Long-Term Health Insurance: Theory Meets Evidence

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Abstract

To insure policyholders against contemporaneous health expenditure shocks and future reclassification risk, long-term health insurance constitutes an alternative to community-rated short-term contracts with an individual mandate. Relying on unique claims panel data from a big private insurer in Germany, we study a real-world long-term health insurance application with a life-cycle perspective. We show that German long-term health insurance (GLTHI) provides large welfare gains compared to a series of risk-rated short-term contracts. Although, by design, the GLTHI contract differs substantially from the optimal dynamic contract, we only find modest welfare differences between the two. Moreover, we show that a simple modification to the GLTHI contract would further close this welfare gap. Finally, we conduct counterfactual policy experiments to illustrate the welfare consequences of integrating GLTHI into a system with a "Medicare-like" public insurance that covers people above 65.

Keywords: long-term health insurance, spot price market, individual private health insurance, welfare effects, health policy reform

JEL classification: G22; I11; I18.

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1 Introduction

For decades, academics and policymakers alike have been studying options to regulate private health insurance markets. Such policy options strive to avoid outcomes that are considered undesirable, such as uninsurance or unaffordable premiums for sick individuals (Claxton et al., 2017). However, standard regulatory tools to address these issues, such as community-rated premiums and guaranteed issue, involve cross-subsidization from the healthy towards the sick, and therefore typically imply a trade-off with other unintended consequences such as adverse selection (cf. Akerlof, 1970).

A fundamental alternative to regulated cross-subsidization under individual mandates is an individual long-term health insurance contract. Instead of relying on transfers across individuals with different health statuses, long-term contracts leverage an individual's private intertemporal incentives. Under long-term contracts, sick individuals pay relatively low premiums by paying relatively high premiums in healthy times of their life. In theory, a carefully designed long-term contract can reduce the risk of premium fluctuations due to health shocks ("reclassification risk"), while ensuring participation and eliminating adverse selection (cf. Pauly et al., 1999; Patel and Pauly, 2002; Pauly and Lieberthal, 2008).

In this paper, we study the private health insurance market of Germany, where 10 percent of the population (or 8.8 million individuals), hold an individual long-term health insurance policy sold by private insurance companies. After an initial risk-rating, the policies are guaranteed renewable until death (without an expiration date or enrollment period) and future premium changes have to be community rated; that is, premium changes over the lifecycle are independent of changes in the policyholder's health status. (Germany has no public insurance specifically for people above the age of 65, like Medicare in the United States.)

The simple design of German long-term health insurance (henceforth GLTHI) differs substantially from the welfare-maximizing contract derived by Handel et al. (2017) (henceforth HHW). The German contract foresees the payment of constant premiums over the lifecycle, regardless of the evolution of an individual's income and health status. As a consequence, the GLTHI contract almost entirely eliminates reclassification risk—at the expense of relatively high premiums during the early life years. In contrast, the optimal dynamic contract involves

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a premium path that is income-dependent, and that changes over the lifecycle after the realization of health shocks. The optimal contract considers the individual's lifecycle income profile to find the welfare-maximizing balance between insurance against reclassification risk and consumption smoothing over the lifecycle.[1]

The main goal of this paper is to evaluate the welfare consequences of the GLTHI design and to compare it to the theoretically optimal benchmark. Specifically, we assess the welfare gains of replacing GLTHI contracts with optimal dynamic contracts for a large and representative population of German enrollees. For this purpose, we combine administrative data from a unique panel of more than 620 thousand individual GLTHI policyholders with more than three decades of lifecycle income panel data from the German Socio-Economic Panel Study (SOEP).

Our findings show that the simple GLTHI design generates only small welfare losses compared to the optimal contract. Under our preferred parametrization, replacing GLTHI contracts with optimal contracts would increase welfare by only 1 percent. Within a plausible range of parameter values, we find that the welfare gains are smaller than 4 percent. Compared to the optimal contract, the GLTHI entails less consumption smoothing over the lifecycle but also less reclassification risk. On balance, compared to the optimal contract, the lower welfare due to less consumption smoothing is almost entirely offset by better reclassification risk insurance in the GLTHI contract. Moreover, we show that a simple modification of the GLTHI contract could achieve almost the same welfare as the optimal contract.

In light of these results, we then study the welfare consequences of implementing the GLTHI and the optimal dynamic contract in an economy with a public pay-as-you-go insurance program for retirees, like the Medicare program in the United States. In this simple economy, individuals buy a long term contract during their working ages. Then, public insurance for retirees is modeled as free insurance in old age, fully financed by mandatory payroll taxes during working ages. Therefore, the Medicare program acts as a mandatory frontloaded health insurance program to cover for expenses in old-age. The mandatory taxes of the Medicare program alleviate the welfare loss due to one-sided commitment, but at the cost of additional front-loading.

Overall, we find that combining long term contracts during working ages with a Medicare-like program *decreases* welfare relative to an economy with long term contracts during the

[1] The contract derived by Handel et al. (2017) and described here is optimal under one-sided commitment and no-borrowing constraints. The first-best contract corresponds to a constant consumption profile over an individual's lifetime but is unattainable under those assumptions, which we also maintain in this paper.

entire lifecycle. On the other hand, replacing a series of short-term contracts with a long-term contract during working ages increases welfare substantially, even in the presence of a Medicare-like program.

This paper contributes to the literature on dynamic contracts, for which vast theoretical work, but relatively little empirical evidence exists. Pauly et al. (1995) propose a "guaranteed-renewable" contract with a pre-specified path of premiums that fully eliminates adverse selection and reclassification risk. Similarly, Cochrane (1995) proposes a scheme of severance payments, made after the realization of health shocks, which fully insurance reclassification risk. Hendel and Lizzeri (2003) and Handel et al. (2017) show that the optimal contract only partially insures reclassification risk, because fully eliminating reclassification risk requires large frontloaded payments, preventing consumption smoothing over the lifecycle. A common issue with these contracts is the complexity of their design. We contribute to this literature by illustrating how an existing and simple real-world alternative addresses reclassification risk with low information requirements.

Hendel and Lizzeri (2003), Herring and Pauly (2006), Finkelstein et al. (2005), and Atal (2016) investigate empirically the workings of long-term contracts in different contexts. Compared to the literature, we quantify the welfare effects of existing long-term contracts in the world's fourth largest economy. As we benchmark the welfare effects of the GLTHI with the optimal contract, our work builds particularly on Handel et al. (2017). We extend their calibration approach by considering risks over the entire lifecycle. We also provide refinements to the definition and modeling of health risks.

A few papers have studied the GLTHI. Hofmann and Browne (2013) describe GLTHI contracts and switching behavior that is consistent with the incentives of long-term contracts. Christiansen et al. (2016) empirically study determinants of lapsing and switching behavior. Baumann et al. (2008) and Eekhoff et al. (2006) discuss the potential effects of higher switching rates on market competition if the capital accumulated through frontloaded payments were to be made portable across insurers. While these two papers discuss a hypothetical reform, Atal et al. (2018) theoretically and empirically study the effects of the actual 2009 portability reform on switching behavior. The main contribution of this paper is to study the GLTHI design from a welfare perspective.

2 Institutional Details

Germany has a two-tier health insurance system with a co-existing multi-payer public statutory health insurance (SHI) and an individual private health insurance market. Ninety percent of the population is covered by the public tier in one of the 110 non-profit sickness funds (Schmitz and Ziebarth, 2017; Bünnings et al., 2018). Enrollees pay income-dependent contribution rates for a standardized benefit package with very little cost-sharing. However, for historical reasons, select population subgroups have the right to leave the public system permanently and fully insure their health risks on a private market. In the private market, individuals can choose among thousands of individual long-term plans. Ziebarth (2010) and Karlsson et al. (2016) provide more details on the general structure of the German health insurance market. Hofmann and Browne (2013) and Atal et al. (2018) provide additional specific details on the individual private market.

Besides Chile (cf. Atal, 2016), Germany is the only country in the world with an existing individual private long-term health insurance market. About 8.8 million enrollees are long-term insured on this market (Association of German Private Healthcare Insurers, 2018b). For historical reasons, the GLTHI market covers three main population subgroups: (a) the self-employed; (b) high-income earners with gross labor incomes above a politically defined federal threshold (2019: €60,750 or about $72,900 p.a.); and (c) civil servants. These population subgroups have the option to leave the public SHI system and insure their health risks privately with a long-term contract (Nuscheler and Knaus, 2005; Hullegie and Klein, 2010; Polyakova, 2016). The decision to enter the private market is essentially a "lifetime decision". Switching back to SHI is strictly limited to avoid that individuals strategically switch back and forth and game the system; the basic principle is "once privately insured, always privately insured" (Schencking, 1999; Innungskrankenkasse Berlin Brandenburg, 2018). We discuss the institutional specifics of this rule, as well as empirical evidence on switching from GLTHI to SHI in Appendix A2.

The GLTHI market consists of 44 private insurers that sell *comprehensive* and *supplemental* insurance coverage. The focus of this paper are comprehensive or "substitutive (to SHI)" policies, which are solely sold as individual policies. Consumer advantages of opting out of SHI and getting comprehensive private GLTHI coverage include that GLTHI offers actuarially fair premiums as well as choice.[2] Compared to the post-ACA era in the U.S., the GLTHI market is less regulated. Applicants can freely choose their level of coverage in terms of benefits and cost-sharing amounts. This results in thousands of different health plans among the 8.8 million policyholders, most of which are sold across state lines and nationwide. The majority of private insurers operate nationwide and are open to all applicants who opt out of SHI.

Provider Networks. Provider networks and "Managed Care" are unknown in the public and private system; that is, people can freely choose their providers in either system. Moreover, in both the public and private system, reimbursement rates are centrally determined and do not vary by insurers or health plans. Private insurers customize health plans and process, scrutinize, and deny claims. Thus, the GLTHI contract primarily constitutes a financial contract.

Guaranteed Renewability and One-Sided Commitment. While insurers can initially deny coverage to bad risks, insurers cannot cancel ongoing contracts. In other words, guaranteed renewability exists. In addition, whereas the initial premium is risk-rated, all subsequent premium increases are community-rated at the health plan level, such that the contract provides insurance against reclassification risk. In addition, there is no fixed enrollment period; contracts are permanent and do not have to be renewed. Because enrollees can cancel their permanent contracts but insurers cannot, the GLTHI is a market with a one-sided commitment. However, because switching carriers typically entails a new risk rating, it is relatively common that enrollees remain insured with their carrier until they die (Medicare does not exist in Germany). In our sample, the policyholders' average age is 46 years and policyholders have been with the insurer for an average of 13 years; the oldest client is 106 years old and has been with the insurer for 85 years, see Table A1 (Appendix).

Premium Calculation and Old Age Provisions. The initial GLTHI premium is individually underwritten.[3] Premiums consist of several components whose calculations are regulated by

[2]GLTHI premiums are actuarially fair in a lifetime perspective. In general, premiums are higher than expected contemporaneous health care claims in early ages and lower than expected contemporaneous health care claims in old ages. See Figure 1 and below for a detailed discussion of the premium calculation.

[3] The only exception is the "Basic Plan" (*Basistarif*). The Basic Plan must be offered by all carriers and is structured after the SHI with the same essential benefits and actuarial values. For the Basic Plan, guaranteed issue exists for people above 55 and those who joined the PHI after 2009. The maximum premium is capped at the maximum SHI premium (2018: €703,32 per month). The legislature mandated the Basic Plan to provide an "affordable" private option for PHI enrollees who cannot switch back to SHI, are uninsured, would have to pay excessive premiums, or would be denied coverage. However, the demand for the Basic Plan has been negligible which is why, henceforth, we will abstain from it. In 2017, in the entire PHI, only 31,400 people or 0.3 percent were enrolled in the

the *Kalkulationsverordnung (KalV)*. The insurers' actuaries carry out the specific actuarial calculations which have to be approved by a federal financial regulatory agency, the *Bundesanstalt für Finanzdienstleistungsaufsicht (BaFin)*. As mentioned, guaranteed renewability exists and premium changes have to be community-rated at the plan level after the initial risk-rating. However, when switching carriers, a new risk rating is routinely carried out.

One important and distinct characteristic of the GLTHI market is the legal obligation of insurers to build up old-age provisions, typically until around age 60 of the policyholder. Thus, premiums are heavily front-loaded over enrollees' life cycles (Nell and Rosenbrock, 2007, 2009).[4]

Figure 1 provides an exemplary illustration of this front-loading for four combinations of age at initial enrollment and health: high and low health risk, and initial enrollment at either age 30 or 50. The low health risk type corresponds to a hypothetical individual with no pre-existing conditions—who pays a premium based on age, sex and the benefit package. The high health risk type corresponds to a hypothetical individual who has 50 percent higher expected health care costs at each age.

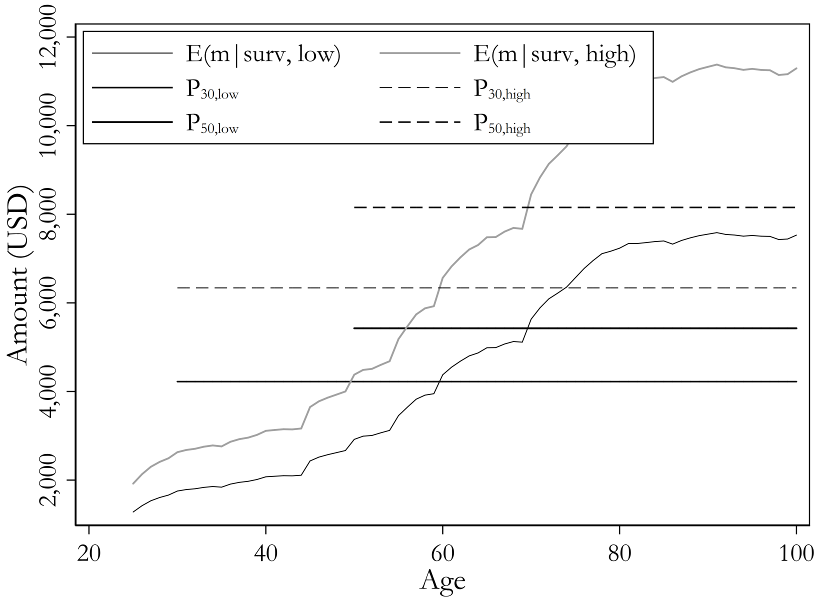
Figure 1 shows the following: First, the premium is generally higher for enrollees who joined GLTHI later in their life: the low-risk type faces a premium of $4,225 if joining at age 30, compared to $5,426 if joining at age 50.[5] Second, due to the initial risk rating, high-risk types (the "sick") are offered a higher premium at enrollment as compared to low-risks (the "healthy"), and would permanently pay a higher premium if they remain high-risk. On the other hand, a individual who is high-risk at 30 and becomes low-risk at 50 could lapse and buy a cheaper contract. Finally, young enrollees' premiums significantly exceed their expected health claims, while old enrollees' premiums are significantly lower than their expected health claims. The main idea of GLTHI is to frontload premiums and dampen reclassification risk and age-related increases in premiums via the capital stock built through old-age provisions. Ideally, as illustrated by Figure 1, real premiums would then remain entirely stable over enrollees'

Basic Plan (Association of German Private Healthcare Insurers, 2018a). In our data, only 1,006 enrollees chose the basic plan in 2010.

[4] Such front-loading creates a "lock-in" effect, in addition to the lock-in induced by guaranteed renewability (Nell and Rosenbrock, 2008; Atal, 2016). To strengthen consumer power and reduce this lock-in, the German legislature made a standardized portion of these old-age provisions portable across carriers for contracts signed after Jan 1, 2009; see Atal et al. (2018) for an evaluation of this reform. For existing contracts, Atal et al. (2018) do not find a significant impact on external switching rates. However, they find a one-time increase in internal plan switching during the limited six months period from January to June 2009 where portability was granted for existing contracts.

[5] In our data, this is true for most age ranges. However, initial premiums start to decrease at very high ages, as the need to frontload for future expenses decreases (see Section 6.1.)

Figure 1: Premiums and Health Expenditures over the Lifecycle in the GLTHI



Source: German Panel Claims Data (see Section 4.1), own calculations, own illustration.

life cycles. In 2017, the capital stock built through old-age provisions amounted to €210.5 billion ($252,6 billion) for 8,753,400 policies, or to €24,048 ($28,857) per policy (Association of German Private Healthcare Insurers, 2018a).

3 Welfare Consequences of Long-Term Health Insurance

3.1 Lifecycle Premiums in the German Long-Term Health Insurance (GLTHI)

We start by formalizing the calculation of GLTHI premiums over the lifecycle. Then we compare them to the lifecycle premium profile of the optimal dynamic contract as derived by Handel et al. (2017) (HHW).

Let $P_t(\xi_t)$ be the premium offered when signing a GLTHI contract in period t. $P_t(\xi_t)$ depends on the individual's health risk in year t, ξ_t, as GLTHI contracts are individually underwritten at inception (see Section 2). In subsequent periods, each contract is guaranteed-renewable until death. As such, individuals who sign a contract in period t can renew the contract for the same premium, $P_t(\xi_t)$, in all periods between $t+1$ and T, regardless of the evolution of their health status.

As a result of mandated old-age provisions (see Section 2), the contract breaks-even in equilibrium, given premium $P_t(\xi_t)$. Consequently, we express $P_t(\xi_t)$ as the solution to a fixed-point problem in which $P_t(\xi_t)$ covers exactly the expected claims of enrollees who stay in the contract at premium $P_t(\xi_t)$ until death. We solve for $P_t(\xi_t)$ recursively, starting from the last period, $t = T$. In T, there is no uncertainty regarding future health shocks and future lapsation. Let m_t denote health care expenditures in year t. Assuming full coverage, it follows that $P_T(\xi_T) = \mathbb{E}(m_T|\xi_T)$.

To calculate the equilibrium premium in $t < T$, we need to consider endogenous lapsation. Enrollees will lapse their current contract if, given the evolution of their health status, they can obtain a lower premium than their guaranteed-renewable premium in the spot market. Formally, lapsing a contract signed in $t < T$ at the risk-rated premium $P_t(\xi_t)$ occurs at the first $\tau > t$ where $P_\tau(\xi_\tau) < P_t(\xi_t)$.[6]

For a given t, we denote $\mathbf{P}^{\tau}_{t+1}$ as the set of guaranteed premiums from $t+1$ to $t+\tau$, i.e., $P_{t+1}(.), P_{t+2}(.), ..., P_{t+\tau}(.)$. Then, we can write the flat GLTHI lifecycle premium, $P_t(\xi_t)$ as:

$$P_t(\xi_t) = \frac{\mathbb{E}(m_t|\xi_t) + \sum_{\tau>t}^{T} \sum_{z} \delta^{\tau-t} \mathbb{E}(m_\tau|z) \times p_\tau(z|\xi_t, \mathbf{P}^{\tau}_{t+1}, P_t(\xi_t))}{1 + \sum_{\tau>t}^{T} \sum_{z} \delta^{\tau-t} \times p_\tau(z|\xi_t, \mathbf{P}^{\tau}_{t+1}, P_t(\xi_t))} \quad (1)$$

The first element of the numerator is expected health care costs in period t, given ξ_t. The second element of the numerator is the sum of expected future health care costs over all remaining life years, which are discounted with δ. Future spending is weighted by $p_\tau(z|\xi_t, \mathbf{P}^{\tau}_{t+1}, P_t(\xi_t))$, the probability that (1) $\xi_\tau = z$ and (2) the individual does not lapse (or die) between periods t and τ, given the subsequent premium guarantees $\mathbf{P}^{\tau}_{t+1}$. These expected lifecycle health care claims are then normalized by the expected number of years in the contract in the denominator. In other words, in the GLTHI market, the lifecycle premium $P_t(\xi_t)$ equals the average of today's expected health care spending and all expected future health care spending, given the health risk today and in the future, weighted by the likelihood to lapse in any of the future time periods until death.

Equation (1) implicitly determines the constant GLTHI equilibrium lifecycle premium for a contract signed in period t. Note that the break-even constraint determines the GLTHI life-

[6]Note that we abstain from horizontal differentiation across plans, and from switching costs.

cylce premium in any period for different health statuses, considering the likelihood to lapse in future periods. These lifecycle premiums do not maximize any *ex ante* consumer objective functions; conceptually, they are not designed to maximize social welfare.

3.2 Lifecycle Premiums in the Optimal Dynamic Health Insurance Contract (HHW)

In contrast, Handel et al. (2017) study the optimal dynamic health insurance contract that maximizes consumer welfare, subject to break-even, no lapsation, and no borrowing constraints. Handel et al. (2017) show that the optimal dynamic insurance contract provides a consumption guarantee that is a function of enrollees' health risk and income paths. In particular, the optimal dynamic insurance contract provides a minimum consumption guarantee $\bar{c}_t(\xi_t)$ that increases whenever a competing firm offers a higher consumption guarantee and still breaks-even in expectation.

Analogous to the GLTHI lifecycle premium calculation, $\bar{c}_t(\xi_t)$ is solved by backwards induction. Specifically, the consumption guarantee in period T is given by $\bar{c}_T(\xi_T) = y_T - \mathbb{E}(m_T|\xi_T)$ where y_t is enrollees' income. Denoting the set of future consumption guarantees $\mathbf{C_{t+1}}$, an algebraic reformulation of the consumption guarantee in Handel et al. (2017) yields:

$$\bar{c}_t(\xi_t) = \frac{y_t - \mathbb{E}(m_t|\xi_t) + \sum_{\tau>t}^{T}\sum_{z}\delta^{\tau-t}(y_\tau - \mathbb{E}(m_\tau|z)) \times p_\tau(z|\xi_t, \mathbf{C}_{t+1}, \bar{c}_t(\xi_t))}{1 + \sum_{\tau>t}^{T}\sum_{z}\delta^{\tau-t} \times p_\tau(z|\xi_t, \mathbf{C_{t+1}}, \bar{c}_t(\xi_t))} \quad (2)$$

where $p_\tau(z|\xi_t, \mathbf{C}_{t+1}, \bar{c}_t(\xi_t))$ is, with some slight abuse of notation, the probability that (1) $\xi_\tau = z$ and (2) the individual does not lapse (or die) between periods t and τ, given the set of future consumption guarantees $\mathbf{C}_{t+1}$. Again, as above, Equation (2) implicitly determines the consumption guarantee in period t. As noted in Handel et al. (2017), these consumption guarantees can be re-interpreted as a series of contracts with guaranteed premium paths $P_\tau = y_\tau - \bar{c}_t(\xi_t)$ for $\tau \geq t$ from which the consumer would lapse at a time $\tau' > \tau$ whenever $\bar{c}_{\tau'}(\xi_{\tau'}) > \bar{c}_\tau(\xi_\tau)$.

3.3 GLTHI vs. HHW from a Welfare Perspective

The design of the GLTHI contract differs substantially from the welfare-maximizing HHW contract, leading to different consumption profiles.[7] On the one hand, GLTHI implies the payment of a constant premium regardless of policyholders' income and the evolution of their health (with the exception of those who become healthy enough to switch to a contract with lower premiums. As shown later, this is a rare occurrence). As a consequence, the GLTHI contract almost completely eliminates the reclassification risk. However, the elimination of reclassification risk comes at the expense of large premium payments at early ages to prevent future premium hikes. These large upfront premiums have negative welfare implications when income is low and the marginal utility of consumption high at early ages. On the other hand, the optimal dynamic contract involves a path of consumption guarantees (and therefore, a path of premiums) that is income-dependent; and that changes over the lifecycle after health shocks. The reason is that the optimal contract penalizes large premiums when the marginal utility of consumption is large.

We quantify the welfare consequences under each contract from the perspective of lifetime utility U:

$$U = \mathbb{E}\left(\sum_{t=1}^{T} S_t \delta^{t-1} u(c_t)\right)$$

where S_t is an indicator of survival until period t. Expectation is taken over the individual's lifetime health history $(\xi_1, \xi_2, ..., \xi_t)$ and survival.[8] With a parametric assumption for flow utility $u()$, and knowing income y_t, we can summarize welfare with the "certainty income equivalent", denoted CE, such that:

$$u(CE) = \frac{\mathbb{E}\left(\sum_{t=1}^{T} S_t \delta^{(t-1)} u\left(c_t\right)\right)}{\mathbb{E}\left(\sum_{t=1}^{T} S_t \delta^{t-1}\right)}$$

This simple expression captures the main trade-offs in health insurance design for lifetime welfare. Lifetime utility is higher when consumption is smoothed across health states and across periods. In particular, the first-best consumption level is equal to the present discounted

[7] In the special case of flat income over the lifecycle ($y_t = \bar{y}$), the consumption guarantee $y - P_t(\xi_t)$ in GLTHI coincides with the optimal consumption guarantee, cf. Equations (1) and (2). That is, GLTHI equals HHW when lifecycle income is flat.

[8] We assume that there are no annuity markets, so mortality risk is still considered.

value of "net income" $y_t - \mathbb{E}(m_t)$, taking into account mortality risk. This constant optimal consumption level C^* is given by:

$$C^* = \frac{\mathbb{E}\left(\sum_{t=1}^{T} S_t \delta^{t-1}(y_t - \mathbb{E}(m_t))\right)}{\mathbb{E}\left(\sum_{t=1}^{T} S_t \delta^{t-1}\right)} \tag{3}$$

In contrast, under a series of actuarially fair short-term contracts, $C_t = y_t - \mathbb{E}(m_t|\xi_t)$, the certainty equivalent CE becomes:

$$u(CE_{ST}) = \frac{\mathbb{E}\left(\sum_{t=1}^{T} S_t \delta^{t-1} u(y_t - \mathbb{E}(m_t|\xi_t))\right)}{\mathbb{E}\left(\sum_{t=1}^{T} S_t \delta^{t-1}\right)} \tag{4}$$

4 Claims and Survey Panel Data from Germany

This section describes the claims panel dataset and the survey panel dataset used in this paper. The main working samples focus on the privately insured in the GLTHI market. We use the claims panel data primarily to estimate individual health transitions and related medical expenditures over the lifecycle. In contrast, we use the survey panel data primarily to estimate individual income dynamics over the lifecycle.

4.1 GLTHI Claims Panel Data

The claims panel data are administrative records for the universe of contracts and claims between 2006 and 2011 from one of the largest private health insurers in Germany. In total, our data include more than 2.6 million enrollee-year observations from 620 thousand unique policyholders along with detailed information on plan parameters such as premiums, claims, and diagnoses. Atal et al. (2018) provide more details about the dataset. The claims data also contain the *age* and *gender* of all policyholders as well as their profession and the age when they first signed a contract with the insurer. We converted all monetary values to 2016 U.S. dollars (USD).

Sample Selection. We focus on primary policyholders. In other words, we disregard children insured by their primary caregivers and other clients who are younger than 25 years (555,690 enrollee-year observations).[9] Moreover, due to the 2009 portability reform (see footnote 4), we disregard inflows after 2009 (328,693 enrollee-year observations).[10] Finally, we disregard a small number of civil servants, who are subject to different regulations and who make up a tiny fraction of the client population (<0.5 percent). Hence, the final sample consists of 1,781,681 enrollee-year observations.

Descriptive Statistics. Table A1 in the Appendix shows the descriptive statistics. As seen, the mean age is 46 years and the oldest enrollee is 106 years old. Almost half of the sample are high-income earners in dependent employment and the other half are self-employed. The majority of policyholders (72 percent) are male, because women are underpresented among the self-employed and high-income earners in Germany. On average, policyholders have been clients of the insurer for 13 years and have been enrolled in their current health plan for seven years. Ten percent of all policyholders have been with the insurer for more than 28 years and one policyholder has been with the insurer for as long as 86 years, illustrating the existence of a real-world private long-term health insurance system.[11] The distribution of policyholders' age when joining the company is in Figure A2. The mass of individuals signs their first GLTHI contract around the age of 30, at a time when most Germans have fully entered the labor market but are still healthy and face reasonable expected lifecycle premiums (see Figure 1).

Table A1 shows that the average *annual premium* is $4,407 and slightly lower than the average premium for a single plan in the U.S. group market at the time (Kaiser Family Foundation, 2014). Note that the *annual premium* is the total premium—including employer contributions for privately insured high-income earners.[12] The average *deductible* is $675 per year.

In terms of benefits covered, we simplify the rich data and focus on three health plan generosity indicators provided by the insurer. These classify plans into *TOP*, *PLUS*, and *ECO* plans. *ECO* plans differ by their lack of coverage for services like single rooms in hospitals and treatments by a leading senior M.D. *TOP* and *PLUS* plans resemble PPO plans—a 20 percent coinsurance rate applies if enrollees see a specialist without referral from their primary care

[9]Children obtain their own individual risk-rated policies. However, if parents purchase the policy within two months of birth, no risk-rating applies. Under the age of 21, insurers do not have to budget and charge for old-age provisions.

[10]Below we show that the composition of enrollees has remained very stable between 2006 and 2011.

[11]Our insurer doubled the number of clients between the 1980s and 1990s and has thus a relatively young enrollee population, compared to all GLTHI enrollees. Gotthold and Gräber (2015) report that a quarter of all GLTHI enrollees are either retirees or pensioners.

[12]Employers cover roughly one half of the total premium and the self-employed pay the full premium.

physician. About 38 percent of all policyholders have a *TOP* plan, 34 percent a *PLUS* plan, and 23 percent an *ECO* plan. Because these plan characteristics have mechanical effects on claims and correlate strongly with policyholders' age, we control for them in our estimation of health care costs in Section 5.2.

4.2 Socio-Economic Panel Study

The German Socio-Economic Panel Study (SOEP) is a representative longitudinal survey that started in 1984. It collects annual information at the household and individual level from individuals above the age of 17. Currently, the SOEP surveys more than 20,000 respondents from more than 10,000 households per year (Wagner et al., 2007). We use SOEPlong (SOEP, 2018), and all existing waves as of writing, from 1984 to 2016, in order to fully exploit the lifecycle dimension of this panel survey. Table A2 provides summary statistics for our SOEP sample. Again, all monetary values are in 2016 USD.

Sample Selection. We leave the representative sample as unrestricted as possible, but exclude observations with missings on core variables such as age, gender, employment status or the insurance status. Other than that, we only exclude respondents below the age of 25 as many Germans have not entered the labor market before that age. Also, prior to 1990, the SOEP was not in the field in East Germany but started covering East Germans right after the reunification in 1990 (Wagner et al., 2007).

Income Measures. Our main income measure, *equivalized post-tax post-transfer annual income* considers redistribution within households and controls for economies of scale by assigning each individual a needs-adjusted income measure. Specially, *equivalized post-tax post-transfer annual income* sums over all post-tax monetary income flows at the household level, such as income from labor, capital, public and private retirement accounts, or social insurance programs.[13] Then, the total annual post-tax household income is divided by the number of household members, where we use the modified OECD equivalence scale.[14] As Table A2 shows, from 1984 to 2016, the average annual income per household member was $26,433.

[13] The SOEP group also generates and provides these single components in a time-consistent manner.

[14] The modified OECD equivalence scale assigns a value of 1 to the household head, 0.5 to other adults, and 0.3 to children up to 14 years of age.

Note that this measure has positive values for *all* respondents, including those who are not active in the labor market.

For completeness, Table A2 shows statistics for two additional income measures: *monthly gross wage* and *monthly net wage*. These measures have positive values for all working people with labor earnings (58 percent of observations in Table A2). The SOEP Group generates and provides these individual-level income measures to guarantee consistency over time. As seen in Table A2, the average *monthly gross wage* was $2,940 and the average *monthly net wage* was $1,921 between 1984 and 2016.

Socio-Demographics. Table A2 also lists all other socio-demographics. In the SOEP sample, the average age is 47 and 52 percent are female. About 27 percent are white collar workers, 6 percent are self-employed, and 4 percent are civil servants. 42 percent work full-time and 14 percent part-time.

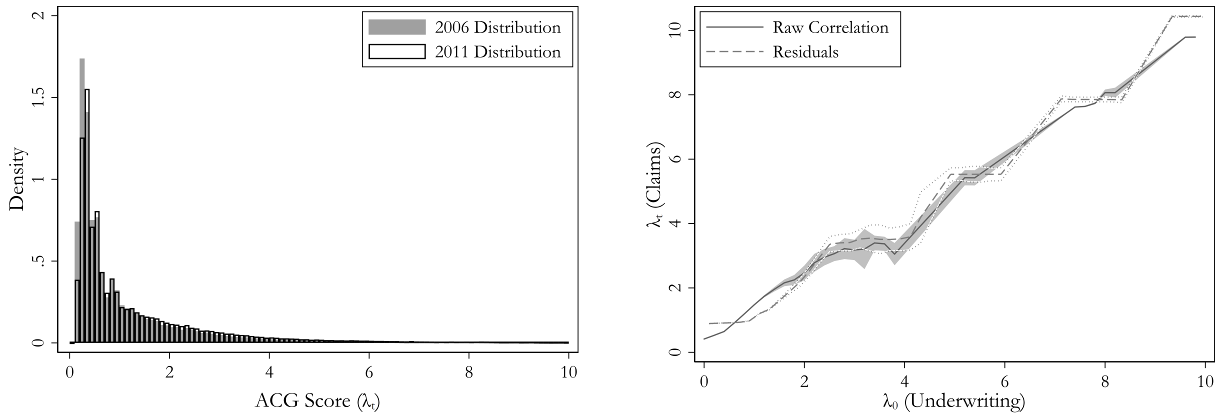
Below, we differentiate the lifecycle income processes by educational status. We do this because, after age 25, schooling degrees are largely time-invariant and determine lifecycle income substantially. Germany has a three-tier education system: *Ed 13* is one for individuals with the highest schooling degree after 13 years of schooling. *Ed 10* is one for individuals with an intermediate degree after 10 years of schooling. And *Ed 8* is one for individuals who earned a degree after 8 or 9 years of schooling.

5 Modeling Health Risk and Income over the Lifecycle

5.1 Risk Classification

Risk classification is a key ingredient for calculating prices and welfare in short- and long-term insurance contracts. The risk classification variable represents the observed risk type of an individual at the beginning of each year. Following the state-of-the art literature (e.g. Einav et al., 2013; Handel et al., 2015, 2017), we construct the risk classification variable by the John Hopkins ACG© software. Commercial insurers routinely use this software for underwriting; therefore it serves our purpose very well. The ACG© software provides a continuous *risk score* λ^*. As we discuss below, we then discretize this score into *risk categories* λ.

Figure 2: (a) Distribution of λ_t^* in 2006 and 2011 and (b) Correlation of λ_t^* and λ_0^*



Source: GLTHI claims data, ACG©, own calculation, own illustration.

In the first step, we calculate two continuous scores, λ_0^* and λ_t^*. Both scores use the *unscaled total cost predicted risk* variable provided by ACG©. The first variable λ_0^* is the client's score at inception of the contract; based on the observables used by the company to risk-rate each plan, namely: age, sex and possible pre-existing conditions (each individual can have up to 40 ICD codes for pre-existing conditions). The second variable λ_t^* is the score in any given year t. It is based on a) diagnosis codes (pre-existing conditions and claim diagnoses), b) costs of treatments and c) treatment episode dates. λ_t^* represents the *expected costs* in year t. In the reference population, it has a mean of 1. In our population, the mean is 1.2.

Figure 2a shows the empirical distributions of λ_t^* for our working sample in 2006 (the first year) and 2011 (the last year). Both distributions are approximately unimodal and very stable over time.[15] Figure 2a also illustrates that the distribution of λ_t^* is heavily skewed and has a long right tail (consistent with stylized facts regarding the distribution of health expenditures, see French and Kelly, 2016). For example, the top percentile of the λ^* distribution has expected health expenditures $\mathbb{E}\left(m\right)$= \$16,416; the second highest percentile has $\mathbb{E}\left(m\right) = \$8,680$ and the following three percentiles have $\mathbb{E}\left(m\right) = \$6,868$.

Figure 2b plots the correlation between λ_0^* and λ_t^* before and after controlling for age and sex. Clearly, λ_0^* is highly predictive of λ_t^* along the entire range of support. We also see that the high correlation is not driven by age and sex, as illustrated by a comparison of the line produced by the "raw correlation" vs. the "residuals," after netting out age and sex effects.

[15]This suggests that excluding inflows in 2010 and 2011 due to the portability reform, see Section 2, poses no major issue.

Discrete Risk Categories

Next we decompose the λ^* distribution into *risk categories*. These categories will be used as inputs for the construction of discrete health types. Modeling risk types as a discrete state serves two specific purposes. First, we model the contract terms to depend on the risk type. Hence, the granularity in our model should capture the granularity of the information used by the underwriters, both in the actual environment and in counterfactual scenarios. Second, the model should be parsimonious enough to allow for modeling health dynamics with a reasonable number of parameters.

The considerable skewness in Figure 2a implies that the amount of reclassification risk will strongly depend on the granularity allowed for in the risk classification; which will ultimately depend on how we divide the right tail of the λ^* distribution.

We split the task of discretizing the distribution of λ^* in two sequential problems: (1) Given a number of k partitions, decide on the "efficient" $k-1$ cutoffs $c_1, c_2, ...c_{k-1}$ that split the distribution of λ^* into k different risk categories. (2) Find the value of k for which its efficient partition best approximates the degree of granularity used by the underwriter. We explain the details of each step below.

(1) Efficient Cutoffs. According to the actuarial science literature (cf. Finger, 2006), an efficient risk classification system has two properties: *homogeneity*—meaning that individuals in one risk category are similar in terms of risk, and *separation*—meaning that categories are sufficiently different in terms of expected loss to warrant their specification as a distinct category.[16]

The most commonly used efficiency measure in the literature of risk classification is the ratio between the variance explained by the classification system and the total variance—or the coefficient of determination (R^2). Thus, when using the ACG© score for risk classification, and for a given number of risk categories k, the optimal classification consists of the set of cutoff points $\{c_0 = 0, c_1, c_2, ..., c_{k-1}, c_k = +\infty\}$ that solve the problem:

$$\min_{c_1,...,c_{k-1}} \sum_{g=1}^{k} \int_{\lambda=c_{g-1}}^{c_g} \int_{m=0}^{\infty} f\left(m, \lambda^*\right) \left(m - \mathbb{E}\left[m \mid c_{g-1} < \lambda^* < c_g\right]\right)^2 \mathrm{d}m\mathrm{d}\lambda^* \tag{5}$$

[16] For instance, given the distribution of λ^* in Figure 2a it is easy to see that equally-sized categories are unlikely to be optimal as they would assign similar individuals in terms of λ^* into different categories in the left tail of the distribution, failing the *separation* principle. In addition, it would assign individuals with substantial λ^* differences into identical categories in the right tail of the distribution, failing the *homogeneity* principle.

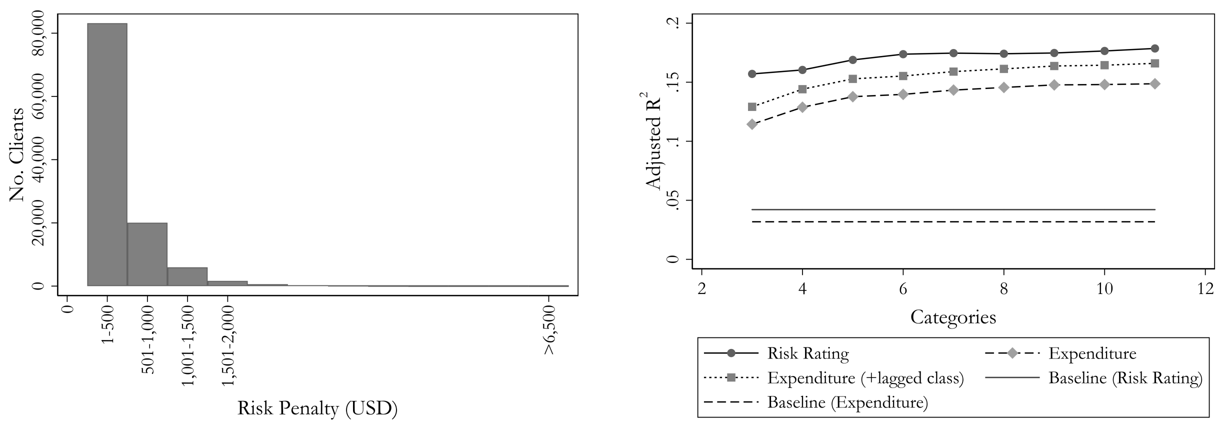
where $f(m, \lambda^*)$ represents the joint distribution of m and λ^*. Using the fact that λ^* represents the expected value of claims—that is, $\mathbb{E}(m_i \mid \lambda_i^*) = \mu\lambda_i^*$ where $\mu = \mathbb{E}[m]$ is the global mean of costs—it can be shown that the classification that minimizes the residual variation in costs is the same as the classification that minimizes the residual variation in λ^*. Denoting the residual $u_i = m_i - \mu\lambda_i^*$ and using the CEF decomposition property $\mathbb{E}[u_i \mid \lambda_i^*] = 0$ (Angrist and Pischke, 2008), Equation (5) simplifies to:

$$\min_{c_1,\ldots,c_{k-1}} \int_{\lambda^*=0}^{\infty} \int_{u=-\infty}^{\infty} \hat{f}(u, \lambda^*)\, u^2 \mathrm{d}u \mathrm{d}\lambda^* + \mu^2 \sum_{g=1}^{k} \mathrm{Var}\left(\lambda^* \mid c_{g-1} < \lambda^* < c_g\right) \Pr\left(c_{g-1} < \lambda^* < c_g\right) \quad (6)$$

where $\hat{f}$ is the joint distribution of u and λ^* that is derived from f, the joint distribution of m and λ. Note that the classification cutoffs $c_1, \ldots, c_{k-1}$ do not affect the first term of Equation (6). Thus, the classification that minimizes the residual variance in λ^* is also efficient with regard to m. This reduces the problem to a one-dimensional clustering problem and we can use standard clustering techniques to determine the optimal cutoff points $\{c_1, \ldots, c_{k-1}\}$.

(2) The Number of Risk Categories. The actuarial science literature provides less guidance on how to decide on the optimal *number* of risk categories. Instead, we opt for a data-driven approach to determine the number of categories k that best approximates the degree of granularity used by the unterwriter.

Figure 3: (a) Distribution of Risk Penalty, (b) Predictive Power of Risk Categories.



Source: GLTHI claims data, ACG©, own calculation, own illustration.

Figure 3a displays the distribution of the variable *annual risk penalties*. This variable measures what the insurer charges *in addition* to the pricing factors gender, age, and type of health plan (see also Table A1). This information is in our dataset.[17] A large majority (70 percent) pays a risk-rated premium solely based on the three pricing factors age, gender and health plan. However, for individuals with pre-existing conditions, the *annual risk penalty* ranges from US $2 to US $21,000 per year and exhibits a right skew similar to Figure 2.

We proceed as follows: starting from only two risk categories, we regress the risk penalty of new enrollees on the ACG© score λ_0^* (which is based on the observables at inception, as described above). Then we gradually increase the number of risk categories until no significant improvements in the adjusted R^2 remain. Figure 3b shows the results. This approach yields the optimal number of categories as five (which increases the adjusted R^2 from 0.05 to 0.16).[18]

5.2 Health and Claim Dynamics

After having defined the discrete state space for λ^*, we now define the risk type ξ and its dynamics, as well as a model for health expenditures, conditional on the risk type. The goal is to estimate a model that is flexible enough to accommodate the patterns in the data but also parsimonious enough to be estimable with our sample. Our approach is to start from a very parsimonious model and then to sequentially add complexity based on the marginal improvements in the model's explanatory power.

Our model also aims to capture the degree of information used by underwriters. By basing our model on the discretized ACG© score, λ_t^*, our analysis rests on the assumption that this variable correctly captures the actual information used by the insurer for underwriting. The strong correlation between λ_t^* and λ_0^* in Figure 2b reinforces this assumption.

Model. We posit that the risk type at age t, ξ_t, is given by a unique combination of age at t (in 5-year bins), the contemporaneous risk category λ_t, and the previous risk category λ_{t-1}, that is;

$$\xi_t \equiv (A_t; \lambda_t; \lambda_{t-1})$$

[17] To make the variable comparable across individuals, Figure 3a only includes enrollees without deductibles.

[18] The idea is similar to the Heckman and Burton Singer (1984) method to determine the number of unobservable types in dynamic discrete choice models.

where A_t is an indicator for one of the eleven age groups (five-year bands from age 25 to age 75, plus the age group 76 to 94). The following empirical facts motivate this specification: a) transition rates across λ_t categories are age-dependent, b) mean health expenditures *conditional on* λ_t and λ_{t-1} are age-dependent, and c) a first order Markov process for λ_t is strongly rejected empirically.[19] Moving beyond a first-order Markov process is consistent with the underwriting score λ_0^* covering a relatively long medical history of the applicant (specifically, all diseases of the past 5 years and all surgeries of the past 10 years).

Allowing for such a rich model precludes a non-parametric estimation for the transition matrices $g(\xi_t|\xi_{t-1})$ and mean expenditures $\mathbb{E}(m_t|\xi_t)$. Instead, we resort to a parametric, yet flexible model. To model the individual-level health dynamics, we estimate a multinomial logit model specified as:

$$\eta_{it}^j = A_{it}\beta_j + L_{it}\gamma_j + L_{i,t-1}\kappa_j + h\left(A_{it}, L_{it}, L_{i,t-1}; \theta_j\right) + \epsilon_{it}^j \tag{7}$$

where η_{it}^j represents the log odds for $\lambda_{t+1} = j$, for $j \in \{2, \ldots, 6\}$. The category $\lambda_{t+1} = 1$ is the reference category and $\lambda_{t+1} = 6$ represents death. A_{it} represents age groups and $L_{i,t}$ the categories of λ_t. In addition, Equation (7) includes $h\left(A_{it}, L_{it}, L_{i,t-1}; \theta_j\right)$ which consists of pairwise interactions of A_{it}, L_{it} and $L_{i,t-1}$ with the associated parameter vector θ.[20]

To model expected claims based on risk type, we follow a similar approach, but use predicted values of claims from an OLS regression.[21] In addition to the controls in Equation (7), we also control for a vector of dummies Q_{it} representing health plan generosity $q \in \{ECO, PLUS, TOP\}$. The base specification is:

$$m_{it} = A_{it}\beta + L_{it}\gamma + L_{i,t-1}\kappa + Q_{it}\delta + h\left(A_{it}, L_{it}, L_{i,t-1}, Q_{it}; \theta\right) + \epsilon_{it} \tag{8}$$

As in equation (7), L_{t-1} has a highly significant impact on m_{it}, even after controlling for L_t; that is, the health risk of the past year is highly predictive of claims in the current year, even after controlling for the current health risk. In an iterative process, we add pairwise interaction

[19]Even after conditioning on λ_t, λ_{t-1} affects transition rates and the inclusion of these lagged values increases the persistence of the process.

[20]We selected the interacted terms sequentially: in each iteration, we include the interaction term with the strongest association with transition rates (based on a χ^2 test), until none of the remaining interaction terms is statistically significant.

[21]Here, we restrict the sample to enrollees without deductibles because health care utilization is only partly observed below the deductible.

terms between A_{it}, L_{it}, $L_{i,t-1}$ and Q_{it} to Equation (8) (represented by $h(A_{it}, L_{it}, L_{i,t-1}, Q_{it}; \theta)$) until no remaining term is statistically significant.

Descriptives. Table 1 shows summary statistics of total claims m by age group. Following Handel et al. (2017), we decompose the variation of m into two components: the part that is explained by λ (S.D. of $\mathbb{E}(m \mid \lambda)$) and the residual variation around the predicted value (S.D. around $\mathbb{E}(m \mid \lambda)$).

As expected, mean claims strongly increase in age: They more than double from $1,099 in age group 25 to 30, to $2,266 in age group 45 to 50, and more than double again to $5,278 in age group 65 to 70. For enrollees above 75 years, the average amount of claims is $7,594 (all values are in 2016 U.S. dollars).

Table 1: Health Expenditure Claims m by Age Group

Ages	Mean	S.D.	S.D.($\mathbb{E}(m \mid \lambda)$)	S.D.($m - \mathbb{E}(m \mid \lambda)$)
All	2,815	7,855	2,952	7,281
25-	1,099	3,630	1,287	3,490
30-	1,442	3,899	1,398	3,994
35-	1,707	4,643	1,685	4,814
40-	1,919	5,430	1,930	5,495
45-	2,266	6,505	2,482	6,550
50-	2,875	7,686	3,195	7,415
55-	3,549	8,287	3,297	8,009
60-	4,425	12,020	3,608	12,523
65-	5,278	11,719	4,623	11,383
70-	6,194	12,869	4,420	12,804
75-	7,594	11,947	4,043	11,591

Source: German Claims Panel Data. Sample includes all age groups and uses the ACG© score as λ.

Table 2 shows how different age groups are distributed across risk categories λ. The age gradient in health expenditure risk is very clear: The probability of being in the lowest risk category 1 declines progressively with age, whereas the share of enrollees in the other four categories all increase in age; the pattern is particularly strong for categories 3 and 4. Only 1 percent of enrollees between 25 and 30 years are in health risk category 3. This share quadruples to 4 percent in age group 45 to 50, and then more than quadruples again to 19 percent in age group 65 to 70. It is 41 percent for enrollees above 75 years. On the other hand, risk category 5 clearly represents catastrophic costs and covers at most 1 percent of the population in any age group.

Table 2: Health Risk Categories λ by Age Group

Age	1 (Healthiest)	2	3	4	5 (Sickest)
25-	0.92	0.06	0.01	0.00	0.00
30-	0.89	0.09	0.02	0.01	0.00
35-	0.84	0.12	0.03	0.01	0.00
40-	0.81	0.14	0.03	0.01	0.00
45-	0.76	0.18	0.04	0.01	0.00
50-	0.69	0.23	0.06	0.02	0.00
55-	0.57	0.30	0.09	0.03	0.01
60-	0.47	0.34	0.14	0.05	0.01
65-	0.33	0.42	0.19	0.05	0.01
70-	0.20	0.44	0.28	0.07	0.00
75-	0.10	0.37	0.41	0.12	0.01

Source: German Claims Panel Data. Sample includes all age groups and uses the ACG© score as λ.

Transitions between States. Table 3 displays one-year transition rates between health risk categories (by previous risk λ_{t-1}) for all age groups; the numbers are predicted probabilities based on Equation (7). Table A3 (Appendix) shows the unconditional one-year transition rates.

Two facts emerge from these tables. First, we find strong persistence in health risk dynamics over time. For instance, an individual with $\lambda_t = 1$ has a 85 percent probability of $\lambda_{t+1} = 1$ (Table A3). This likelihood decreases over risk categories but, still, 33 percent of individuals in category 5 remain in category 5 in the next year. Second, despite the high persistence, the likelihood of a severe health shock (and thus the value of reclassification risk insurance) is non-trivial even when just considering two calendar years. For example, the probability of ending up in risk category 4 in $t + 1$ is three percent after being category 2 in year t (Table A3).

Third, the transition matrix in Table 3 illustrates the violations of the first-order Markov property: An individual who stayed in risk category 1 over two periods is 30 percentage points more likely to remain in category 1 as compared to someone who was in category 5 in period $t - 1$ before transitioning to category 1 in period t. Similar differences are evident for other combinations of λ_t and λ_{t-1}. Thus, there is likely more persistence in the health process than the transition matrix in Table A3 can capture.

Table 3: One Year Health Risk Category Transitions by Previous Health Risk

		λ_{t+1}					
λ_t	λ_{t-1}	1	2	3	4	5	6 (†)
	1	0.877	0.098	0.017	0.006	0.001	0.001
	2	0.631	0.299	0.053	0.014	0.001	0.001
1	3	0.593	0.266	0.110	0.026	0.002	0.002
	4	0.574	0.240	0.087	0.092	0.007	0.000
	5	0.565	0.234	0.104	0.068	0.018	0.011
	1	0.517	0.386	0.074	0.019	0.002	0.001
	2	0.226	0.589	0.148	0.031	0.002	0.003
2	3	0.158	0.518	0.262	0.051	0.004	0.006
	4	0.173	0.492	0.210	0.114	0.005	0.007
	5	0.168	0.459	0.225	0.117	0.024	0.008
	1	0.415	0.325	0.204	0.047	0.005	0.003
	2	0.123	0.435	0.358	0.071	0.006	0.007
3	3	0.065	0.248	0.543	0.119	0.009	0.016
	4	0.061	0.186	0.490	0.217	0.023	0.022
	5	0.051	0.181	0.452	0.222	0.072	0.022
	1	0.383	0.242	0.138	0.193	0.025	0.019
	2	0.129	0.357	0.251	0.220	0.024	0.018
4	3	0.049	0.158	0.404	0.324	0.030	0.034
	4	0.062	0.099	0.230	0.507	0.054	0.048
	5	0.030	0.064	0.175	0.476	0.173	0.082
	1	0.185	0.118	0.129	0.198	0.247	0.123
	2	0.092	0.199	0.178	0.240	0.196	0.096
5	3	0.034	0.092	0.256	0.305	0.223	0.091
	4	0.030	0.039	0.108	0.360	0.313	0.150
	5	0.009	0.022	0.066	0.211	0.545	0.146

Source: German Claims Panel Data. Sample includes all years, all age groups, and uses the ACG© score as λ.

5.3 Lifecycle Income Paths

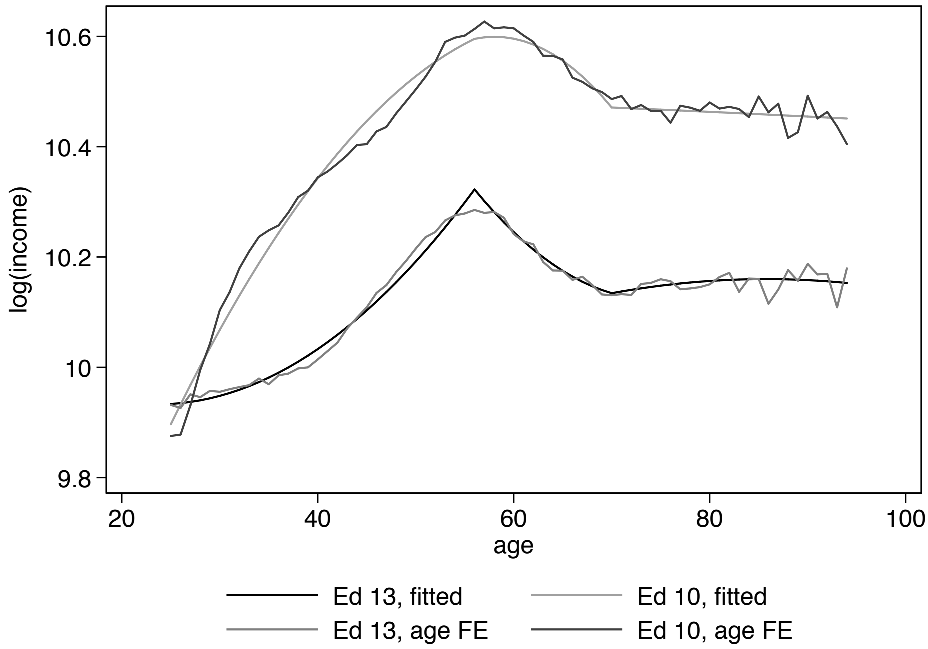
We estimate the lifecycle income paths using 33 years of SOEP panel data. Because individuals may enroll in GLTHI contracts during their entire lifetime, we consider all sources of income beyond wages. Our main income measure is the *equivalized post-tax post-transfer annual income*, which sums over all post-tax income flows at the household level, and then normalizes by the number of household members (see Section 4.2). Using this income measure, we estimate the following individual fixed effects model:

$$log(y_{it}) = \theta_i + f(age_{it}) + \epsilon_{it} \tag{9}$$

where y_{it} stands for our income measure in 2016 U.S. dollars in year t for individual i. θ_i are individual fixed effects which net out all persistent individual time-invariant income determinants, such as gender, preferences, or work productivity. The flexible function $f(age_{it})$ represents a series of age fixed effects and identifies the main coefficients of interest. They capture the main features of the German lifecycle income profiles from 1984 to 2016.

We estimate this income process separately by educational status for the two following groups: a) individuals with the highest schooling degree after 13 years of schooling (*Ed 13*), and b) individuals with an intermediate degree after 10 years of schooling (*Ed 10*).[22] We estimate separate income processes because lifecycle profiles differ by educational degree (Becker and Chiswick, 1966). As mentioned, the steepness of these lifecycle income profiles will determine the welfare consequences of long-term health insurance to a large extent.

Figure 4: Lifecycle Income Paths Nonparametric and Fitted.



Source: SOEP (2018), own calculation, own illustration.

The solid black lines in Figure 4 show the estimated coefficients of $f(age_{it})$ for the two groups. Income rises sharply between age 25 and age 57. Then it decreases substantially until around age 70, from which point it remains relatively flat until death. It is also easy to observe a level difference in income paths between the two educational groups over the entire lifecycle.

[22]Germany has three different schooling tracks where the majority of students complete school after 10 years and then start a three-year apprenticeship (cf. Dustmann et al., 2017).

Several factors can explain the lifecyle income pattern in Figure 4: First, the labor market entry and subsequent careers significantly increase post-tax income between the main working ages 25 and 55. Second, recall that our income measure includes social insurance benefits (and the German welfare state is known for its generosity.) Third, it may be surprising that equivalized household income starts to decrease after age 57 until around age 70. However, especially in the 1980s and 1990s and also today, many Germans retire early (Börsch-Supan and Jürges, 2012); others reduce their working hours, for example, to take care of their grandchildren or provide long-term care for their parents (Schmitz and Westphal, 2017). Finally, the stable permanent income stream from age 70 until death may be explained by the fact that our income measure includes primarily statutory pensions, employer-based pensions and private pensions (Geyer and Steiner, 2014; Kluth and Gasche, 2016; Engels et al., 2017).

We accommodate these lifecycle income pattern by fitting $f(age_{it})$ as a piece-wise squared polynomial of age, where we allow the parameters of age and on the square of age to differ across three different age bins: $[25, 56]$, $[56, 70]$ and $70+$. This is illustrated by the two gray solid lines in Figure 4. It is noteworthy that the piece-wise squared polynomials fit the empirical lifecycle profiles very well.

6 Results

6.1 Equilibrium Lifecycle GLTHI Premiums

After estimating the health risk process we can calculate the equilibrium GLTHI lifecycle premiums by solving Equation (1) using backwards induction. Note that $P_t(\xi_t)$ in Equation (1) is the guaranteed-renewable premium that an individual with health ξ_t would be offered if she entered a contract in period t in the GLTHI market. Therefore, the equilibrium GLTHI premiums correspond to 1,750 values: premiums depend on enrollee's current and past health category $(\lambda_{t-1}, \lambda_t) \in 1, 2, ..., 5^2$, as well as age ($t \in 25..94$).[23] We use a discount factor $\delta = 0.975$.

Figure 5 plots the resulting premiums for a handful of relevant combinations: $\lambda_{t-1} = 1, \lambda_t = 1$ and $t \in [25..64]$; $\lambda_{t-1} = 1, \lambda_t = 2$ and $t \in [25...74]$; $\lambda_{t-1} = 2, \lambda_t = 2$ and $t \in [65...94]$; and $\lambda_{t-1} = 3, \lambda_t = 3$ and $t \in [65...94]$ and $t \in [25...94]$. These are the two most common combinations of λ_{t-1} and λ_t for each corresponding age interval.

[23] Although ξ_t depends on 5-year age bins, age determines the remaining length of the contract and, consequently, the premium.

Figure 5: Calibrated Starting Premiums $P(\xi_t)$ by Age at Inception in the GLTHI

Source: German Claims Panel Data. Own calibration, own illustration.

Three forces at play determine the lifecycle profile of $P_t(\xi_t)$ in Figure 5. First, $P_t(\xi_t)$ is an increasing function of λ_t and of λ_{t-1} as, for any age, a higher health risk classification is associated with higher current and future health claims (both through their effect on current claims and their effect on transition matrices).

Second, for any given health risk classification, total health claims increase over time as transition matrices and expected claims depend on age (through the A_t component of ξ_t). As a consequence, the annualized net present value of health care expenditures of an individual with a given ξ_t increases with age for most of the age ranges.

However, when individuals enter the contract later in their lives, the need to frontload premiums to fund future negative health shocks *decreases* over the lifecycle. This force explains why $P_t(\xi_t)$ decreases with t when t is sufficiently large.

In Figure B1 (Appendix) we plot the empirical counterparts of $P_t(\xi_t)$. Overall, we find that the level differences and shapes of the curves are very similar for the relatively common states ($\lambda_t \leq 2$), although our model overstates premiums for the sickest states.

6.2 Comparison with the Optimal Dynamic Contract.

The optimal dynamic contract as derived by Handel et al. (2017) implies evolving consumption guarantees over the lifecycle. These consumption guarantees depend on lifecycle income profiles (see Equation (2)).

We start by illustrating the differences between the optimal and the GLTHI contract by showing the contract terms at age 25. Panel (a) of Table 4 shows the GLTHI premium and frontloading amount for a 25 year old by $\lambda_{25} \in \{1, 2, 3\}$, assuming her health status at age 24 to be 1, i.e., $\lambda_{24} = 1$. If the current health status is $\lambda_{25} = 1$, this individual pays a premium of \$2,994, which is \$1,713 in excess of the expected claims. Individuals with $\lambda_{25} = 2$ and $\lambda_{25} = 3$ pay higher premiums, but there is less frontloading, \$935 and \$926, respectively. Note that the amount of frontloading depends on the relationship between current expenditures and expected future expenditures among individuals who stay in the contract. Therefore it is not necessarily a monotonic function of the health state. Also, note that the GLTHI premiums are not contingent on the lifecycle income paths.

Panel (b) of Table 4 shows the premium and frontloading amount under the optimal dynamic contract for an enrollee with the highest schooling degree (*Ed 13*). For all health states, frontloading is lower and consumption is higher when compared to the GLTHI contract. The optimal contract penalizes frontloading because it increases the marginal utility of consumption, particularly in the sickest states. As such, in the optimal contract, the amount of frontloading depends not only on the implications of the current health state for future health states, but also on its implications for the marginal utility of consumption.

Panel (c) of Table 4 shows the optimal contract for an individual with a schooling degree after 10 years of schooling (*Ed 10*). This individual has a flatter income profile over the lifecycle (see Figure 4). Consequently, the individual can afford a higher degree of frontloading.

6.3 Welfare Results

This subsection calculates welfare under the different contracts as defined in Section 3.3. As discussed in Section 5.3, we stratify the findings by different education-dependent lifecycle income paths. We calculate welfare by simulating the economy for a lifecycle of 70 years, from age 25 to age 94 for $N = 500,000$ individuals. We assume that λ_{25} is drawn from the

Table 4: Contract Terms at Inception, for Age 25 by Health State ($\lambda_{t-1} = 1$), (Th USD)

λ_{25}	**1**	**2**	**3**
Expected Costs	1.281	2.612	5.148
	(a) GLTHI		
Premium	2.994	3.547	6.073
Frontloading	1.713	0.935	0.926
	(b) Optimal Contract, *Ed 13*		
Premium	1.411	2.921	5.586
Frontloading	0.130	0.309	0.439
	(c) Optimal Contract, *Ed 10*		
Premium	1.676	3.466	6.035
Frontloading	0.395	0.834	0.887

Source: Health transitions based on German Claims Panel Data. Lifecycle income paths based on SOEP (2018), own calculation, own illustration.

distribution implied by the transition matrix at age 25, given $\lambda_{24} = 1$ (Table A4, Appendix). By doing so, we accurately replicate the distribution of ξ among the 25 to 30 year old.

We simulate welfare using a CARA utility function of the form: $[u(c) = -\frac{1}{\gamma}e^{-\gamma c}]$. In our main results, following Handel et al. (2017), we use a risk aversion parameter $\gamma = 0.0004$. Section 6.7 explores the robustness of the welfare results with respect to γ.

Table 5: Welfare under Various Contracts (Th USD)

	C^* (1)	C_{ST} (2)	C_{GLTHI} (3)	C_{HHW} (4)	$\frac{C_{GLTHI}-C_{ST}}{C^*-C_{ST}}$ (5)	$\frac{C_{HHW}-C_{GLTHI}}{C_{HHW}}$ (6)
Ed 10	24.411	9.004	19.577	19.800	0.686	0.011
Ed 13	36.256	18.898	21.901	22.037	0.173	0.006

Source: Health risk transitions are based on the German Claims Panel Data. Lifecycle income paths are based on the SOEP (2018), own calculation, own illustration.

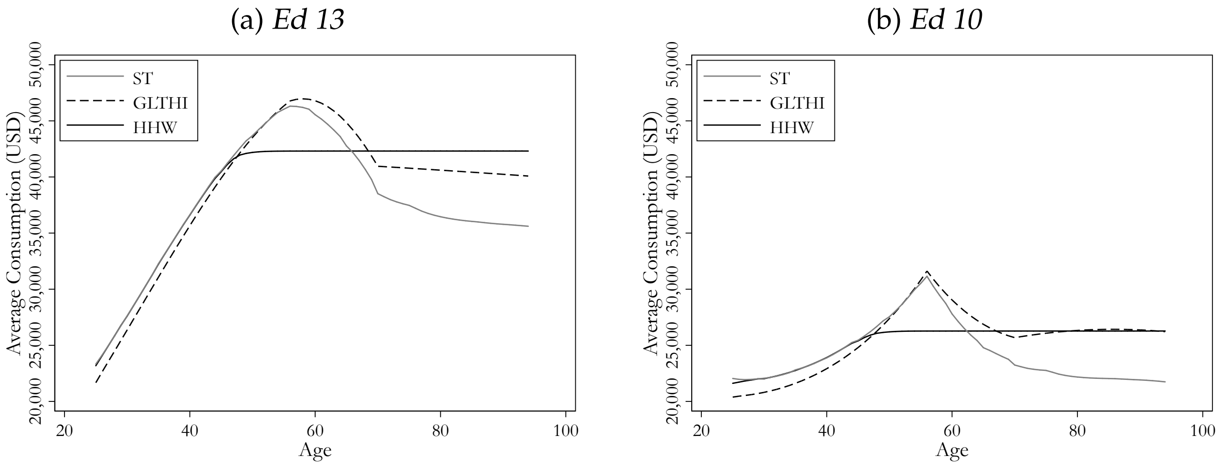
Table 5 shows the main results. Column (1) shows the first-best as benchmark. Column (2) illustrates that a series of short-term contracts C_{ST} produces large welfare losses, compared to the first-best. Under the short-term contracts, the consumption equivalent is \$9,004 for individuals with a schooling degree after 10 years (*Ed 10*). It is \$18,898 for individuals with a schooling degree after 13 years (*Ed 13*). The values are just 37 and 52 percent of the first-best, respectively.

Column (3) shows that the GLTHI produces substantial welfare gains compared to the short-term contracts. Under the GLTHI, the consumption equivalent (C_{GLTHI}) is \$19,577 for *Ed 10* and to \$21,901 for *Ed 13*, or 80 and 60 percent of the first best, respectively. The GLTHI closes 69 percent and 17 percent of the gap between the short-term contracts and the first best for each educational group, respectively (Column 5).

As shown in columns (4) and (6), the consumption equivalent under the GLTHI and the optimal dynamic contract (C_{HHW}) are very close, and almost identical. Welfare under the GLTHI falls only 1.1 percent short of welfare under the optimal contract for *Ed 10*. For *Ed 13*, the gap is even smaller at 0.6 percent.

By plotting average consumption levels at each age for *Ed 10* and *Ed 13*, Figure 6 illustrates the driving forces behind these welfare differences. As shown by the gray lines, under a series of short-term contracts, average consumption equals income minus expected medical spend-

Figure 6: Expected Consumption over the Lifecycle by Education



Source: German Claims Panel Data, SOEP data, own calculation, own illustration.

ing. Consumption is therefore hump-shaped over the lifecycle for both education groups. As shown by the black dashed lines, average consumption under the GLTHI has a similar shape, but starts at a lower level and is higher at older ages. This reflects the heavy frontloading of GLTHI up to the early 50s. As shown by the black solid lines, average consumption under the optimal HHW contract takes into account the utility from reducing reclassification risk, but also from smoothing consumption over the lifecycle. Hence, the optimal contract implies a much smaller degree of frontloading than the GLTHI contract (Table 4). Thus average consumption starts at a higher level, particularly for the highly educated, who have a steeper income profile and for whom frontloading is costlier. As individuals approach their middle ages, the optimal contract allows to fully smooth consumption, which is illustrated by the straight flat consumption line subsequent age 40.

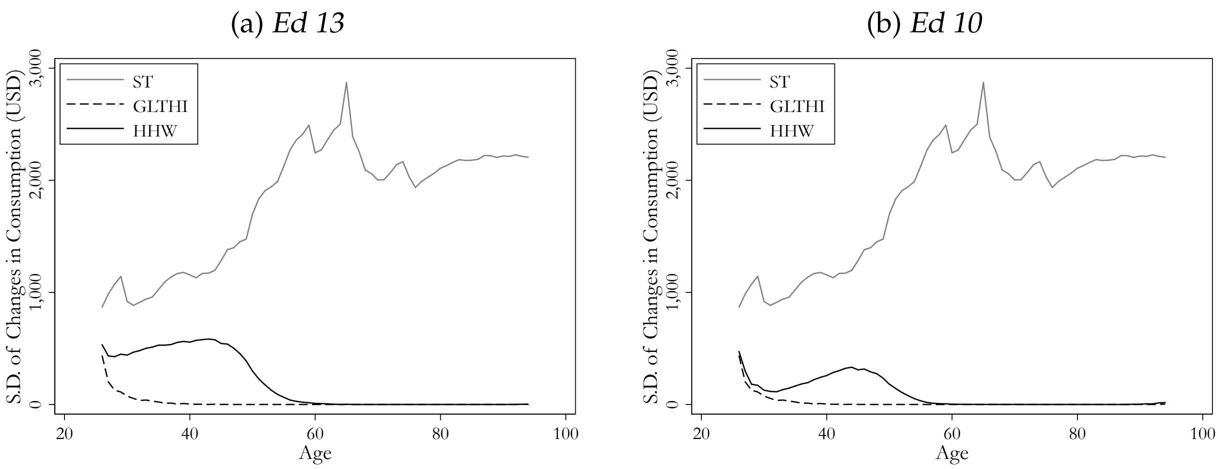
Furthermore, as we will show in Figure 11 in Section 6.7, with a risk aversion parameter of $\gamma = 4 * 10^{-4}$, the welfare differences due to differences in the *expected* consumption profiles over the lifecycle between GLTHI and HHW are substantial. Barring differences in reclassification risk across contracts, the lifecycle path of consumption under HHW produces welfare gains of approximately US 6,900 per year.

However, relative to GLTHI, the optimal contract achieves consumption smoothing at the expense of more reclassification risk. To illustrate the degree of reclassification risk over the lifecycle, we display the standard deviation of consumption changes at each age in Figure 7.[24]

[24] That is, Figure 7 plots for each t the standard deviation of $\Delta C_{i,t} \equiv C_{i,t+1} - C_{i,t}$.

As seen, the GLTHI contract imposes very little reclassification risk as most individuals lock $P_1(1)$ in the first period. Since $P_t(\xi) > P_1(1)\ \forall t, \forall \xi$, only individuals who start at $\xi_1 > 1$ and become sufficiently *healthier* over the lifecycle (such that $P_t(\xi_t) > P_1(\xi_1)$ for some t) would switch to a cheaper contract. However, this is a rare event. On the other hand, the optimal contract specifies consumption *bumps*. For instance, consumption increases for individuals who start at $\lambda_1 = 1$ and remain at $\lambda_2 = 1$ in period 2. A competing insurer can then take these "good news" regarding future health into account, offer the individual a higher consumption guarantee, and still break even in expectation.

Figure 7: Simulated Standard Deviation of Consumption Changes

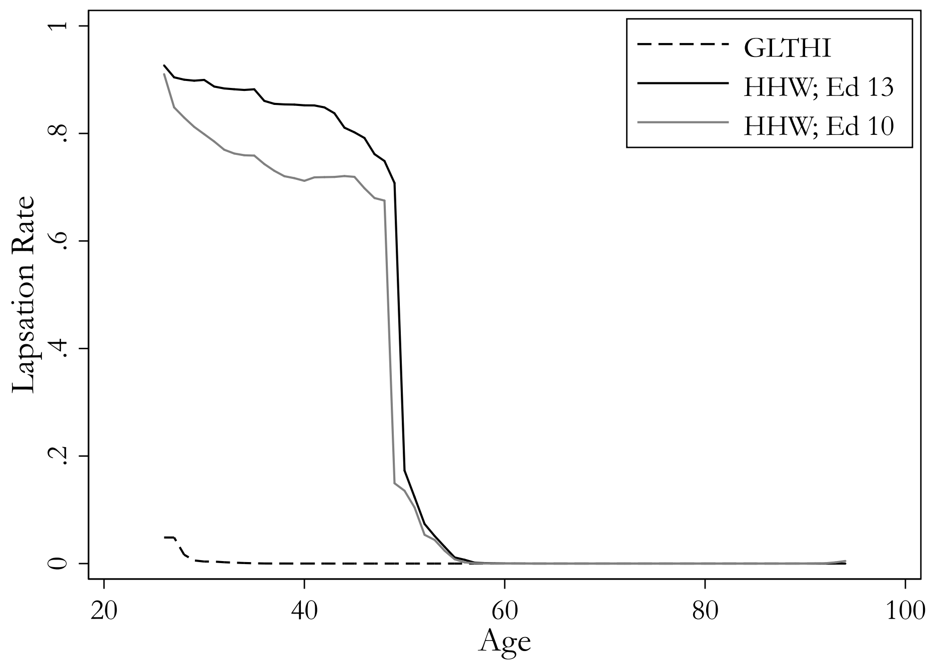


Source: German Claims Panel Data, SOEP data, own calculation, own illustration.

Figure 8 compares the average lapsation rates under each contract, where lapsing under HHW is defined as an increase in the consumption guarantees.[25] As expected, lapsation from GLTHI is very low. Contrarily, when expected future health improves, HHW leads to a higher consumption for the healthiest types (and therefore for almost everyone) in the early periods. Still, lapsation under HHW decreases substantially in the late 40s. At this point, most individuals have achieved their consumption *plateau*. Subsequently, consumption remains constant in order to transfer resources intertemporally and to save for old age.

[25] As noted by Handel et al. (2017), optimal contracts impose a "no-lapsation constraint" in the sense that the consumer will always stay in the contract. However, an increase in the consumption guarantee can be also interpreted as a lapsation from an equivalent set of guaranteed premium paths. It is the latter interpretation of a *lapsation* that we use in Figure 8.

Figure 8: Laspation Rates by Type of Contract and Education



Source: German Claims Panel Data, SOEP data, own calculation, own illustration.

6.4 Savings

Our main welfare calculations assume that individuals cannot save. This assumption may substantially underestimate welfare under short-term contracts and under GLTHI. As noted above, the GLTHI contracts result in a consumption profile that closely tracks the hump-shaped life-cycle income profile. Moreover, under short-term contracts, individuals experience large premium shocks that could be smoothed with precautionary savings. Hence, this section allows for precautionary savings. We do so by solving a dynamic programming problem of optimal savings with mortality risk as in Yaari (1965). Individuals solve the following maximization problem:

$$
\begin{aligned}
\max_{c_t} \quad & \mathbb{E}\left(\sum_{t=0}^{T} S_t \delta^t u(c_t)\right) \\
\text{s.t.} \quad & a_0 = 0 \\
& a_t \geq 0 \quad \forall t \\
& a_{t+1} = (1+r)a_t + y_t - P(\Xi_t)
\end{aligned}
$$

where $P(\Xi_t)$ is the premium in period t as a function of an individual's medical history $\boldsymbol{\Xi_t} \equiv (\xi_1, \xi_2, ..., \xi_t)$, and a_t is the level of assets.

Different contracts result in different mappings between an individual's medical history up to period t and an individual's premium in t. Under a series of short-term contracts, only an individual's current health status matters since $P(\Xi_t) = \mathbb{E}(m_t|\Xi_t) = \mathbb{E}(m_t|\xi_t)$. In contrast, for a GLTHI contract, the entire medical history matters. Due to guaranteed-renewability, $P(\Xi_t)$ is defined recursively: In the first period, $\boldsymbol{\Xi_1} = \xi_1$ and $P(\boldsymbol{\Xi_1}) = P_1(\xi_1)$, where Equation (1) defines $P_t(\xi_t)$. In any period $t > 1$, $P(\boldsymbol{\Xi_t}) = \min\{P(\boldsymbol{\Xi_{t-1}}), P_t(\xi_t)\}$.[26] (Note that, in this optimal consumption problem with savings, there is uncertainty regarding net income $y_t - P(\Xi_t)$ and mortality risk.[27])

For a given lifecycle income profile, the dynamic program provides an optimal consumption policy $C_t^*(\xi_t, a_t)$ where a_t is the level of assets carried into period t. The certainty equivalent of the dynamic problem is equal to:

$$u(C_{SAV}) = \frac{\mathbb{E}\left(\sum_{t=1}^{T} S_t \delta^{t-1} u(C_t^*(\xi_t, Z_t)\right)}{\mathbb{E}\left(\sum_{t=1}^{T} S_t \delta^{t-1}\right)}$$

Table 6 shows the welfare results when allowing for savings, assuming $r = 1/\delta - 1$. Precautionary savings substantially improve welfare under the series of short-term contracts. The consumption certainty equivalent increases from $CE_{ST} = \$9,004$ to $CE_{ST,PS} = \$17,186$ for *Ed 10* individuals, and from $CE_{ST} = \$18,898$ to $CE_{ST,PS} = \$20,979$ for *Ed 13* individuals. On the other hand, precautionary savings do not significantly improve welfare under the GLTHI. Intuitively, the GLTHI contract already achieves substantial savings through the large amount of frontloading without allowing for savings. As shown in Handel et al. (2017), under the optimal contract individuals have no incentives to engage in additional precautionary savings. Thus, introducing savings does not affect the certainty equivalent and welfare. As before, $C_{HHW} = \$19,800$ for *Ed 10* and $C_{HHW} = \$22,037$ for *Ed 13*.

[26] The state variable in the dynamic program under GLTHI is the guaranteed-renewable premium; its law of motion is given by the probability of qualifying for a lower premium.

[27] Mortality risk implies that individuals may die with positive assets. Therefore, the expected net present value of consumption with optimal savings will be lower than the net present value of resources. Our calculations implicitly assume that individuals do not derive value from bequests.

Table 6: Welfare by Type of Contract with Savings (Th USD)

	C_{HHW}	$CE_{GLTHI,PS}$	$CE_{ST,PS}$
Ed 10	19.800	19.582	17.186
Ed 13	22.037	21.901	20.979

Source: German Claims Panel Data, SOEP data, own calculation.

6.5 Optimizing German Long Term Health Insurance

A very appealing feature of the GLTHI contract is its simplicity and very little information requirements. While HHW's optimal dynamic contract achieves the maximum welfare, its consumption path depends on enrollees' wages and health risk realizations. In contrast, a GLTHI contract entails a constant premium path during the entire lifetime for almost the entire population. The results in Table 5 demonstrate that, despite its simplicity, a GLTHI contract achieves almost the same welfare than the optimal dynamic HHW contract.

In this section we explore whether a modification of the original GLTHI contract could improve welfare and close the gap to HHW, while maintaining its simplicity. In particular, we now allow the reclassification of all enrollees at some period $\tilde{T}$. This "piece-wise" GLTHI contract would consist of two parts: A GLTHI contract starting at $t = 1$ (age 25) with termination year $\tilde{T} - 1$, followed by a GLTHI contract starting at $\tilde{T}$ and termination year T. In period $\tilde{T}$, individuals are reclassified, so that the terms for the second contract depend on $\xi_{\tilde{T}}$. The main benefit of this piece-wise GLTHI is less frontloading: Young enrollees do not have to pre-pay for their expected expenditures at old age. On the other hand, this piece-wise GLTHI imposes reclassification risk at $\tilde{T}$.

Figure 9 shows the certainy equivalent comsumption of the modified GLTHI contract for different values of the reclassification period, $CE(\tilde{T})$ with $\tilde{T} \in [2, T]$. Note that $CE(\tilde{T})$ has several local maxima but one global maximum. Its overall shape reflects the underlying health dynamics, which we allow to vary every 5 years, generating discrete changes in the slope of $CE(\tilde{T})$. To illustrate one extreme: When $\tilde{T} = 2$, individuals are subject to a short-term contract in period 1, followed by a GLTHI contract starting in period 2 with terms that are very close to the original ones (and thus substantial front-loading). Hence, the welfare benefits are relatively small, but the costs potentially large. (Even though the majority is healthy at young age, the

Figure 9: Certainty Equivalent by Age and Type of Contract

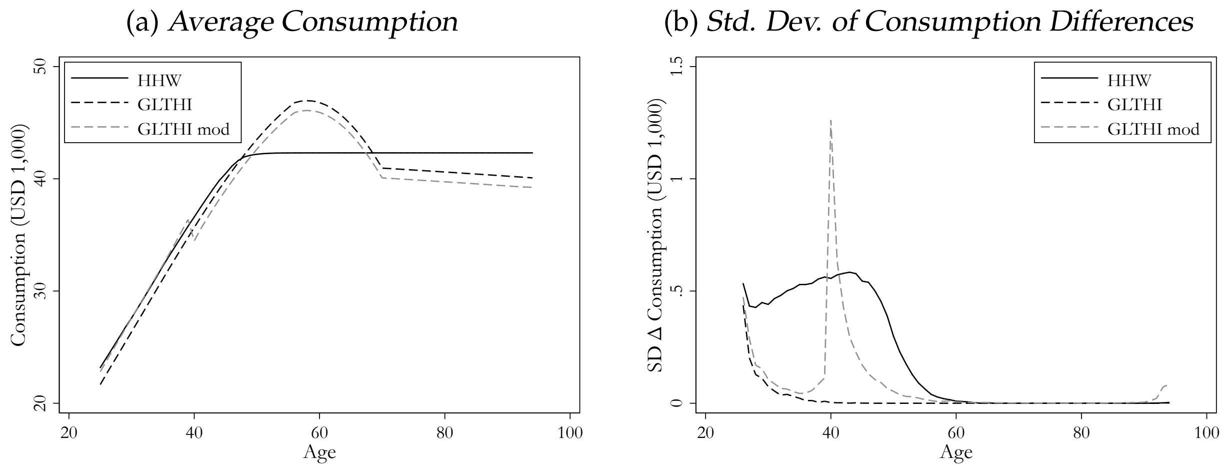
Source: German Claims Panel Data, SOEP data, own calculation, own illustration.

risk of a higher premium in period 2 is relatively large.) On the other hand, when $\tilde{T} = T$, the piece-wise GLTHI delivers almost the same certainty equivalent than the original GLTHI. In this case, the contract terms are almost the same, except for a short-term contract in period T. However, in the calculation of lifetime utility, this modification is highly discounted.

To evaluate by how much welfare could increase under this piece-wise GLTHI, we find the $\tilde{T}$ that maximizes the consumption certainty equivalent $CE(\tilde{T})$ of this modified GLTHI contract. As illustrated by the gray dashed line in Figure 9, we find $T^* = 40$. This means that, in the optimal piece-wise GLTHI, individuals buy a long-term contract at age 25 which expires at age 39. Then, at age 40, they buy another GLTHI contract (with new underwriting) that expires at age 94 (T). Figure 9 also compares the certainty equivalents for the original GLTHI (black dashed line), the piece-wise GLTHI (gray dashed line), and the HHW (black solid line) contract. As seen, by allowing for this simple modification of the original GLTHI, the gap between the GLTHI and HHW almost entirely vanishes.

Figure 10 provides further intuition regarding this result. It shows a) the average consumption and b) the standard deviation of consumption differences for the three contracts. As seen in Figure 10a, under the piece-wise GLTHI, average consumption during the early years is

Figure 10: Lifecycle Consumption by Type of Contract



Source: German Claims Panel Data, SOEP data, own calculation, own illustration.

closer to HHW than the original GLTHI, as the modified version imposes less frontloading. Compared to the original GLTHI, this reduced frontloading comes at the expense of lower future consumption. However, given the lifecycle income profile, such an intertemporal shifting of consumption increases welfare. On the other hand, the piece-wise GLTHI contract imposes reclassification risk at $\tilde{T}^*$, illustrated by a large spike in the standard deviation of consumption at age 40 (gray dashed line in Figure 10b). Although such reclassification risk is welfare-decreasing, it is overcompensated by a lower degree of frontloading.

6.6 Introducing a Medicare-Like Public Insurance for 65 Years Old and Over

So far, we have contrasted welfare under the GLTHI, the optimal dynamic contracts of Handel et al. (2017), and under sequences of short term contracts. In each case, we assumed that policyholders would keep each contract for their entire lives. Although this assumption is realistic for the GLTHI (because Germany has no special insurance program for retirees), it is instructive to evaluate the welfare consequences of introducing a "Medicare-like" program for those 65 and above. Even though we use German data to conduct this counterfactual experiment, a proper interpretation can illustrate possible welfare effects of transforming the current U.S. private health insurance system into a German-style long-term health insurance system. Another motivation to study the welfare consequences of this program is theoretical: The fact that the Medicare tax is fully enforceable reduces the one-sided commitment problem, and therefore the welfare predictions are theoretically ambiguous.

Medicare Tax + Full Coverage after 65. Specifically, we consider a social insurance program where, at age 65, individuals qualify for free health insurance that is financed by a proportional tax on income. Albeit being a highly simplified version of the U.S. Medicare program, its structure captures the main effect of Medicare in the context of long-term contracts. The Medicare tax acts as an additional, frontloaded premium during working ages to fund full free insurance for all people above 65, regardless of their health status.

We assume that the proportional Medicare payroll tax τ^* covers all expenses during the Medicare period (age 65 and above), such that[28]

$$\tau^* \mathbb{E}\left(\sum_{t=25}^{64} S_t \delta^{t-24} y_t\right) = \mathbb{E}\left(\sum_{t=65}^{94} S_t \delta^{t-24} m_t\right)$$

where, as above, S_t is an indicator of survival until period t, y_t is income, m_t medical spending, and δ is the discount rate.

To evaluate welfare under Medicare, we compute a new set of GLTHI premiums and consumption guarantees under HHW, assuming that the terminal period is $T = 64$.[29] Therefore, the certainty equivalent is the constant consumption level that provides the same lifetime utility than the combination of a) the GLTHI contract up to age 64 (and paying Medicare taxes) and b) free Medicare after age 65.

Table 7a shows the welfare results, separately for *Ed10* and *Ed13* lifecycle income profiles. Table 7b replicates the baseline results without medicare (and the corresponding contract over the entire lifecycle). We find that introducing a Medicare-like program is welfare *decreasing*. In particular, compared to the optimal contract, the Medicare program reduces consumption at earlier ages, with no substantial changes in the reclassification risk. As seen in Figure 7, the optimal HHW contract involves no reclassification risk after age 65. For similar reasons, the Medicare program does not improve welfare when combined with the GLTHI contract. GLTHI has already *too much* frontloading and *too little* reclassification risk relative to HHW.

In principle, because it substantially decreases consumption volatility at old ages, introducing a Medicare-like program could increase welfare in an economy with short-term contracts.

[28] In conducting this exercise separately for *Ed 10* and *Ed 13*, we do not allow for cross-subsidization and redistribution between high and low-income earners. By doing so, we can compare Medicare to our baseline scenario for the same net present value of resources. Consequently, all welfare consequences are due to intertemporal substitution and reclassification risk, and not due to transfers across individuals of different income levels. Also note that we abstract from the fact the marginal Medicare tax increases for individuals with annual incomes of more than $200K.

[29] For HHW, we also assume that income is taxed at the rate τ^*.

Table 7: The Impact of Introducing a Medicare-Like Public Insurance Program

	Ed 10	*Ed 13*
	Panel a: Medicare Tax up to 64 + Free Medicare from 65	
Tax (%)	4.67	3.31
CE_{GLTHI}	18.199	20.675
CE_{HHW}	18.294	20.751
CE_{ST}	9.198	17.666
	Panel b: Baseline	
CE_{GLTHI}	19.577	21.901
CE_{HHW}	19.800	22.037
CE_{ST}	9.004	18.898

Source: German Claims Panel Data, SOEP data, own calculation, own illustration.

On the other hand, the Medicare tax decreases consumption at early ages, when the marginal utility of consumption is high. As Table 7 shows, the findings for the two income groups are in line with this intuition. For the *Ed 13* group, which has a steeper income-age profile, the Medicare tax forces higher (tax) "savings" that substantially decrease the marginal utility of consumption. The welfare decrease under Medicare corresponds to a consumption drop of $1,232 per year. On the other hand, for the *Ed 10* group, introducing Medicare is beneficial in a short-term contract environment. Because people with less education have flatter lifecycle income profiles, the reduction in reclassification risk at older ages overcompensates the tax on income during working ages.

Comparing across contracts in Table 7a, we find that replacing short-term contracts with long-term contracts is highly beneficial from a welfare perspective, even in combination with a Medicare-like program.

Medicare Tax + Medicare Premium after 65. The results in Table 7 assume that the Medicare payroll tax during working ages fully covers all medical expenses for the population above 65. In reality, however, Medicare Part B beneficiaries do pay a (subsidized) premium.[30] Premium-free Medicare coverage at old-age increases the tax rate needed to fund the program and, therefore, the degree of frontloading. Because our findings show that our simplified version of

[30] In addition, Medicare Part A imposes substantial cost-sharing, from which we have abstracted throughout in the paper.

Medicare imposes *too much* frontloading, it is instructive to investigate the effect of introducing a Medicare premium with a corresponding decrease in the tax rate. In Appendix C, we refine our baseline calculations by illustrating the trade-off between charging a higher Medicare payroll tax for future beneficiaries vs. a higher Medicare premium for current beneficiaries. In conclusion, we find that a higher premium for current beneficiaries increases welfare because it increases consumption at early ages. However, even a very high Medicare premium (such that the Medicare tax is close to zero), combined with either the optimal contract or the GLTHI contract, would not achieve the same level of welfare achieved with the optimal (HHW) contract during the entire lifecycle.

Medicare Tax + Savings. We also investigate the robustness of the results in Table 7 by allowing for savings in the Medicare environment. In this economy, individuals are offered the GLTHI premium profile up to age 65, and (free) Medicare coverage starting at age 65. Such an insurance structure creates incentives to save. As in Section 6.4, we calculate welfare under an optimal level of savings and find a certainty equivalent of $18,649 (*Ed 10*) and $21,126 (*Ed 13*). This level of welfare is higher than welfare without savings (see Table 7), but still lower than welfare under either a lifetime GLTHI contract or a lifetime HHW contract.

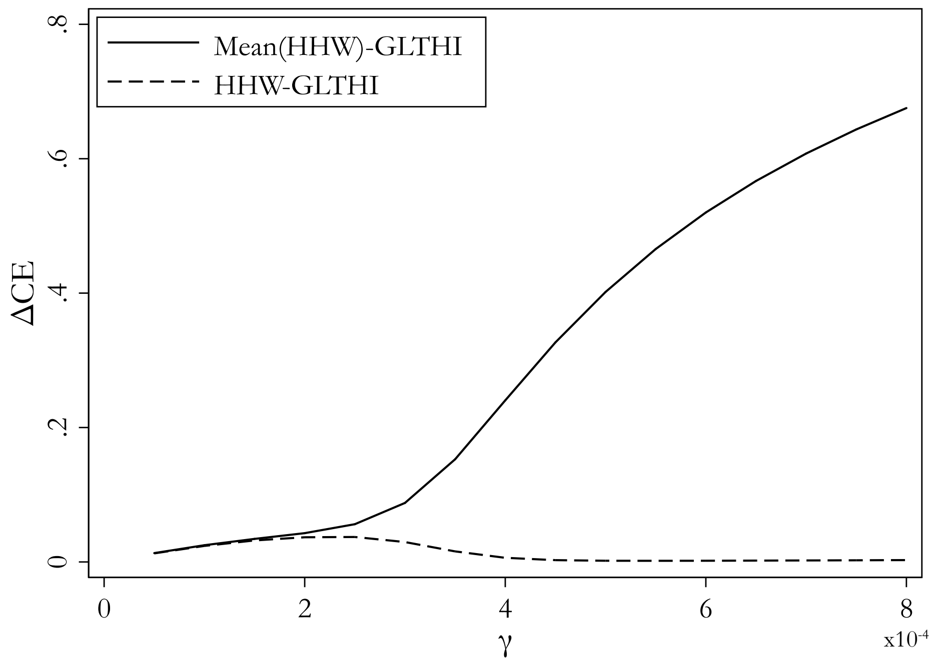
Discussion. It may be instructive to use the counterfactual results in Table 7 to assess the potential welfare consequences of transforming the current private health insurance system in the U.S. to a German style long-term health insurance system. In the U.S., Medicare covers people above 65 (and the disabled), financed by payroll taxes. Among the working age population, about 60 percent have employer-sponsored health insurance (ESI) and about 40 percent have either short-term private health insurance or are uninsured (Claxton et al., 2017). As a first order approximation, assume that the 60 percent with ESI are similar to GLTHI, and the other 40 percent are similar to short-term health insurance.[31] Then the current U.S. system could be considered a $60-40$ combination of CE_{GLTHI} and CE_{ST}, with welfare as reported in the top panel of Table 7. Hence, transforming the current private U.S. system by converting the 40 percent with CE_{ST} to CE_{GLTHI} would be welfare improving.

[31] This is a simplification of reality as the Affordable Care Act (ACA) implemented community-rating requirements but still allows to charge older people and smokers more. Given the political discussions, uncertainty about the future of the ACA, and the fact that the pre-ACA individual private market resembled short-term health insurance as modeled here, we find this simplification justifiable. Also, ESI is not long-term in the sense that it is tied to the current job.

6.7 Robustness: The Value of Risk Aversion

Under our parametric assumptions on preferences, the GLTHI contracts entail a small welfare loss relative to the optimal dynamic HHW contracts as characterized by Handel et al. (2017). Almost entirely eliminating reclassification risk basically compensates the welfare loss from heavier frontloading in GLTHI. Our main results assume a level of risk-aversion of $\gamma = 4 \times 10^{-}4$; with this level of risk aversion, an individual would be indifferent between a) a gamble where she wins \$1000 with a 50 percent chance and loses \$713 with a 50 percent chance and b) no gamble (i.e., the status quo). Although this level of risk aversion is consistent with the literature (cf. Handel et al., 2017), we investigate the robustness of our findings with respect to different levels of γ.

Figure 11: Difference in Consumption Equivalent, GHLTI vs. HHW, by Risk Aversion



Source: German Claims Panel Data, SOEP data, own calculation, own illustration. The x-axis shows the level of risk aversion γ. The y-axis shows differences in certainty equivalents between HHW and GLTHI as a fraction of total HHW welfare, in other words, the welfare loss of GLTHI relative to HHW. The dashed line shows total welfare differences, and the solid line shows only welfare differences due to differences in consumption.

Figure 11 shows the results graphically. The x-axis spans values of $\gamma \in [8 \times 10^{-}3; 8 \times 10^{-}4]$. For each γ, the y-axis shows the corresponding difference in certainty equivalents, as a fraction of the welfare in the optimal HHW contract. The dashed line plots total welfare difference between the GLTHI and the optimal dynamic HHW contract. As seen, the difference is small when γ is either very low or very high. That is, our main qualitative finding that the simple GLTHI contract can basically achieve the same welfare as the optimal dynamic HHW contract is robust to the degree of risk aversion, γ.

To investigate the underlying reason for the robustness of the findings with respect to γ, the solid line plots the percentage point differences in welfare when we only focus on differences in consumption across the lifecycle. In other words, we eliminate the welfare difference that is due to differences in reclassification risk. As seen, we find that HHW is superior to GLTHI and that the difference is increasing in γ.[32] At $\gamma = 4 \times 10^{-4}$, the welfare difference due to lifecycle consumption differences is very large (around $6,900). Hence, varying levels of risk aversion affect the differences between GLTHI and HHW via two underlying channels: The first is due to differences in lifecycle consumption, which clearly favors HHW, and even more so the larger γ; the second is due to differences in reclassification risk, which clearly favors GLTHI, and even more so the larger γ. As we vary γ, these two opposing forces almost completely cancel out.

When risk aversion is close to 0, the GLTHI and the HHW contract coincide. In the extreme case of risk-neutrality, the volatility of premiums and the lifecycle shape of expected consumption are irrelevant. For strictly positive γ's, HHW's welfare clearly exceeds GLTHI's. For low levels of γ, the lifecycle path of expected consumption is the most relevant factor determining the welfare differences between the two contracts. However, when γ becomes large enough, the higher degree of reclassification risk in HHW becomes increasingly relevant. Even though individuals with large γ strongly prefer the smoother consumption under HHW, they also dislike the higher associated reclassification risk.

The dashed line in Figure 11 shows that the maximal welfare difference between HHW and GLTHI arises when $\gamma = 2.16 \times 10^{-}4$;[33] this maximal difference amounts to 3.7 percent of the welfare attained under the optimal dynamic HHW contract.

[32] In practice, the line represents the CE of consumption after replacing the actual consumption under HHW with the expected consumption at each age under HHW, thus eliminating the reclassification risk component of the optimal contract. By contrast, the reclassification risk component of GLTHI is negligible.

[33] Under this level of risk aversion, an individual would be indifferent between a) a gamble where she wins $1,000 with a 50 percent chance or loses $822 with a 50 percent chance, and b) no gamble.

7 Conclusion

A fundamental challenge of pricing regimes in health insurance contracts is to balance reclassification risk, adverse selection, moral hazard and the desire to intertemporally smooth consumption over the lifecycle. In this paper, we study an existing real-world alternative to short-term insurance markets— the private health insurance market of Germany. This market features long-term contracts that almost fully eliminate health reclassification risk over the lifecycle. This elimination of reclassification risk comes at the expense of limited intertemporal consumption smoothing due to a high frontloading of premiums. However, overall, we find that the long-term contracts generate substantial welfare gains relative to short-term contracts. Most important, we show that the lower degree of reclassification risk almost fully compensates the welfare loss due to more frontloading relative to the optimal contract as derived by Handel et al. (2017). As a consequence, the German-style long-term contracts achieve almost the same welfare as the optimal dynamic contract. We also find large welfare gains of replacing short-term contracts by German-style contracts during working ages even in the presence of a Medicare-like program.

Compared to the optimal contract, an unquantified advantage of the German long-term contract is its simple design, combined with significantly lower information requirements. However, several unmodeled aspects and limitations could decrease the appeal of long-term contracts in general, and the German long-term contracts in particular. First, our model assumes time-consistent individuals. However, the large degree of frontloading in the German contract might appear highly undesirable from the perspective of a present-biased consumer.[34] Second, our model abstains from moral hazard. In the presence of moral hazard, eliminating reclassification risk could induce inefficiencies in spending that decrease the desirability of long-term contracts. Quantifying the role of moral hazard in long-term contracts is an important avenue for future research.

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[34] Gottlieb and Zhang (2018) show that, with a large number of periods, the inefficiencies arising from time inconsistency vanish, and time-inconsistent agents achieve the same level of welfare than time-consistent agents with the long-term contract that emerges in equilibrium

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Appendix A

A1 Descriptive Statistics

Table A1: Summary Statistics: German Claims Panel Data

	Mean	SD	Min	Max	N
Socio-Demographics					
Age (in years)	45.7	11.3	25.0	106.0	1,781,671
Female	0.285	0.451	0.0	1.0	1,781,671
Policyholder since (years)	6.7	5.0	1.0	40.0	1,781,671
Client since (years)	12.8	11.1	1.0	86.0	1,781,671
Employee	0.447	0.497	0.0	1.0	1,781,671
Self-Employed	0.485	0.500	0.0	1.0	1,781,671
Health Risk Penalty	0.363	0.481	0.0	1.0	1,781,671
Pre-Existing Condition Exempt	0.016	0.126	0.0	1.0	1,781,671
Health Plan Parameters					
TOP Plan	0.380	0.485	0.0	1.0	1,781,671
PLUS Plan	0.342	0.474	0.0	1.0	1,781,671
ECO Plan	0.278	0.448	0.0	1.0	1,781,671
Annual premium (USD)	4,407	2,155	2,025	7,467	1,781,545
Annual risk penalty (USD)	159	454	0	476	1,781,671
Deductible(USD)	675	665	0	1,326	1,781,671
Total Claims (USD)	3,347	8,583	0	8,809	1,781,671

Authors' calculations and illustration. *Policyholder since* is the number of years since the client has enrolled in the current plan; *Client since* is the number of years since the client joined the company. *Employee* and *Self-Employed* are dummies for the policyholders' current occupation. *Health Risk Penalty* is a dummy that is one if the initial underwriting led to a health-related risk add-on premium on top of the factors age, gender, and plan; *Pre-Existing Conditions Exempt* is a dummy which equals one if the initial underwriting led to a coverage exclusion of services for some conditions. The mutually exclusive dummies *TOP Plan*, *PLUS Plan* and *ECO Plan* capture the generosity of the plan. *Annual premium* is the annual premium, and *Annual Risk Penalty* is the amount of the health risk penalty charged. *Deductible* is the deductible and *Total Claims* the sum all claims in a calendar year. See Section 4.1 for further details.

Table A2: Summary Statistics: German Socio-Economic Panel Study

	Mean	SD	Min	Max	N
Socio-Demographics					
Female	0.5217	0.4995	0	1	530,228
Age	46.9119	17.4922	17	105	530,228
No degree yet	0.058	0.2338	0	1	530,228
Dropout of high school	0.0378	0.1908	0	1	530,228
Degree after 8/9 years of schooling (Ed 8)	0.3619	0.4805	0	1	530,228
Degree after 10 years of schooling (Ed 10)	0.2737	0.4459	0	1	530,228
Degree after 13 years of schooling (Ed 13)	0.1746	0.3796	0	1	530,228
Employment					
Civil servant	0.0393	0.1943	0	1	530,228
Self-employed	0.0624	0.2419	0	1	530,228
White collar	0.2736	0.4458	0	1	530,228
Full-time employed	0.4152	0.4928	0	1	530,228
Part-time employed	0.1402	0.3471	0	1	530,228
Income Measures in 2016 USD					
Monthly gross wage	2,940	2,506	0	215,093	310,460
Monthly net wage	1,921	1,527	0	134511.5	310,460
Individual annual total income	20,361	24,434	0	2,580,000	530,228
Equivalized post-tax post-transfer annual income	26,433	18,731	0	2,155,394	530,228
Insurance and Utilization					
Hospital nights in past calendar year	1.6652	8.3794	0	365	530,228
Doctor visits in past 3 months	2.4941	4.1436	0	99	461,971
Privately insured	1	0	1	1	57,558

Authors' calculations and illustration. Data source is the SOEP (2018), the long version from 1984 to 2016. Whenever the number of person-year observations is less than 530,228 the question was not asked in all years from 1984 to 2016. For example, *Doctor visits in past 3 months* has only been routinely asked since 1995. *Privately insured* indicates that 57,558/530,228=10.8% of all observations are by people who are insured on the German LTHI market. All income measures have been generated and cleaned consistently by the SOEP team; e.g., *Monthly gross wage* is labeled *labgro* and *Monthly net wage* is labeled *labnet* in SOEP (2018). See Section 4.2 for a detailed discussion of the variables.

A2 Switching from GLTHI to SHI

As mentioned in Section 2, the decision to enter the private market is essentially a "lifetime decision." The basic social insurance principle is: "Once private, always private[ly insured]." Below, we discuss the specific and very limited institutional exemptions for GLTHI enrollees to return to the public SHI system. We also provide empirical evidence on the switching rates.

First, for people above the age of 55, switching back to the public system is essentially impossible, even when their income decreases substantially or they become unemployed. One of the few options for people above 55 would be to exit the labor force and enroll under the public family insurance of the spouse, if available. Rules for switching back to SHI have been very strict for older employees to avoid strategic switching to the private system when individuals are young and healthy, and switching back to the public system when they are old, sick and have little income (and thus low income-dependent contribution rates).

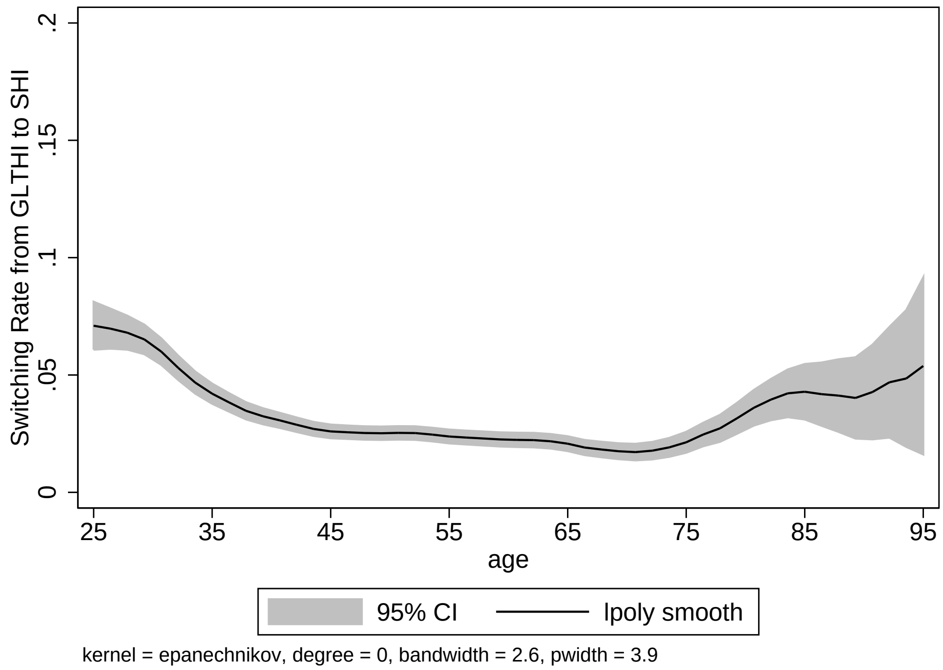
Second, people below the age of 55 may return to SHI only if they become unemployed (and receive UI benefits), or if their gross wage from dependent employment permanently drops below the income threshold. Assuming an average annual premium of €3,900 (as observed in our data), a privately insured would need to reduce her annual labor income to €25,000 for an equally high SHI contribution amount (15.5% of the gross wage). This suggests that income reductions that (rationally) justify a switch towards SHI are substantially larger than income drops that qualify individuals for switching. Moreover, switching towards SHI entails loosing the entire old-age provision which averaged about $29K per policyholder in 2017 (Association of German Private Healthcare Insurers, 2018a). In addition, in case of switching back to GLTHI in the future, those individuals would be subject to risk reclassification.

Third, the self-employed below 55 can only switch to the public system if they give up their business and become an employee with a gross salary below the income threshold (see Social Code Book V, Para. 6 for details of the law, Büser, 2012; Cecu, 2018).

Official statistics show that the absolute number of people who switched from the private to the public system has been relatively stable at around 130,000 since the beginning of the 1990s, which corresponds to around 1.5 percent of the GLTHI market per year.[35] Figure A1 below uses SOEP

[35]Since the total number of enrollees in private insurance has steadily increased in the last decades, this implies declining switching rates over time. Several reforms in the last decades are likely to be the cause of these declining switching rates over time: The *Gesundheitsreformgesetz* of December 20, 1988 substantially tightened the possibility of switching for pensioners; the *Gesundheitsstrukturgesetz*, passed on December 21, 1992, also likely affected switching between the systems as it introduced the free choice of SHI sickness funds, along with other provisions about the regulation of private

Figure A1: Likelihood to Return to SHI by Age



Source: SOEP data, own calculation, own illustration.

data to plot switching rates by age. As seen, the likelihood to return to SHI decreases substantially between the age of 25 and 35. We conjecture that this is mostly because people who were privately insured as students enter the labor market and have to enroll in SHI if their gross salaries are below the income threshold. Switching rates remain stable at a low level between age 40 and age 75, and then slightly increase again. Using a fixed effects regression for the probability of switching to SHI among the universe of Germans who were at least once policyholder of a comprehensive private plan, we find very few significant determinants of switching back from the private to the public system. In particular, health care utilization measures (number of hospital nights and doctor visits) are not significant determinants and neither is the equivalized household income. The results of this analysis are available upon request.

insurers. Likely due to these and other reforms (e.g. the *GKV-Wettbewerbsstärkungsgesetz* of 2007), the rate as a share of all privately insured has declined in the last decades.

Figure A2: Age Distribution of Initial Plan Inception

Source: German Claims Panel Data, own calculation, own illustration.

Table A3: One-Year Health Risk Category Transitions

	λ_{t+1}					
λ_t	1	2	3	4	5	6 (†)
1	0.849	0.120	0.022	0.007	0.001	0.001
2	0.342	0.495	0.129	0.030	0.002	0.003
3	0.163	0.328	0.397	0.093	0.008	0.010
4	0.141	0.206	0.258	0.324	0.037	0.032
5	0.061	0.081	0.136	0.264	0.332	0.126

Source: German Claims Panel Data. Sample includes all years, all age groups, and uses the ACG© score as λ.

Table A4: λ Risk Category Transitions: Enrollees 25–30 Years

		λ_{t+1}					
λ_t	λ_{t-1}	1	2	3	4	5	6 (†)
1	1	0.928	0.056	0.012	0.003	0.000	0.000
	2	0.805	0.162	0.028	0.005	0.001	0.000
	3	0.784	0.146	0.060	0.009	0.001	0.000
	4	0.777	0.134	0.051	0.034	0.004	0.000
	5	0.741	0.154	0.070	0.023	0.010	0.002
2	1	0.647	0.279	0.062	0.011	0.000	0.000
	2	0.435	0.450	0.099	0.015	0.001	0.000
	3	0.349	0.435	0.188	0.026	0.003	0.000
	4	0.360	0.407	0.164	0.065	0.003	0.000
	5	0.295	0.437	0.200	0.054	0.013	0.001
3	1	0.549	0.244	0.179	0.027	0.001	0.000
	2	0.294	0.397	0.268	0.036	0.004	0.000
	3	0.206	0.272	0.452	0.063	0.007	0.001
	4	0.191	0.203	0.447	0.139	0.019	0.001
	5	0.120	0.217	0.487	0.123	0.051	0.003
4	1	0.540	0.198	0.134	0.118	0.006	0.003
	2	0.306	0.355	0.207	0.116	0.015	0.001
	3	0.173	0.213	0.396	0.191	0.025	0.002
	4	0.213	0.131	0.247	0.361	0.045	0.004
	5	0.098	0.108	0.259	0.356	0.164	0.015
5	1	0.371	0.140	0.187	0.178	0.090	0.034
	2	0.248	0.241	0.199	0.160	0.140	0.013
	3	0.115	0.134	0.331	0.223	0.186	0.012
	4	0.118	0.061	0.162	0.340	0.291	0.028
	5	0.035	0.045	0.123	0.186	0.574	0.038

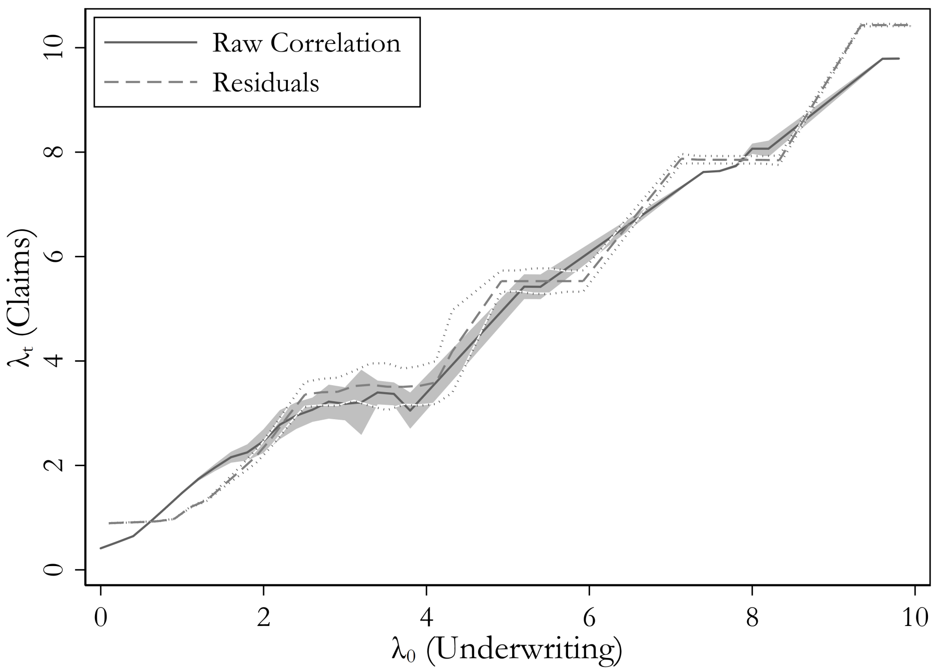
Source: German Claims Panel Data. Sample includes all years, 25-30 year old enrollees, and uses the ACG© score as λ.

A3 Defining Health Risk λ: Using Underwriter's Risk Predictors

For new clients, our data contain all risk predictors that the carrier's underwriters use to calculate risk-rated premiums. In addition, for all policyholders, we know whether pre-existing conditions existed at the time of initial enrollment, whether these have been excluded from coverage, or whether the enrollees have been charged an additional risk penalty due to their pre-existing condition. Table A1 shows that about a third of all enrollees have been charged a *health risk penalty* (on top of the gender-age risk cells).

In a robustness check, we calculate the ACG© score using the same information as the underwriters and denote the variable λ_0^*. Figure A3 compares both ACG© scores for new clients—before and after controlling for age and sex. As seen, λ^* and λ_0^* are highly correlated, suggesting—not surprisingly—that the underwriters' risk predictors are strong predictors of future claim risk. In another robustness check below, we solely focus on health plans without deductibles to approximately full coverage.

Figure A3: Correlation of λ^* and λ_0^*



Source: German Claims Panel Data, ACG©, own calculation, own illustration.

A4 Defining Health Risk λ: Only Zero-Deductible Plans

This robustness section focuses on plans without deductibles. These plans have approximately full coverage and thus more reliable information on the universe of health care expenditures. Figure A4 compares the distributions of the two latent variables. As expected, the zero-deductible plans have higher ACG© scores in general.

Figure A4: Distribution of λ^* for Standard Approach vs. Zero-Deductible Plans.

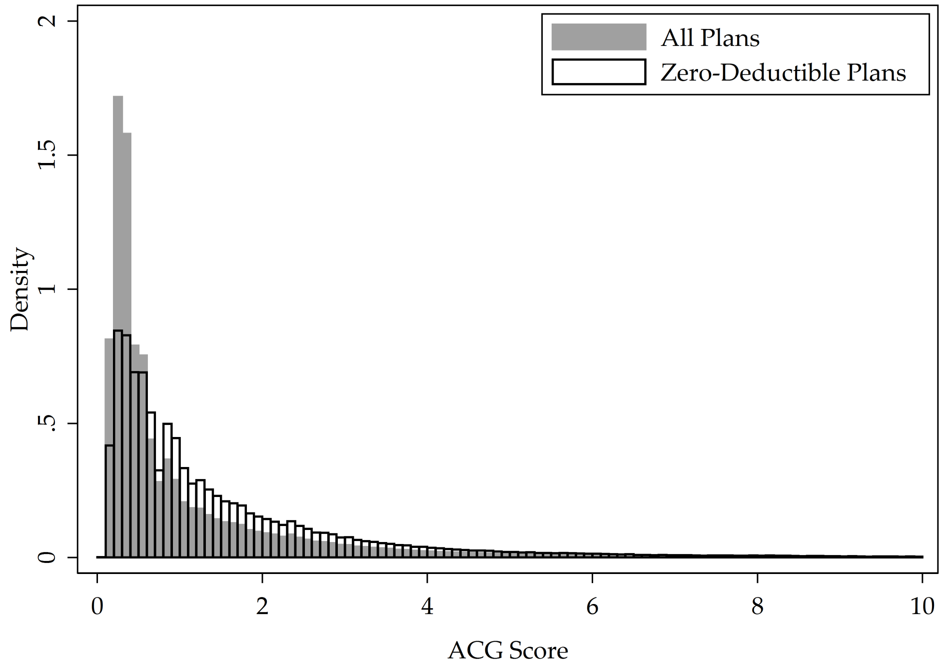


Table A5: Zero-Deductible Plans—Health Risk Categories by Age Group

Age	1 (Healthiest)	2	3	4	5 (Sickest)
25-	0.84	0.12	0.03	0.01	0.00
30-	0.81	0.15	0.04	0.01	0.00
35-	0.74	0.20	0.04	0.01	0.00
40-	0.71	0.22	0.05	0.02	0.00
45-	0.63	0.28	0.06	0.02	0.00
50-	0.54	0.34	0.09	0.03	0.00
55-	0.39	0.44	0.13	0.04	0.01
60-	0.29	0.47	0.18	0.06	0.01
65-	0.17	0.54	0.23	0.05	0.00
70-	0.08	0.51	0.33	0.08	0.00
75-	0.04	0.40	0.44	0.12	0.01

Source: German Claims Panel Data. Sample includes all years, all age groups, and uses the ACG© score as λ.

Table A6: Zero-Deductible Plans—Health Risk Category Transitions

	λ_{t+1}					
λ_t	1	2	3	4	5	6 (†)
1	0.772	0.189	0.029	0.009	0.001	0.000
2	0.265	0.557	0.143	0.031	0.002	0.002
3	0.105	0.344	0.432	0.100	0.009	0.010
4	0.100	0.217	0.281	0.341	0.035	0.026
5	0.045	0.095	0.167	0.290	0.305	0.098

Source: German Claims Panel Data. Sample includes only zero-deductible plans but otherwise all years, all age groups, and uses the ACG© score as λ.

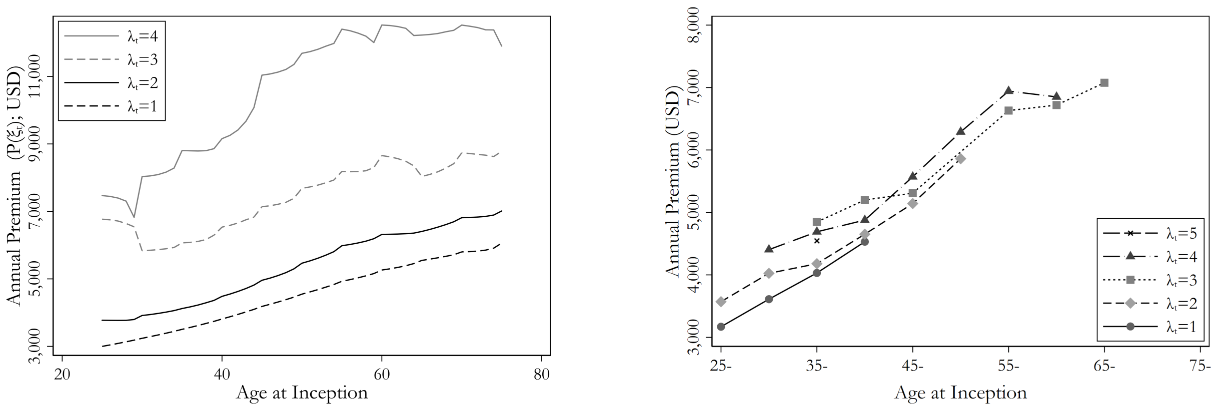
Appendix B

B1 German LTHI Premium Profiles

Figure B1 compares the (a) calibrated and (b) observed premium profiles for individuals entering their plan at different ages. Figure B1 (a) shows calibrated premiums for given λ_t averaged over λ_{t-1} (as there is no equivalent of λ_{t-1} in the ACG© score λ_0^*). Figure B1 (b) shows the corresponding actual premiums by age and risk type when entering the plan.

Figure B1: Calibrated vs. Actual Starting Premiums $P(\lambda_t)$ by Age at Inception

(a) Calibrated (b) Observed



Source: German Claims Panel Data. Sample includes all years and all health plans. Own calculation, own illustration. In Figure B1 (b), we averaged premiums for each of the three benefit categories *TOP, PLUS, ECO* and then aggregated them according to the share of each category in the enrollee population.

Appendix C

C1 Trading Off the Medicare Payroll Tax and Medicare Premiums

In this section, we evaluate the welfare consequence of changing the timing of payments into Medicare. Our baseline scenario assumes that Medicare coverage is completely free without any premium. However, the actual Medicare program in the US entails a premium (Part B) and cost-sharing provisions (Part A and B). In the context of our lifecycle model, premiums and cost-sharing provisions backload Medicare expenses by reducing the Medicare tax rate required to fund Medicare.

As a first approach, we maintain the assumption of no cost-sharing, but vary the level of premiums charged during retirement. Specifically, we assume a Medicare premium p has to be paid, starting at age 65. The associated Medicare tax rate $\tau(p)$ is such that the revenue neutrality condition holds

$$\tau(p)\,\mathbb{E}\left(\sum_{25}^{64} S_t \delta^{t-24} y_t\right) = \mathbb{E}\left(\sum_{65}^{94} S_t \delta^{t-24}(m_t - p)\right)$$

It is clear from this equation that a higher premium at old age is compensated by a lower tax rate at younger ages. Figure B1 shows this trade-off, where the x-axis depicts the tax rate that is needed for each premium level depicted on the y-axis.

Figure B1: Tax Rate and Medicare Premium

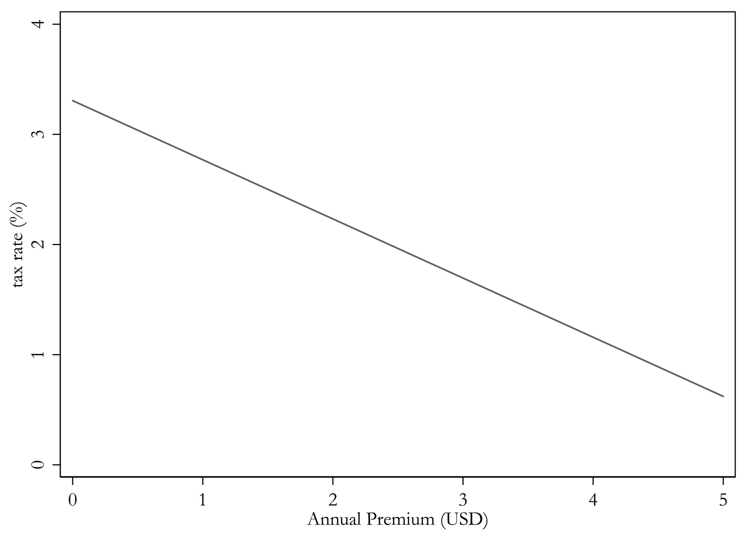
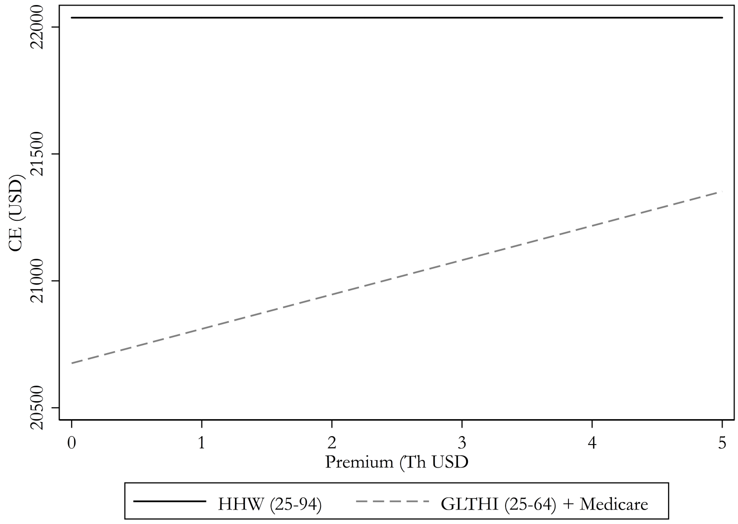


Figure B2 shows welfare for the combined GLTHI + Medicare case, and when charging a Medicare premium in addition to the Medicare tax. The x-axis shows different premium levels, and the y axis shows the welfare consequences.

Figure B2: Welfare of HHW and Medicare with different Premiums



Three findings emerge from Figure B2: 1) a higher Medicare premium (and thus lower tax rate) is desirable from a welfare perspective, and 2) at any premium level, HHW does better than GLTHI.

To understand the intuition behind the welfare result in Figure B2, Figure B3 shows the expected lifecycle consumption profiles under (a) HHW over the entire lifecycle, (b) GLTHI + Medicare with a zero premium and the corresponding tax rate in Figure B1, (c) GLTHI + Medicare with a premium of $5K and the corresponding tax rate in Figure B1.

Figure B3: Expected Consumption Profile

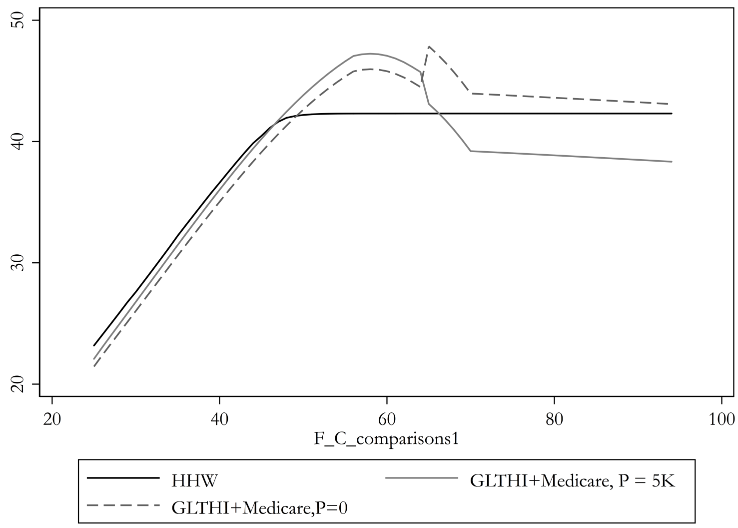


Figure B3 illustrates that a higher Medicare premium increases consumption in early ages (because it decreases the tax rate). Under the GLTHI + free Medicare scencario, one observes a sharp increase in consumption at retirement, because individuals stop paying GLTHI premiums and stop paying Medicare taxes. Under the GLTHI + Medicare with a $5K premium scenario, one observes a reduction in consumption at retirement because the Medicare premiums exceeds the GLTHI premium. Figure B3 also illustrates than even a very large Medicare premium (and almost zero Medicare tax) does not outperform HHW because it fails to achieve the same level of consumption at early ages. Compared with the optimal contract, it still has too much frontloading.