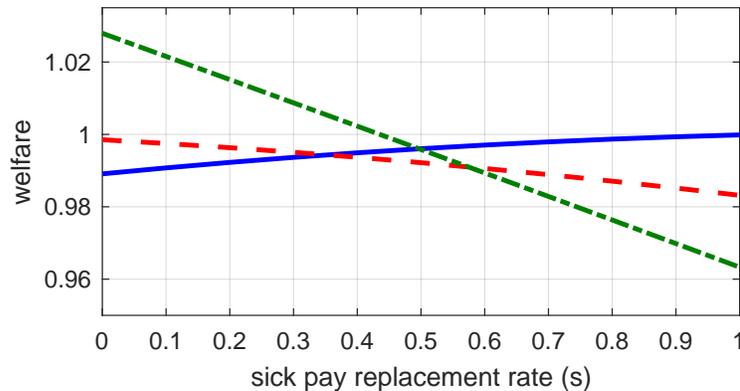


The figure presents welfare deviations from the status quo policy scenario ($s = \phi = 1$), measured in consumption equivalents. Blue (solid) lines: low education group. Red (dashed) lines: middle education group. Green (dashed-dotted) lines: high education group.

5.3. Effects of Lower Sick Pay when Publicly Financed. In this section, we look at the effects of varying the sick pay replacement rate if sick pay were entirely financed by the public health care system ($\phi = 0$). Although this is not the case in Germany, the results may be indicative for countries like France where sick pay fully relies on social insurance (*Sécurité Sociale*). Panel C of Table 4 summarizes the results.

Moving from full sick pay $s = 1$ to completely abolishing sick pay ($s = 0$) reduces the health care contribution rate τ_g from 21.49% to 14.51% because the health care system no longer has to finance any sick pay. Net wages increase from 0.92 to 1.10 relative to the status quo (where $s = 1$ and $\phi = 1$) when sick pay is abolished because gross wages remain constant (employers do not pay any sick pay in all scenarios) and health contributions decrease. Although the sick pay replacement rate reduces, this increase in net wages leads to an increase in labor supply of 2%. However, average earnings (that include sick pay) decrease from 1.07 to 1.01 relative to the status quo. In response, individuals aim to reduce sick time by increasing private health spending from 0.94 to 1.19. Increased average private health expenditure leads to lower average sick time and eventually to a slight increase in life expectancy from 58.70 to 58.99 years. Since low-education groups suffer more from reductions in sick pay due to their higher frailty, the earnings ratio increases from 1.96 to 2.28. This leads to a higher ratio of private health expenditure between the low- and high-skilled individuals and increases the gap in life expectancy from 6.25 to 6.52 years.

FIGURE 5. Sick Pay Generosity and Welfare with Publicly Financed Sick Pay



The figure presents welfare deviations from the status quo policy scenario ($s = \phi = 1$) measured in consumption equivalents. Blue (solid) lines: low education group. Red (dashed) lines: middle education group. Green (dashed-dotted) lines: high education group.

As can be seen in Figure 5, again, lower sick pay generosity benefits the high-education group the most. This group suffers only mildly from reduced sick pay because the number of sick days is low.

However, they benefit greatly from a lower health contribution rate. Therefore, highest lifetime utility is achieved for $s = 0$. This result also holds for the middle-education group, although quantitatively less pronounced, contrary to the case of paid sick leave ($\phi = 1$), where $s = 0.9$ is optimal. This implies that for the middle-education group, the general equilibrium effect on welfare of less generous sick pay via lower health contribution rates (when sick pay is publicly financed) is more preferable than the general equilibrium effect stemming from higher wages (when employers provide paid sick leave). Albeit to a lower degree, the low-education group also benefits from lower contribution rates, but at the same time values sick pay more due to their higher amount of sick days. The latter effect dominates, resulting in a welfare-maximizing sick pay replacement rate of $s = 1$ also in the case where $\phi = 0$.

5.4. Optimal Combination of Sick Pay Generosity and Sick Pay Finance. Having identified the mechanisms of sick pay and its composition of finance, a natural question is which combination of sick pay and sick pay finance is optimal for the groups in terms of welfare.¹⁸ To this end, we calculate and display in Figure 6 group-specific welfare for all combinations of the sick pay replacement rate s (x-axis) and the employer share ϕ (y-axis) in 0.1 steps from zero to one (121 combinations). Welfare levels are provided relative to the welfare of the status quo scenario with $\phi = 1$ and $s = 1$. The upper panel shows the low-education group (L-Welfare), the center panel shows the middle-education group (M-welfare), and the lower panel shows the high-education group (H-welfare).

We first focus on the low-education group. As already suggested by Figures 3 and 5, the combination of full sick pay $s = 1$ is optimal irrespective of the way of financing. The direct beneficial effect of sick pay outweighs the distortionary general equilibrium effects on wages and contribution rates because their number of sick days is relatively high. Regarding sick pay finance, recall from Section 5.2 that for $s = 1$ low-skilled workers prefer an employer share of $\phi = 0.5$.

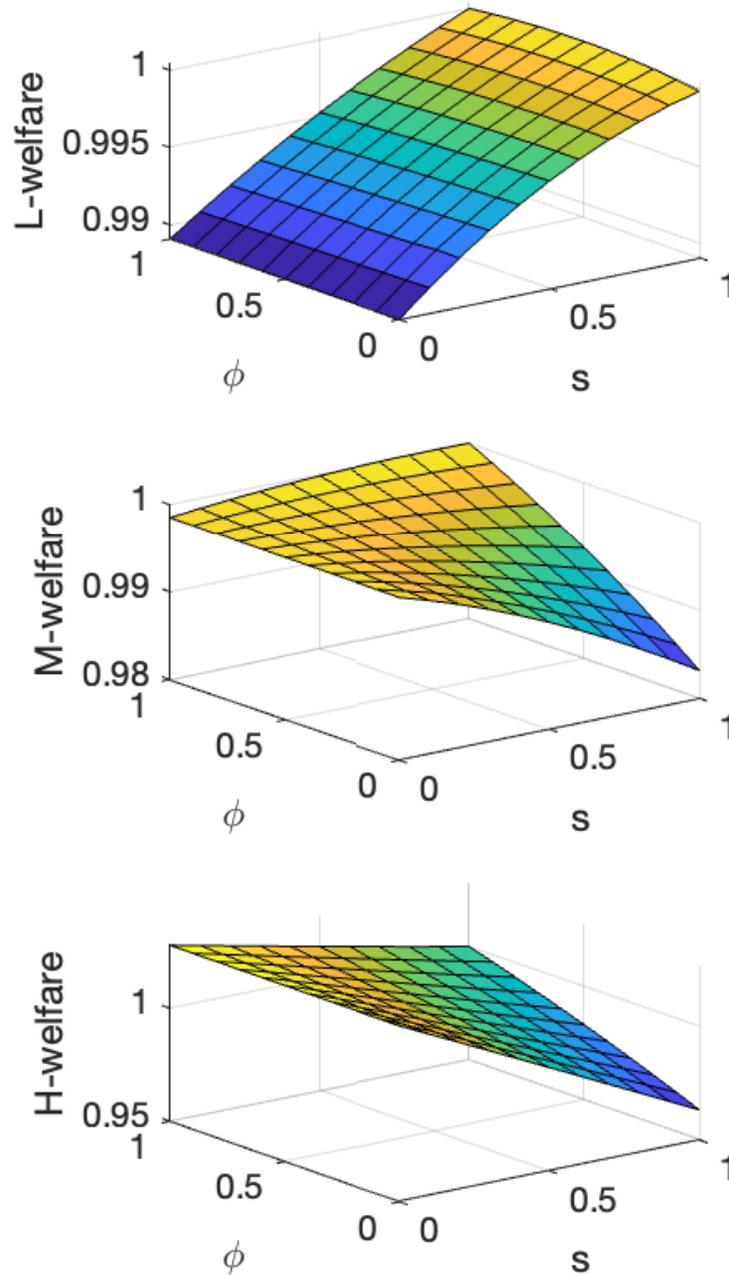
As the second panel of Figure 6 shows, high rates of sick pay are optimal for the middle-education group when it is financed by the employer. In fact, the lowest welfare is achieved when there is full sick pay that is fully financed by the public health care system ($s = 1, \phi = 0$). As the employer share increases, so does the optimal sick pay rate. The optimal combination of sick pay and employer share is given by $s = 0.9$ and $\phi = 1$.

¹⁸We refrain from making value judgments and do not specify and maximize a social welfare function. That said, the preferred policy of low-skilled individuals follows the Rawlsian social welfare criterion.

The last panel of Figure 6 illustrates welfare implications for the high-education group. As for the middle-education group, the lowest welfare results from full sick pay ($s = 1$) and an employer share of $\phi = 0$. However, increasing the employer share never leads to a situation in which any positive rate of sick pay becomes optimal because the number of sick days is lower than that of the middle-education group. Therefore, the optimal sick pay replacement rate is $s = 0$.

The upper part of Table 5 shows the implied welfare changes in percent relative to the status quo (again, measured in consumption equivalents) when implementing each of the group-specific preferred policies. The first, second, and third rows show results for the optimal policy of the low-, middle-, and high-education groups, respectively. Introducing the optimal policy for the low-education group ($s = 1.0$, $\phi = 0.5$) only very slightly increases the welfare level of that group by 0.05% relative to the status quo. Since this policy implies a reduction in the employer share from $\phi = 1$ to $\phi = 0.5$, medium-skilled and high-skilled individuals suffer a welfare loss (-0.74% and -1.68%, respectively). If the optimal policy for the middle-education group is implemented ($s = 0.9$, $\phi = 1$), this group will experience only a very small welfare gain (not visible in the table due to rounding). Since this policy requires reducing the sick pay replacement rate (from $s = 1$ to $s = 0.9$), the welfare level of the low-education group decreases (-0.08%), while the welfare level of the high-education group increases by 0.27%. Finally, as already seen in Figure 3, introducing the optimal policy for the high-education group ($s = 0$) implies a welfare increase of 2.79% for this group, while low-skilled individuals suffer a considerable welfare reduction when abolishing sick pay (-1.09%) while the middle-education group loses only slightly (-0.15%).

FIGURE 6. Group-Specific Welfare as a Function of the Homogeneous Sick Pay Replacement Rate (s) and the Employer Share of Sick Pay (ϕ) in the Benchmark Model



The upper panel displays welfare of the low-education group as a function of the sick pay replacement rate (s) and the employer share of sick pay (ϕ); analogously, the center panel of the middle-education group, and the lower panel of the high-education group. Welfare levels are given as deviations from the status quo policy scenario ($s = \phi = 1$) and measured in consumption equivalents.

TABLE 5. Welfare Implications of Sick Pay Policy Reforms

Case	ΔU^1	ΔU^2	ΔU^3
Homogeneous Sick Pay ($s^1 = s^2 = s^3 = s$)			
$s = 1, \phi = 0.5$ (optimum for low-education group)	0.05	-0.74	-1.68
$s = 0.9, \phi = 1.0$ (optimum for middle-education group)	-0.08	0.00	0.27
$s = 0$ (optimum for high-education group)	-1.09	-0.15	2.79
Sick Pay Cap ($s^1 = s^2 = \tilde{s}$ and $s^3 = 0.66\tilde{s}$)			
$\tilde{s} = 1, \phi = 0.5$ (optimum for low-education group)	0.78	0.21	-1.94
$\tilde{s} = 1, \phi = 1$ (optimum for middle-education group)	0.75	0.87	-0.50
$\tilde{s} = 0$ (optimum for high-education group)	-1.09	-0.15	2.79

s^1 , s^2 , and s^3 refer to the sick pay replacement rate of the low-, middle-, and education group, respectively; ϕ denotes the employer share of sick pay. ΔU^1 , ΔU^2 , and ΔU^3 represent welfare changes in percent from the status quo scenario ($s^1 = s^2 = s^3 = \phi = 1$), measured in consumption equivalents, for the low-, middle-, and high-education group, respectively. Optimal policies for the respective group are under constraints $s^1 = s^2 = s^3 = s$ in the upper panel and $s^1 = s^2 = \tilde{s}$ as well as $s^3 = 0.66\tilde{s}$ in the lower panel.

6. DISCUSSION

6.1. Cap on Sick Pay. Some countries like France and Great Britain have publicly financed sick pay institutions (social insurance) that restrict sick pay to a maximum amount. Such a sick pay cap is binding for workers with sufficiently high earnings. On the one hand, high-income workers have a relatively low number of sick days such that a cap on sick pay benefits disrupts the earnings stream relatively little. On the other hand, the total amount of sick pay benefits saved is potentially large because sick pay benefits per sick day for high-earning individuals are large. In this way, a cap may alleviate the general equilibrium effects of sick pay on wages (if employers provide paid sick leave) or the health contribution rate (if sick pay is financed by the public health care system). It is even conceivable that it is beneficial to the high-education group if the welfare effect associated with an increase in wages and/or a decrease in the health care contribution rate offsets the welfare effect of a reduction in sick pay.

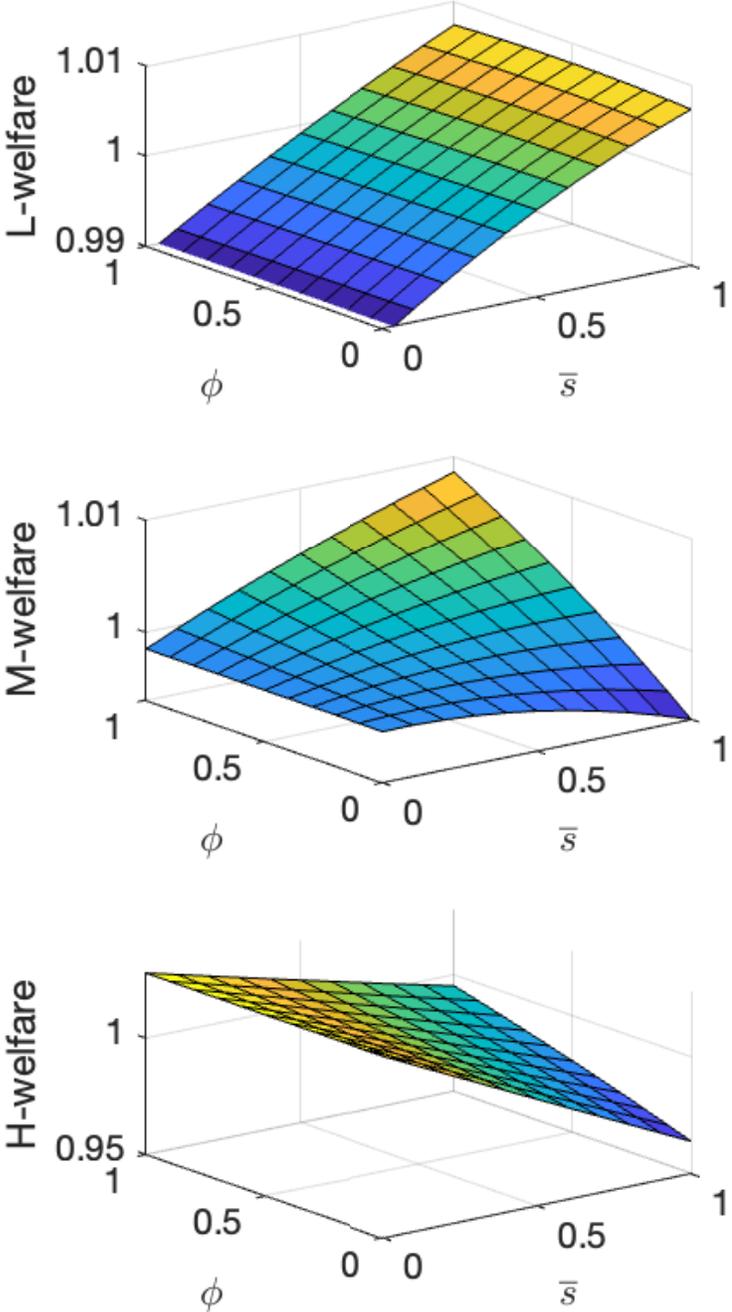
In order to analyze the effects of a sick pay cap, we constrain the sick pay benefits per unit of labor supply by the amount that the middle-education group receives. Effectively, this reduces the sick pay rate of the high-education group by the inverse of the relative wage to the middle-education group, i.e. by $a^2/a^3 = 0.66$. Figure 7 shows the welfare implications for the three groups

for different combinations of the sick pay replacement rate $s^1 = s^2 \equiv \tilde{s}$ for the low- and middle-education group (that are constrained to be the same) and the employer share of sick pay, ϕ , under constraint $s^3 = 0.66\tilde{s}$.

Comparing the center panel with that in Figure 6 reveals that higher rates of sick pay become more beneficial to middle-education households. Due to the cap on sick pay benefits to the high-education group, the distortionary effects of sick pay weaken such that middle-income households now prefer 100% employer-based sick pay ($\tilde{s} = \phi = 1$). The outcomes for the other two groups remain qualitatively similar to those without a sick pay cap, i.e. low-skilled individuals prefer $\tilde{s} = 1$ and high-skilled ones prefer $\tilde{s} = 0$).

The lower part of Table 5 shows the associated welfare changes relative to the status quo scenario, where ($s^1 = s^2 = s^3 = \phi = 1$). Introducing a sick pay cap while leaving sick pay replacement rates for low- and medium-skilled workers at 100% and keeping the employer-based finance ($\tilde{s} = \phi = 1$), which is the optimal policy for the middle-education group, is associated with a welfare increase of 0.87% for this group, while the welfare level of the low-education group increases by 0.75%. The welfare level of the high-education group decreases (-0.50%). Abandoning sick pay (the optimal policy of the high-education group) leads to the same outcome as under homogeneous sick pay because a sick pay cap is not effective for a zero sick pay replacement rate. Introducing the sick pay cap along with a switch from $\phi = 1$ to $\phi = 0.5$ while \tilde{s} remains at 100%, which is the optimal policy for the low-education group, implies a welfare increase of 0.78% for low-skilled individuals and a welfare increase of 0.21% for medium-skilled individuals. Intuitively, the sick pay cap limits the distortionary general equilibrium effects. High-skilled individuals experience a considerable welfare reduction (-1.94%) from the policy switch.

FIGURE 7. Group-Specific Welfare as a Function of the Sick Pay Replacement Rate for the Low- and Middle-Education Group (\bar{s}) and the Employer Share of Sick Pay (ϕ) with a Sick Pay Cap



The upper panel displays welfare of the low-education group as a function of the sick pay replacement rate $\bar{s} = s^1 = s^2$ when $s^3 = 0.66\bar{s}$ and the employer share of sick pay (ϕ); analogously, the center panel of the middle-education group, and the lower panel of the high-education group. Welfare is measured as deviation from the status quo policy scenario ($s^1 = s^2 = s^3 = \phi = 1$) and in terms of consumption equivalents.

6.2. Hand-to-Mouth Consumers. In the previous section, we analyzed the effects of sick pay generosity and sick pay finance under the assumption of unconstrained access to capital markets. As a consequence, even in the absence of sick pay, households were able to alleviate the effect of illness by relying on savings. However, one could argue that especially low-income households live “hand-to-mouth” rather than smoothing consumption through the capital market. According to Grabka and Halbmeier (2019, Tab. 1), about 15% of adults in Germany did not have positive net wealth in the year 2017; the 25th percentile had total net wealth of about €1600, including cars. The lack of savings becomes relevant in our context because these households may face instantaneous drops in consumption levels without sick pay. In order to investigate these effects, we replace the asset accumulation equation in (17) for the low-education group $j = 1$ by

$$(1 - \tau_t)y_{v,t}^1 + \mathcal{T}_{v,t} + (1 - \tau_t^g)B_{v,t}^1 = c_{v,t}^1 + h_{v,t}^1. \quad (25)$$

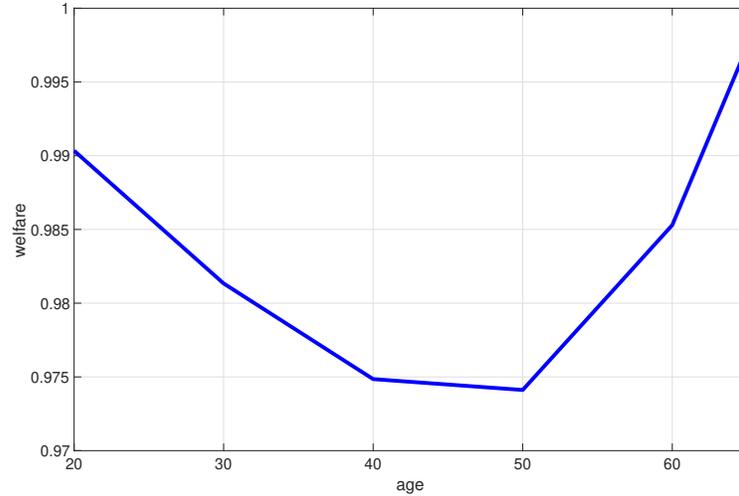
The equation implies that consumption and private health expenditure (right-hand side) each period are financed solely by contemporaneous (net) labor income (including the lump sum transfer) when working and by contemporaneous pension income when retired. Therefore, low-skilled individuals do not accumulate savings, which could be used to mitigate the effects of disease. In addition, these households are borrowing constrained such that they cannot smooth consumption by taking up a loan. We recalibrate the model so that the original calibration targets are met.¹⁹

This setting opens up an interesting way to analyze welfare implications of sick pay, which is to look at welfare at different ages over the life cycle. The welfare effects of abandoning sick pay can differ by age because older households during working age face a higher number of sick days. When welfare is calculated at these higher ages, the removal of sick pay leads to larger consumption drops in the near future compared to younger people for whom a high number of sick days in the distant future are discounted more heavily in calculating lifetime utility. This feature is not prevalent in the baseline version of the model because households can perfectly smooth consumption over the life cycle. In fact, with full access to capital markets, the effect of sick pay becomes more detrimental with age because the retirement period is closer. Therefore, the working-age period in which the positive effects of sick pay are materialized loses weight in calculating lifetime utility.

Figure 8 shows the welfare change for low-skilled hand-to-mouth consumers for different age levels when sick pay is removed relative to the status quo with $s = 1$ and $\phi = 1$. The figure implies a U-shaped relationship between welfare loss and age. Until age 50, the discounting effect

¹⁹The calibration results can be found in Online Appendix A.3.

FIGURE 8. Welfare Effects of Abandoning Sick Pay for Hand-to-Mouth Consumers at Different Ages



The figure shows the welfare change from the status quo policy scenario ($s = \phi = 1$) in consumption equivalents as a function of age for low-skilled hand-to-mouth consumers (who cannot borrow) when sick pay is removed.

dominates. Instantaneous consumption drops due to illness are larger the older the individual is. As a result, calculating welfare at higher ages implies that these consumption drops are less heavily discounted compared to calculating welfare at the age of 20 where these consumption drops lie farther in the future. Starting at age 50, this mechanism is overcompensated by the effect of an approaching retirement period, in which the benefits of sick pay are only moderate. When the individual retires at age 65, the only benefit of sick pay is its positive impact on the conversion rate as pension benefits are also paid on sick pay receipts of those currently working. Expressing the welfare changes in terms of consumption equivalents, introducing the optimal policy for the high-education group and removing sick pay results in a welfare loss of the low-education group at age 20 (-0.97%), which is similar to the effect from the benchmark model (-1.09%). However, at age 30 the welfare loss of the hand-to-mouth consumer is about twice as high (-1.87%) and is highest mid-life (-2.51% at age 40 and -2.59% at age 50). At age 60 it is still higher than at age 20 (-1.47%) despite being close to retirement age, but is becoming small at retirement age 65 (-0.26%).

6.3. Lower Generosity of Public Health Care. The German healthcare system is perceived as quite generous, with negligible co-payments and universal healthcare coverage. Looking at other countries or in the wake of calls for cuts in public healthcare spending, it is therefore interesting

to see how the role of health insurers changes when public healthcare is less generous. For this purpose, we lower the health contribution rate from the German status quo level of $\tau_g = 0.146$ to $\tau_g = 0.100$, maintaining full employer-based sick pay finance ($s = \phi = 1$). This implies that the parameter capturing the generosity of the health care system reduces from $G = 857.4$ to $G = 594.4$. As a consequence, the ratio of private health expenditure in total health expenditure increases from 0.21 to 0.30. While income inequality remains basically unchanged, the life expectancy gap between high-skilled and low-skilled individuals rises from 6.3 for the benchmark calibration (recall Table 4) to 6.42 years. Average life expectancy slightly decreases from 58.77 to 58.53 years (see Table 6).

TABLE 6. Lower Generosity of Public Health Care: Comparative Dynamics

Case	(1) τ^g	(2) \hat{w}^{net}	(3) $\hat{\ell}$	(4) \hat{y}	(5) \hat{h}	(6) \hat{Z}	(7) LE	(8) ℓ^3/ℓ^1	(9) y^3/y^1	(10) h^3/h^1	(11) Z^3/Z^1	(12) Δ LE
Panel A (for $\phi = 1$)												
Sick pay repl. rate												
$s = 1.0$	10.00	1.00	1.00	1.00	1.00	1.00	58.53	1.31	2.65	2.03	0.50	6.42
$s = 0.0$	9.94	1.10	1.00	1.01	1.19	0.96	58.75	1.34	2.92	2.32	0.48	6.66
Panel B (for $s = 1$)												
Empl. share of sick pay												
$\phi = 1.0$	10.00	1.00	1.00	1.00	1.00	1.00	58.53	1.31	2.65	2.03	0.50	6.42
$\phi = 0.0$	17.23	0.93	0.98	1.08	0.95	1.01	58.47	1.34	2.71	1.98	0.50	6.38

See table notes of Table 4

If the preferred policy of the high-education group were implemented and sick pay removed completely ($s = 0$), the welfare reduction for low-skilled individuals would be larger than in the benchmark run. Measured in consumption equivalents, welfare now changes by -1.26% instead of -1.09% (see Table 5). Thus, with a lower generosity of the public health care system, sick pay becomes more important for low-skilled individuals.

Finally, considering a switch in the sick pay financing method from paid sick leave to full coverage by the public health care system (from $\phi = 1$ to $\phi = 0$), the health contribution rate has to increase from $\tau_g = 0.100$ to $\tau_g = 0.172$. Implementing this policy would result in a welfare increase for the low-education group of 0.37% measured in consumption equivalents. Consequently, the low-education group now prefers sick pay to be financed fully by the public health care system instead

of (partially) by the employer. Intuitively, since the health contribution rate is lower to begin with, labor supply distortions are less pronounced, and publicly financed sick pay becomes preferable for them. The other two groups still prefer paid sick leave.

6.4. Permanent Sick Leave. In Germany, disabled workers who have paid pension contributions for at least five years can claim permanent sick leave (“Erwerbsminderungsrente”). It is a statutory pension from the German statutory pension insurance paid to insured persons who cannot (for the foreseeable future) work at least 3 hours per day. It is a regular pension (calculated according to the usual pension formula).

One potential concern of our analysis is that we do not account for permanent sick leave of those at working age with the highest health deficits who are unable to continue working, given our approach of looking at representatives of each education group. Thus, the goal of this subsection is to show how our results change if we account for disability benefits in the government budget. Because the financing of annual pension benefits—which are not strictly proportional to lifetime contributions—is funded through taxes, we model disability benefits as a reduction in the lump-sum transfer component (\mathcal{T}), which is paid solely to individuals of working age. According to the European Commission (2024, p.259), disability pensions in Germany amounted to about 0.6% of GDP in 2022, which equals 5.9% of total public pension spending. We thus reduce the lump-sum component by that level compared to the benchmark level that balanced the government budget from income taxation.

Given the relatively small number of people of working age who are entitled to disability insurance, the impact at the aggregate level is very moderate. Reducing lump-sum transfers by 5.9% of total pension spending reduces the equilibrium wage rate w by 0.0092%, increases the equilibrium conversion rate b by 0.035%, and decreases the health contribution rate τ^G by 0.05 percentage points to 14.55%. As a consequence, the comparative analyses carried out in sections 5 and 6 remain virtually unaffected by accounting for permanent disability benefits.

7. CONCLUDING REMARKS

We have examined how the generosity and financing structure of sick pay affect health inequality, income distribution, health spending behavior, life expectancy, and welfare in an education-stratified society. To this end, we developed a dynamic general equilibrium model with overlapping generations, endogenous labor supply, and biologically grounded processes of health and aging. A central feature of the model is the dual interaction between acute illness and chronic health deficits,

allowing us to capture how sick pay policies shape both short-term behavior and long-term health trajectories.

Calibrated to the German economy, our simulations show that more generous sick pay narrows socioeconomic health and welfare gaps, while simultaneously generating labor market distortions. The distributional effects are pronounced: low-income individuals prefer full sick pay, while high-income earners benefit most from its elimination. Middle-income earners would prefer a lower sick pay replacement rate, except in scenarios where a cap on benefits becomes binding for high-income earners. The preferred financing method also varies by income group, with low-skilled workers being almost indifferent between public and employer-based financing, and higher-income groups favoring employer-paid sick leave for given sick pay generosity.

If the public health care coverage were less generous than currently, low-income earners would prefer a switch to fully employer-based sick pay finance. Inequality of both health and income would increase along with private health spending.

In sum, our results suggest that the current German system—characterized by full employer-financed sick pay for the majority of illness durations—is nearly optimal for low-income earners. Moreover, the demand for a reduction in sick pay on the part of the employers’ association in Germany is in line with the demands of high-income earners.

Our findings underscore the importance of considering both health and labor market dynamics in the design of social insurance systems and highlight the redistributive potential of sick pay in mitigating health inequality and income disparities. The inevitable distributional conflict arising from sick pay may also help in future research to understand why—depending on the political power of various interest groups—different sick pay institutions exist around the globe that range from no sick pay to full sick pay for an extended illness duration.

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APPENDIX A. ONLINE APPENDIX

In this online appendix, we first present the equilibrium analysis (following the definition of the equilibrium in Section 3.8) and then outline how we compute welfare effects of changes in policy instruments.

A.1. Equilibrium Analysis. We start the equilibrium analysis with deriving the equilibrium wage rate from profit maximization of firms and then turn to government budget constraints. Finally, we solve the individual optimization problem.

A.1.1. Equilibrium Wage Rate. Total labor costs of the representative firm with effective labor input L_t are $LCosts_t \equiv w_t L_t + \phi w_t \sum_j s^j L_t^{N,j}$. Recalling $L_t = \sum_j (L_t^{C,j} - L_t^{N,j})$ and $L_t^{N,j} = \bar{Z}_t^j L_t^{C,j}$, we can write

$$L_t = \sum_{j=1}^J (1 - \bar{Z}_t^j) L_t^{C,j}, \quad (26)$$

$$LCosts_t = w_t \sum_{j=1}^J L_t^{C,j} (1 - \bar{Z}_t^j (1 - \phi s^j)). \quad (27)$$

The representative final goods producer thus chooses capital input and the amount of contractual labor by maximizing profits $\Pi_t \equiv Y_t - (\bar{r} + \delta)K_t - LCosts_t$, i.e. solves

$$\max_{K_t, \{L_t^{C,j}\}_{j=1}^J} \left\{ (K_t)^\alpha \left(A \sum_{j=1}^J (1 - \bar{Z}_t^j) L_t^{C,j} \right)^{1-\alpha} - (\bar{r} + \delta)K_t - w_t \sum_{j=1}^J L_t^{C,j} (1 - \bar{Z}_t^j (1 - \phi s^j)) \right\}, \quad (28)$$

according to (13), (26), and (27). The first-order conditions read as

$$\bar{r} + \delta = \alpha \frac{Y_t}{K_t} = \alpha \left(\frac{A L_t}{K_t} \right)^{1-\alpha} \Leftrightarrow \frac{K_t}{A L_t} = \left(\frac{\alpha}{\bar{r} + \delta} \right)^{\frac{1}{1-\alpha}}, \quad (29)$$

$$w_t (1 - \bar{Z}_t^j (1 - \phi s^j)) = (1 - \alpha) \left(\frac{K_t}{A L_t} \right)^\alpha A (1 - \bar{Z}_t^j), \quad j \in \{1, \dots, J\}. \quad (30)$$

Multiplying both sides of (30) by $L_t^{C,j}$, summing over all groups, and using (26) implies

$$LCosts_t = (1 - \alpha) Y_t = (1 - \alpha) \left(\frac{K_t}{A L_t} \right)^\alpha A L_t. \quad (31)$$

(29) and (31) imply that, in equilibrium, $\Pi_t = 0$. Substituting (27) and (29) into (31), recalling $\Psi = (1 - \alpha) \left(\frac{\alpha}{\bar{r} + \delta} \right)^{\frac{1-\alpha}{1-\alpha}} A$, and solving for w_t implies

$$w_t = \frac{\Psi L_t}{\sum_{j=1}^J (1 - \bar{Z}_t^j) L_t^{C,j} + \phi \sum_{j=1}^J s^j \bar{Z}_t^j L_t^{C,j}}. \quad (32)$$

Using (26) and $L_t^{N,j} = \bar{Z}_t^j L_t^{C,j}$ in (32) and dividing both the numerator and the denominator on the right-hand side by L_t confirms the expression (14) for the wage rate.

Finally, with population fraction θ^j and human capital per hour, a^j , contractual labor supply by surviving members from education group j of all non-retired cohorts is given by

$$L_t^{C,j} = \theta^j a^j \sum_{v=t-\bar{R}+1}^t S_{v,t}^j \ell_{v,t}^j. \quad (33)$$

Recalling $g = \tilde{g}(d)$, and $\tilde{Z}(h, d) = Z(h, \tilde{g}(d), d)$, contractual labor units that are not working due to illness are thus given by

$$L_t^{N,j} = \theta^j a^j \sum_{v=t-\bar{R}+1}^t S_{v,t}^j \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j) \ell_{v,t}^j, \quad (34)$$

as stated in (15). Finally, (16) follows from inserting (33) and (34) into $L_t = \sum_j (L_t^{C,j} - L_t^{N,j})$.

A.1.2. Social Insurance Budget Constraints. Total earnings including sick pay is the sum of gross earnings as given by (8), $y_{v,t}^j = \tilde{y}^j(\ell_{v,t}^j, h_{v,t}^j, d_{v,t}^j; w_t, s^j)$, over all workers and the J types of labor. As the income tax revenue (at exogenous marginal tax rate τ^w) is used solely for redistributive purposes, a balanced budget requires that the earned income tax credit of a member of cohort v in period $t \in [v, v + \bar{R} - 1]$ is

$$\mathcal{T}_{v,t} = \frac{\tau^w \sum_{j=1}^J \theta^j \sum_{v=t-\bar{R}+1}^t S_{v,t}^j \tilde{y}^j(\ell_{v,t}^j, h_{v,t}^j, d_{v,t}^j; w_t, s^j)}{\sum_{j=1}^J \theta^j \sum_{v=t-\bar{R}+1}^t S_{v,t}^j} \equiv \bar{\mathcal{T}}_t \text{ for all } j, t \in [v, v + \bar{R} - 1], \quad (35)$$

and $\mathcal{T}_{v,t} = 0$ otherwise, where the numerator is total tax revenue from a proportional labor earnings taxation at tax rate τ^w and the denominator is the total number of individuals that are alive and employed in t .

Equalizing total contributions in the health system (recall that all surviving individuals contribute proportionally to their earnings, including sick pay and pension benefits) with total public expenditure for healthcare and the remaining fraction $(1 - \phi)$ of sick pay $s^j w_t L_t^{N,j}$, not borne by employers, the health contribution rate is endogenously given by

$$\tau_t^g = \frac{\sum_{j=1}^J \theta^j \left(\sum_{v=t-T+1}^t S_{v,t}^j \tilde{g}^j(d_{v,t}^j) + (1 - \phi) s^j w_t a^j \sum_{v=t-\bar{R}+1}^t S_{v,t}^j \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j) \ell_{v,t}^j \right)}{\sum_{j=1}^J \theta^j \left(\sum_{v=t-\bar{R}+1}^t S_{v,t}^j \tilde{y}^j(\ell_{v,t}^j, h_{v,t}^j, d_{v,t}^j; w_t, s^j) + \sum_{v=t-T+1}^{t-\bar{R}} S_{v,t}^j b_v P_{v,t}^j \right)}, \quad (36)$$

where we used (8) for the first summand and pension benefit function (10) for the second summand of the denominator, as well as (7) for the first and (34) for the second summand of the numerator.

Finally, the PAYG pension balanced budget constraint reads as

$$\tau^P \sum_{j=1}^J \theta^j \sum_{v=t-\bar{R}+1}^t S_{v,t}^j \tilde{y}^j(\ell_{v,t}^j, h_{v,t}^j, d_{v,t}^j; w_t, s^j) = \sum_{j=1}^J \theta^j \sum_{v=t-T+1}^{t-\bar{R}} S_{v,t}^j b_v P_{v,t}^j, \quad (37)$$

where the left-hand side equals contributions from aggregate earnings of working-aged individuals in t and the right-hand side is pension benefit payments for all retirees being alive in t .

A.1.3. *Individual Optimization.* Define $u^0 \equiv -[(1 - \sigma)^{-1} + \varrho(1 - \eta)^{-1}] + \bar{u}$. Then, according to (18) and (19), the Lagrangian \mathcal{L}_v^j for the utility optimization problem can be written as

$$\begin{aligned}
\mathcal{L}_v^j = & \dots + \beta^{t-v} S_{v,t}^j \underbrace{\left(\frac{(c_{v,t}^j)^{1-\sigma}}{1-\sigma} + \varrho \frac{\overbrace{[(1 - \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j)) (1 - \ell_{v,t}^j)]^{1-\eta}}^{=l_{v,t}^j}}{1-\eta} + u^0 \right)}_{=u(c_{v,t}^j, l_{v,t}^j)} + \\
& \beta^{t+1-v} S_{v,t+1}^j \left(\frac{(c_{v,t+1}^j)^{1-\sigma}}{1-\sigma} + \varrho \frac{[(1 - \tilde{Z}^j(h_{v,t+1}^j, d_{v,t+1}^j)) (1 - \ell_{v,t+1}^j)]^{1-\eta}}{1-\eta} + u^0 \right) + \dots + \\
& \lambda_{v,t}^j \left[(1 + r_{v,t}^j) k_{v,t}^j + (1 - \tau_t) \tilde{y}^j(\ell_{v,t}^j, h_{v,t}^j, d_{v,t}^j; w_t, s) + \right. \\
& \left. \mathbf{1}_{v,t}(\bar{R}) \mathcal{T}_{v,t} + (1 - \tau_t^g) \tilde{B}(P_{v,t}^j) - h_{v,t}^j - c_{v,t}^j - k_{v,t+1}^j \right] + \\
& \lambda_{v,t+1}^j \left[(1 + r_{v,t+1}^j) k_{v,t+1}^j + (1 - \tau_{t+1}) \tilde{y}^j(\ell_{v,t+1}^j, h_{v,t+1}^j, d_{v,t+1}^j; w_{t+1}, s^j) + \right. \\
& \left. \mathbf{1}_{v,t+1}(\bar{R}) \mathcal{T}_{v,t+1} + (1 - \tau_{t+1}^g) \tilde{B}(P_{v,t+1}^j) - h_{v,t+1}^j - c_{v,t+1}^j - k_{v,t+2}^j \right] + \dots + \\
& \chi_{v,t}^j \left[(1 + \mu^j) d_{v,t}^j + \varsigma \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j) - d_{v,t+1}^j \right] + \\
& \chi_{v,t+1}^j \left[(1 + \mu^j) d_{v,t+1}^j + \varsigma \tilde{Z}^j(h_{v,t+1}^j, d_{v,t+1}^j) - d_{v,t+2}^j \right] + \dots + \\
& \omega_{v,t}^j \left[(1 - \tilde{m}(d_{v,t}^j)) S_{v,t}^j - S_{v,t+1}^j \right] + \\
& \omega_{v,t+1}^j \left[(1 - \tilde{m}(d_{v,t+1}^j)) S_{v,t+1}^j - S_{v,t+2}^j \right] + \dots + \\
& \varepsilon_{v,t}^j \left[P_{v,t}^j + \tau_t^P \tilde{y}^j(\ell_{v,t}^j, h_{v,t}^j, d_{v,t}^j; w_t, s) - P_{v,t+1}^j \right] + \\
& \varepsilon_{v,t+1}^j \left[P_{v,t+1}^j + \tau_{t+1}^P \tilde{y}^j(\ell_{v,t+1}^j, h_{v,t+1}^j, d_{v,t+1}^j; w_{t+1}, s^j) - P_{v,t+2}^j \right] + \dots, \tag{38}
\end{aligned}$$

where $\{\lambda_{v,t}^j\}$, $\{\chi_{v,t}^j\}$, $\{\omega_{v,t}^j\}$ and $\{\varepsilon_{v,t}^j\}$ denote the sequences of shadow prices of capital holdings, health deficits, survival probabilities and pension wealth, respectively. At the end of life, either the pension stock or the shadow price of the pension stock must be equal to zero. Since the pension stock is always greater than zero, transversality condition $\varepsilon_{v,v+T-1}^j = 0$ must hold. Similarly, with respect to health deficits, we have transversality condition $\chi_{v,v+T-1}^j = 0$. Moreover, with respect to the unconditional survival probability, there is the transversality condition $\omega_{v,v+T-1}^j S_{v,v+T-1}^j = 0$. In the numerical implementation, we focus on the case where $S_{v,v+T-1}^j > 0$, i.e. health deficits never reach a value $(1/\kappa)^{1/\psi}$ that would imply $m_{v,t+1}^j = 1$ for some $t \leq v + T - 1$. Thus, $\omega_{v,v+T-1}^j = 0$

must hold. In addition, as the time horizon exogenously ends thereafter, $S_{v,v+T}^j = 0$ by assumption. Finally, as there is no bequest motive, capital holdings after death must be zero, $k_{v,v+T}^j = 0$, i.e. individuals consume their remaining capital stock at $v + T - 1$, since it is not optimal to leave a positive capital stock in absence of a bequest motive.

The first-order conditions $\partial \mathcal{L}_v^j / \partial c_{v,t}^j = \partial \mathcal{L}_v^j / \partial \ell_{v,t}^j = \partial \mathcal{L}_v^j / \partial h_{v,t}^j = \partial \mathcal{L}_v^j / \partial d_{v,t+1}^j = \partial \mathcal{L}_v^j / \partial S_{v,t+1}^j = \partial \mathcal{L}_v^j / \partial P_{v,t+1}^j = \partial \mathcal{L}_v^j / \partial k_{v,t+1}^j = 0$ can be written as

$$\lambda_{v,t}^j = \beta^{t-v} S_{v,t}^j (c_{v,t}^j)^{-\sigma}, \quad (39)$$

$$\begin{aligned} & \left[\lambda_{v,t}^j (1 - \tau_t) + \varepsilon_{v,t}^j \tau^P \right] \left(1 - \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j)(1 - s^j) \right) w_t a^j \\ &= \varrho \beta^{t-v} S_{v,t}^j (l_{v,t}^j)^{-\eta} (1 - \tilde{Z}^j(h_{v,t}^j, d_{v,t}^j)), \end{aligned} \quad (40)$$

$$\begin{aligned} \lambda_{v,t}^j &= -\tilde{Z}_h^j(h_{v,t}^j, d_{v,t}^j) \times \\ & \left(\beta^{t-v} S_{v,t}^j \varrho (l_{v,t}^j)^{-\eta} (1 - \ell_{v,t}^j) - \chi_{v,t}^j \varsigma + \left[\lambda_{v,t}^j (1 - \tau_t) + \varepsilon_{v,t}^j \tau^P \right] (1 - s) w_t a^j \ell_{v,t}^j \right), \end{aligned} \quad (41)$$

$$\begin{aligned} \chi_{v,t}^j &= -\beta^{t+1-v} S_{v,t+1}^j \varrho (l_{v,t+1}^j)^{-\eta} \tilde{Z}_d^j(h_{v,t+1}^j, d_{v,t+1}^j) (1 - \ell_{v,t+1}^j) + \\ & \chi_{v,t+1}^j \left[1 + \mu^j + \varsigma \tilde{Z}_d^j(h_{v,t+1}^j, d_{v,t+1}^j) \right] - \omega_{v,t+1}^j \tilde{m}'(d_{v,t+1}^j) S_{v,t+1}^j - \\ & \tilde{Z}_d^j(h_{v,t}^j, d_{v,t}^j) (1 - s) w_t a^j \ell_{v,t}^j \left[\lambda_{v,t+1}^j (1 - \tau_{t+1}) + \varepsilon_{v,t+1}^j \tau_{t+1}^P \right], \end{aligned} \quad (42)$$

$$\omega_{v,t}^j = \beta^{t+1-v} u(c_{v,t+1}^j, l_{v,t+1}^j) + \omega_{v,t+1}^j (1 - \tilde{m}(d_{v,t+1}^j)), \quad (43)$$

$$\varepsilon_{v,t}^j = \varepsilon_{v,t+1}^j + \lambda_{v,t+1}^j (1 - \tau_{t+1}^g) \tilde{B}'(P_{v,t+1}^j), \quad (44)$$

$$\lambda_{v,t}^j = \lambda_{v,t+1}^j (1 + r_{v,t+1}^j), \quad (45)$$

where we used (9) and, according to (8), $\tilde{y}_\ell^j(\ell, h, d; w, s) = [1 - \tilde{Z}^j(h, d)(1 - s)] w a^j$ as well as $\tilde{y}_x^j(\ell, h, d; w, s) = -\tilde{Z}_x^j(h, d)(1 - s) w a^j \ell$ for $x \in \{h, d\}$. We can rewrite (44) to obtain the first-order difference equation $\varepsilon_{v,t}^j = \varepsilon_{v,t-1}^j - \lambda_{v,t}^j (1 - \tau_t^g) \tilde{B}'(P_{v,t}^j)$. It has the solution

$$\varepsilon_{v,t}^j = \varepsilon_{v,v}^j - \sum_{u=v+1}^t (1 - \tau_u^g) \tilde{B}'(P_{v,u}^j) \lambda_{v,u}^j. \quad (46)$$

To obtain initial value $\varepsilon_{v,v}^j$, combine

$$\varepsilon_{v,v+T-1}^j = \varepsilon_{v,v}^j - \sum_{u=v+1}^{v+T-1} (1 - \tau_u^g) \tilde{B}'(P_{v,u}^j) \lambda_{v,u}^j \quad (47)$$

with transversality condition $\varepsilon_{v,v+T-1}^j = 0$ to find

$$\varepsilon_{v,v}^j = \sum_{u=v+1}^{v+T-1} (1 - \tau_u^g) \tilde{B}'(P_{v,u}^j) \lambda_{v,u}^j. \quad (48)$$

According to (10), $\tilde{B}'(P_{v,t}^j) = 0$ for $t \in \{v, \dots, v + \bar{R} - 1\}$ and $\tilde{B}'(P_{v,t}^j) = b_v$ otherwise. Using this and inserting (48) into (46), we obtain

$$\varepsilon_{v,t}^j = \begin{cases} \sum_{u=v+\bar{R}}^{v+T-1} (1 - \tau_u^g) b_u \lambda_{v,u}^j & \text{for } v \leq t \leq v + \bar{R} - 1, \\ \sum_{u=t+1}^{v+T-1} (1 - \tau_u^g) b_u \lambda_{v,u}^j & \text{for } v + \bar{R} \leq t \leq v + T - 1. \end{cases} \quad (49)$$

Combining (39) and (45) leads to

$$\left(\frac{c_{v,t+1}^j}{c_{v,t}^j} \right)^\sigma = \frac{\beta S_{v,t+1}^j}{S_{v,t}^j} (1 + r_{v,t+1}^j) \quad (50)$$

According to (4), we have $S_{v,t+1}^j/S_{v,t}^j = 1 - m_{v,t}^j$ and, using $S_{v,v}^j = 1$,

$$S_{v,t}^j = \prod_{u=v}^{t-1} (1 - m_{v,u}^j). \quad (51)$$

Moreover, we have $(1 + r_{v,t+1}^j)(1 - m_{v,t}^j) = 1 + \bar{r}$, according to (12). Using these relations in (50) provides us with the simple Euler equation

$$c_{v,t+1}^j = [\beta(1 + \bar{r})]^{\frac{1}{\sigma}} c_{v,t}^j. \quad (52)$$

To eliminate mortality-dependent interest rate factors also from the individual budget constraints, we can derive from combining (17) with $k_{v,v}^j = k_{v,v+T}^j = 0$ and then using both (12) and (51) the intertemporal budget constraint for a member of cohort v from group j as

$$0 = \sum_{t=v}^{v+T-1} \left(\frac{S_{v,t}^j \left[(1 - \tau_t) y_{v,t}^j + \mathbf{1}_{v,t}(\bar{R}) \mathcal{T}_{v,t} + (1 - \tau_t^g) B_{v,t}^j - h_{v,t}^j - c_{v,t}^j \right]}{(1 + \bar{r})^{t-v}} \right). \quad (53)$$

A.1.4. Dynamic System. In sum, the dynamic system is given by (2), (4), (8), (9), (10), (11), (14), (15), (16), (35), (36), (37), (39)-(43), (49), (52), (53), transversality conditions $\chi_{v,v+T-1}^j = 0$ and $\omega_{v,v+T-1}^j = 0$, initial conditions $S_{v,v}^j = 1$, $P_{v,v}^j = 0$ and $d_{v,v}^j = \underline{d}$, terminal condition $S_{v,v+T}^j = 0$, and $\ell_{v,t}^j = 0$ (implying $y_{v,t}^j = 0$) for all $t \geq v + \bar{R}$.

A.2. Welfare Analysis. For the welfare effects of policy experiments, we compute group-specific consumption equivalents with respect to alternative policy scenarios, i.e. we derive the factor by which consumption in the status quo policy scenario is multiplied each period such that an individual experiences the same utility as in the considered policy alternative (*equivalent variation*).

Formally let superscripts “0” and “1” on endogenous variables indicate the values in the status quo and alternative policy scenario, respectively, and define

$$\tilde{U}_v^{j,policy}(\Theta) := \sum_{t=v}^{v+T-1} S_{v,t}^{j,policy} \beta^{t-v} u(\Theta \cdot c_{v,t}^{j,policy}, l_{v,t}^{j,policy}) \quad (54)$$

as the intertemporal utility of any individual from cohort v and group j under policy scenario $policy \in \{0, 1\}$ when the optimally chosen consumption levels are multiplied by factor Θ . The group-specific equivalent variation measure Θ_v^j is then implicitly defined as

$$\tilde{U}_v^{j,0}(\Theta) = \tilde{U}_v^{j,1}(1). \quad (55)$$

A.3. Hand-to-Mouth Consumers: Calibration. Table 7 displays the calibration results for the modified model where low-education households are hand-to-mouth consumers.

TABLE 7. Hand-to-Mouth Consumers: Calibration Results

Parameter	Value	Explanation
η	6	elasticity of marginal utility from leisure
β	0.95	time preference
μ	0.020	rate of ageing
ζ^1	1.60	sick time level parameter of low education group
ζ^2	1.50	sick time level parameter of middle education group
ζ^3	1.29	sick time level parameter of high education group
γ	0.62	sick time curvature parameter
G	270.21	level parameter public health care expenditure
v	3.20	curvature parameter public health care expenditure
ξ	0.060	level parameter effectiveness of health care
ϵ	0.14	curvature parameter effectiveness of health care
ς	0.004	effect of sick time on deficit accumulation
ϱ	0.34	preference parameter for leisure
κ	79.8	mortality level parameter
ψ	3.55	mortality curvature parameter
\bar{u}	4.54	utility constant