German Long-Term Health Insurance: Theory Meets Evidence

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German long-term health insurance (GLTHI) represents the largest market for private long-term health insurance contracts in the world. We show that GLTHI's contract design coincides with the optimal dynamic contract for individuals with constant lifetime income profiles. After estimating the key ingredients of a life-cycle model, we find that, under a variety of assumptions, GLTHI achieves welfare that is at most 4% lower than for the optimal contract. Relative to the gains of replacing short-term contracts with either of the two long-term contracts, this welfare gap is smallest when reclassification risk is high.

I. Introduction

Short-term health insurance contracts can expose policyholders to potentially large premium fluctuations. Such "reclassification risk" can lead to significant welfare losses (Diamond 1992; Cochrane 1995). The standard policies, most notably community-rated premiums and guaranteed issuance regulations, strive to avoid reclassification risk, uninsurance, and unaffordable premiums for sick individuals (Claxton, Levitt, and Pollitz 2017; Cole, Kim, and Krueger 2019). However, these policies can generate adverse selection, which is generally addressed through individual mandates, premium subsidies, or both (see Akerlof 1970).[1]

Long-term (or dynamic) health insurance contracts can provide reclassification risk insurance without triggering adverse selection and without the need for mandates or subsidies. Instead, they leverage individuals' intertemporal incentives to insure reclassification risk with a schedule of "front-loaded" premiums (Pauly, Kunreuther, and Hirth 1995; Pauly, Percy, and Herring 1999; Patel and Pauly 2002; Pauly and Lieberthal 2008). Although front-loading hinders intertemporal consumption smoothing, long-term contracts that optimally balance those detrimental effects with reclassification risk insurance can generate large welfare gains relative to short-term contracts (Ghili et al. 2024).[2] However, despite their theoretical

appeal, little is known about real-world applications of long-term contracting in health insurance and how implementation relates to the theoretical prescriptions.

In this paper, we study the most prominent real-world application of dynamic health insurance contracts: German long-term health insurance (GLTHI). We provide the following main contributions to the literature. First, we show that, despite their simple design, existing GLTHI contracts share several features with the optimal dynamic contract characterized by Ghili et al. (2024). Second, we estimate the key ingredients of a life-cycle model to evaluate welfare under the GLTHI contracts and compare it to welfare under the optimal contracts. Finally, we highlight the general circumstances under which the performance of optimal contracts is robust to the simplifications of the German design.

Several features make the GLTHI contracts especially appealing to study. First, Germany has the largest and oldest individual private long-term health insurance market in existence.[3] Second, contracts in this market are purely financial—with no differentiation in the provider network across insurers or plans. The absence of networks makes it well suited for a comparison with the theory of optimal dynamic pricing in health insurance (which also abstracts away from such differentiation across plans). Third, after an initial risk rating, contracts follow the simple principle of guaranteed renewability with constant and income-independent premiums for as long as the policyholder decides to renew (Hofmann and Browne 2013). This simple design is particularly appealing from a policy perspective.

We first present the main principles of GLTHI and show that its simple contract design coincides with the optimal dynamic contracts derived by Ghili et al. (2024) when the policyholder's income profile is flat over the life cycle. We also use data on premiums to corroborate the finding that the theoretically optimal contract for flat life-cycle incomes matches the observed GLTHI premiums very well. As a consequence, for the typical policyholders with an increasing life-cycle income profile, the simple GLTHI design, relative to that of the optimal dynamic contract, provides more reclassification risk insurance and charges higher premiums early in life, resulting in suboptimal consumption smoothing over the life cycle.

We find that welfare under the GLTHI design, as measured by certainty-equivalent yearly consumption, is close to 96% of what the optimal contract would achieve. To do so, we first estimate the key ingredients of a model of health expenditures and income over the life cycle by combining a unique panel of claims data with 33 years of income data from

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[3] Its roots go back to 1883, and currently it covers almost 9 million individuals. In addition to Germany, the Chilean private health insurance market is the only other private market with comprehensive long-term health insurance.

Germany's representative Socio-Economic Panel (SOEP). As a critical component of our analysis, we propose and implement a novel health risk classification method to parsimoniously model individuals' expected health risks and the evolution of those risks over the life cycle, while recovering relevant features of typical health expenditure distributions.

Our welfare results are robust to multiple alternative assumptions. We find welfare differences of a similar magnitude if we consider (i) a wide range of risk aversion; (ii) different functional forms for utility, including Epstein-Zin recursive preferences; (iii) private savings; (iv) an initial health status that matches the German population as a whole (instead of the population of the privately insured); and (v) US income profiles.

We finish by showing that the extent to which the GLTHI design recoups the welfare gains from the optimal dynamic contracts (relative to short-term contracts) critically depends on the degree of reclassification risk. When policyholders face large reclassification risk, the GLTHI design provides most of the gains from long-term contracting despite being suboptimal, as its excessive front-loading is largely compensated by its higher insurance against reclassification risk. It is important to note that those environments with high reclassification risk are also the cases where long-term contracts are particularly effective, as the welfare gains from reducing catastrophic reclassification risk are large relative to the welfare losses from premium front-loading. In contrast, in contexts with limited catastrophic losses—due to, for example, government social safety net programs—the GLTHI contract would recoup a smaller fraction of the gains from optimal long-term contracting.

Our results have policy implications for the US and elsewhere. Our analysis of Germany's experience shows the effectiveness of a real-world application of long-term contracts in health insurance. It also shows that the simple flat-income version of optimal long-term contracts implemented in Germany—a single long-term contract with constant premium guarantees—can recoup much of the overall potential gains of optimal long-term contracting, especially with large reclassification risk. This result strengthens the case for long-term health insurance as an appealing policy option, particularly in contexts where reclassification risk is not already insured. We see this result as a vindication of the theory of dynamic contracting in health insurance.

This paper contributes to several strands of literature. First, it contributes to the literature on dynamic contracts, for which there is vast theoretical work but relatively little empirical evidence. Pauly, Kunreuther, and Hirth (1995) propose a "guaranteed-renewable" contract with a prespecified path of premiums that fully eliminates adverse selection and reclassification risk. Similarly, Cochrane (1995) proposes a scheme of severance payments between the insured and the insurer, made after the realization of health shocks, which provides full insurance against

reclassification risk. Harris and Holmstrom (1982) and Krueger and Uhlig (2006) study the properties of competitive long-term contracts that insure agents against income risk under one-sided commitment when agents receive endogenous outside offers. Hendel and Lizzeri (2003) and Ghili et al. (2024) show that the optimal dynamic insurance contract only partially insures reclassification risk because full insurance for such risk requires front-loaded premium payments that hinder consumption smoothing over the life cycle. Importantly, we both rely and build upon Ghili et al. (2024), as we use their characterization of the optimal long-term health insurance contract over the life cycle and perform similar welfare comparisons. One crucial addition is to show how GLTHI, the most important real-world application of long-term health insurance contracts, compares to a version of their theoretically optimal contract—the contract that would emerge under flat income profiles—and to quantify the welfare gap from such a suboptimal implementation of their theory. We also characterize and quantify the 1-period state-contingent Arrow securities that can be used to implement the GLTHI, as well as the optimal contract (Krueger and Uhlig 2006). Arrow securities have the advantage of fostering insurer competition by overcoming the detrimental lock-in effects of long-term contracts.[4]

Second, several papers empirically investigate the workings of long-term contracts in different contexts (including Hendel and Lizzeri 2003; Finkelstein, McGarry, and Sufi 2005; Herring and Pauly 2006; Fleitas, Gowrisankaran, and Sasso 2018; Atal 2019). Our paper contributes to this literature by contrasting the empirical applications of health insurance contracts with their optimal design throughout the life cycle. We also introduce a novel data-driven method for classifying health risks. We base our method on an explicit objective function proposed in the actuarial science literature that maximizes the differentiation between risk classes, invoking the properties of homogeneity and separation in risk classification (see Finger 2006). By better capturing the skewness of health expenditures, our method improves on ad hoc methods for discretizing health risks commonly used in the literature. Critically, by accurately modeling the right tail of health expenditure distributions, we highlight the workings of long-term contracts in insuring individuals against catastrophic risks.

Finally, our paper relates to previous work on the German long-term health insurance market. Christiansen et al. (2016) empirically study the determinants of lapsing and switching behavior. Baumann, Meier, and

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[4] We abstract from the effects of long-term health insurance on health transitions in this paper. See Cole, Kim, and Krueger (2019) for a quantitative dynamic model of health investments and insurance that studies the short- and long-term effects of community-rated health insurance.

Werding (2008) and Eekhoff, Jankowski, and Zimmermann (2006) discuss the potential consequences of higher switching rates on market competition if the capital accumulated through front-loaded payments ("old age provisions") were to be made portable across insurers. Avdic et al. (2024) study how cost sharing in GLTHI affects utilization, and Atal et al. (2019) theoretically and empirically study the effects of the 2009 portability reform in Germany on switching behavior. Closest to our work, Hofmann and Browne (2013) describe the actuarial principles of premium calculation in GLTHI. They document that contracts with premium front-loading generate consumer lock-in, that more front-loading is generally associated with lower lapsation rates, and that low-risk individuals are more likely to lapse. They link these findings with the predictions of the 2-period model of optimal dynamic insurance in Hendel and Lizzeri (2003). We explicitly compare the features of the GLTHI contracts with those of the optimal long-term insurance contract over the life cycle as characterized by Ghili et al. (2024) and show that the two contracts coincide under flat life-cycle income profiles. We also evaluate the welfare consequences of GLTHI contracts.

II.   Institutional Background

Germany has a two-tier health insurance system. Since 2009, Germany has an individual mandate that every resident must have health insurance (*Versicherungsvertragsgesetz* [VVG, Insurance Contract Act], § 193).[5] The first tier consists of public health insurance (*Gesetzliche Krankenversicherung*; GKV) and covers 90% of the German population. Every employee whose income is below the politically defined federal threshold (*Versicherungspflichtgrenze*) of €69,300 in 2024 (about $74,000) is mandatorily insured with the public multipayer system. GKV policyholders can choose among 97 private nonprofit sickness funds (*Gesetzliche Krankenkassen*; Bünnings et al. 2019; GKV-Spitzenverband 2024). Premiums consist of income-dependent contribution rates (employees and employers each pay about 8% of the gross wage up to a cap) for a standardized benefit package with very little cost sharing. Germany was the first country in the world to introduce such a public health insurance system in 1883 (*Gesetz betreffend der Krankenversicherung der Arbeiter*), and the basic structure of the system has remained intact since its inception.

For historical reasons, select population subgroups can permanently opt out of the GKV system and join the second tier: private health insurance (*Private Krankenversicherung*; PKV), which covers the remaining 10%

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[5] Despite the two tiers, the uninsurance rate is low, at around 0.1% (Statistisches Bundesamt 2020). Further institutional details on the two-tier German health insurance system can be found in English in Schmitz and Ziebarth (2017) or in German in Henke (2007).

of the population with about 8.7 million policyholders (Koch 1971; VPK 2023). The PKV covers three main population subgroups: the (*a*) self-employed, (*b*) high-income earners with gross incomes above the *Versiche-rungspflichtgrenze*, and (*c*) civil servants. They can decide to leave the public GKV system permanently to join the PKV and sign a private individual long-term health insurance contract for the rest of their lives (Hullegie and Klein 2010; Polyakova 2016; Panthöfer 2016).[6] To prevent individuals from strategically switching back and forth, the decision to enter the private market is essentially a lifetime decision. The basic principle is: "Once private[ly insured], always private[ly insured]" (Schencking 1999; Jacobs et al. 2012; IKKBB 2018). However, in practice, there are (costly) possibilities to switch back to the GKV for people under 55, for example, if one becomes unemployed or (permanently) switches to a private sector job with income below the *Versicherungspflichtgrenze* (see *Sozialgesetzbuch* VI [SGB; Social Code], §6).[7] Note that catastrophic health care costs are not an acceptable reason to switch back. Moreover, GLTHI insures reclassification risk and the regulator sets a maximum annual out-of-pocket cost sharing cap of €5,000 (see VVG, §193, para. 3). In practice, cost sharing is much lower; in our data, the mean deductible is €675 and the highest deductible €3,224 (table A1; tables A1–A11 are available online). Appendix section A1 discusses the institutional specifics and the empirical evidence on the general lack of switching from PKV to GKV.

To our knowledge, Germany is one of only two countries in the world with an existing private individual long-term health insurance market

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[6] Civil servants represent a special case as they receive about 50% of their insurance coverage from the states or federal government as their employer—and typically purchase PKV contracts for the remaining part.

In 1995, Germany introduced a mandatory long-term care (LTC) insurance system. The structure follows the structure of the two-tier health insurance system with some minor differences: (*a*) Those who are mandatorily insured in the public GKV system also have to obtain public long-term care insurance (*Gesetzliche Pflegeversicherung*; GPV), which is funded by an additional 3.05% payroll tax for enrollees with children up to the contribution cap, equally split between employees and employers (Bundesministerium für Gesundheit 2024). (*b*) Those insured in the private PKV system with GLTHI also have to obtain a private LTC insurance from a private insurer. Like GLTHI, premiums are risk rated and front-loaded. However, the benefits have to equal the GPV benefits and the maximum premium is capped at the level of the highest possible premium in the public market (after 5 years as a policyholder; Bundesministerium für Gesundheit 2024; VPK 2024). However, it is important to note that, first, the LTC benefits and health care benefits are well-defined, distinct, and insured separately; second, individuals who opt out of the public system can choose to enroll with different private insurers for their LTC and health insurances; third, from its inception, the private GPV system made the old age reserves of LTC insurance fully portable when switching to another insurer, which was not the case for GLTHI in our study period. While interactions between LTC and traditional health insurance could be relevant—e.g, one's LTC needs may be affected by the healthcare she receives and vice versa—modeling these interactions is beyond the scope of this paper.

[7] Note that deliberate short-term income manipulation is not allowed (TK 2024). Also note that it is impossible for people above 55 to switch back.

(the other is Chile; cf. Atal 2019). The GLTHI market consists of 48 private insurers that sell comprehensive as well as supplemental coverage (VPK 2020). The focus of this paper is comprehensive coverage.[8]

Provider networks.—Provider networks and managed care are largely unknown in both GKV and PKV; that is, in either system, enrollees have the free choice of providers.[9] Moreover, in both systems, reimbursement rates are set centrally and do not vary by insurers or health plans. Although reimbursement rates for inpatient care are identical in both systems, rates are approximately twice as high for outpatient care in the PKV. These structurally higher outpatient reimbursement rates result in significantly shorter waiting times for the privately insured (cf. Werbeck, Wübker, and Ziebarth 2021).[10] Because they do not negotiate rates or build provider networks, private insurers mainly customize health plans and process, scrutinize, and deny claims. Thus, the GLTHI contract mainly constitutes a pure financial contract similar to policies in insurance markets such as life insurance (Fang and Kung 2020). This specific feature substantially simplifies the welfare analysis of GLTHI contracts and its comparison with the optimal long-term contracts.[11]

One-sided commitment and guaranteed renewability.—When individuals apply for a GLTHI policy, insurers have the right to deny applicants with bad risks or impose preexisting condition clauses. However, once contracts are signed, insurers cannot terminate them. GLTHI contracts are not annual contracts, but permanent lifetime contracts without an end date. In other words, GLTHI contracts are guaranteed renewable over the life cycle. However, policyholders can terminate these permanent contracts and switch insurers. Thus, the GLTHI is a market with one-sided commitment. It is very common that policyholders keep their GLTHI contract until they die: Medicare does not exist in Germany.

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[8] While comprehensive plans are not, supplemental plans are also available as group policies, primarily through private employers (*Betriebliche Krankenzusatzversicherung*). However, the market is relatively small and only had 883,400 covered employees for the whole of Germany in 2019 (VPK 2020).

[9] Since 2009, in GKV, sickness funds have to offer select managed care programs such as *Hausarzttarife* where primary care physicians act as gatekeepers. However, these programs are entirely voluntary and only a very small share of those insured by GKV enroll in them; see also SGB V, §73b, and Gesetz zur Weiterentwicklung der Organisationsstrukturen in der GKV [GKV-OrgWG].

[10] Other unintended consequences could be overtreatment of the privately insured and explicit discrimination, such as separate practice waiting rooms or telephone numbers for GLTHI policyholders. While the privately insured individually customize their cost sharing, the publicly insured pay precisely defined copayments that are uniform across sickness funds and set at the federal level, e.g., €10 per night in a hospital (see SGB V, §61).

[11] Compared to public insurance, one could argue that private markets and contracts are less prone to government regulatory risk. Koijen, Philipson, and Uhlig (2016) study the impact of such "government-induced profit risk" on the demand of investors for what they refer to as "medical innovation premium" (197).

Premium calculation.—Whereas the initial GLTHI premium is risk rated, all subsequent premium increases are community rated at the plan level. In fact, premiums are calculated under the basic principle of a constant premium guarantee as long as the individual remains in the contract, as explained in Hofmann and Browne (2013). Since the principles of premium calculation represent a central aspect of our analysis, section III discusses this issue. Appendix section A2 provides additional details on premiums, actuarial principles, and regulatory oversight.

III. Life-Cycle Premiums in GLTHI

A. *Formal Derivation of GLTHI Life-Cycle Premiums*

This section provides a formal treatment of the main principles guiding GLTHI life-cycle premiums: risk-rated initial premiums followed by guaranteed renewability at the same premium as a long as the individual stays in the contract. Appendix section A2 provides a graphical representation and additional details.[12]

Let $P_t(\xi_t)$ be the initial premium when first signing a GLTHI contract in period *t*. As GLTHI contracts are individually underwritten at inception, $P_t(\xi_t)$ depends on individuals' health status in year *t*, ξ_t. We assume that $\xi_t \in \Xi$, where Ξ is a finite set of health states. In subsequent periods, each contract is guaranteed renewable at the same premium. 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. However, they can lapse the existing contract and sign a new one if a new contract is available at a lower premium.

The contract breaks even in equilibrium, given premium $P_t(\xi_t)$ and the subsequent lapsation decisions of the enrollee.[13] Thus, the equilibrium levels of $P_t(\xi_t)$ can be expressed as the solution to a fixed-point problem in which $P_t(\xi_t)$ covers exactly the expected claims of policyholders who stay in the contract at premium $P_t(\xi_t)$.

We solve for $P_t(\xi_t)$ recursively, starting from the last period, $t = T$. In the last period *T*, there is no uncertainty regarding future health status and future lapsation. Let m_t denote health care expenditures in period *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. An interesting and practically convenient feature

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[12] Hofmann and Browne (2013) also explain the guiding principles of premium calculation in GLTHI. We complement Hofmann and Browne (2013) by deriving an explicit formula for how premiums depend on the evolution of health, which we use in the calculations below. This explicit formula enables us to directly compare the GLTHI life-cycle premium calculation with those in the optimal dynamic contract as derived in Ghili et al. (2024).

[13] This is know in the German insurance literature as the principle of equivalence (see, e.g., Hofmann and Browne 2013).

of the GLTHI contract is that policyholders will lapse their current contract if and only if—given the evolution of their health—they can obtain a lower premium than their current guaranteed-renewable premium $P_t(\xi_t)$. Formally, lapsing a contract signed in $t < T$ at the risk-rated premium $P_t(\xi_t)$ occurs at the first $\tau > t$ such that $P_\tau(\xi_\tau) < P_t(\xi_t)$.[14]

REMARK 1. The lapsation decision under GLTHI is only driven by a comparison between the current guaranteed renewable premium $P_t(\xi_t)$ and the premium of a new alternative contract $P_\tau(\xi_\tau)$. Neither risk aversion nor income plays a role in the lapsation decision under GLTHI. As the GLTHI is a pure financial contract, differences in provider networks do not drive the lapsation decision.

For a given $t < T$ and $\tau > t$, we denote $\mathbf{P}_{t+1}^\tau \equiv \{P_{t+1}(.), \dots, P_\tau(.)\}$ as the set of guaranteed premiums from $t + 1$ to $t + \tau$. We can then recursively write the breakeven GLTHI life-cycle premium for new policyholders in period t with health state $\xi_t \in \Xi$, denoted by $P_t(\xi_t)$, as follows:

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

where the first element of the numerator, $\mathbb{E}(m_t|\xi_t)$, is expected health care expenditures in period t, given ξ_t; the second element of the numerator is the sum of the expected future health care expenditures over all remaining life years from t to T. Expected future health care expenditures are discounted at rate δ, with future spending at period τ weighted by $q_\tau(z|\xi_t, \mathbf{P}_{t+1}^\tau, P_t(\xi_t))$, the probability that (i) $\xi_\tau = z$ and (ii) the policyholder does not lapse (or die) between periods t and τ, given the subsequent equilibrium premiums $\mathbf{P}_{t+1}^\tau$. These expected life-cycle expenditures are then divided by the expected number of years in the contract.[15] In other words, the GLTHI life-cycle premium offered in period t to an individual in state ξ_t, $P_t(\xi_t)$, equals the annualized expected health care expenditures starting from t and while the individual remains in the contract, conditional on the individual's health status at the inception of the contract.

Note that these life-cycle premiums do not maximize any ex ante consumer objective function; conceptually, they are not designed to maximize any welfare criterion.

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[14] Note that we abstain from switching costs, and from horizontal differentiation across plans. Horizontal differentiation across plans tends to be minor because, as we explained in sec. II, GLTHI is a pure financial contract.

[15] Of course, $q_\tau(z|\xi_t, \mathbf{P}_{t+1}^\tau, P_t(\xi_t))$ depends on the evolution of the health status $\xi_{t+1}, \dots, \xi_\tau$ and death, conditional on current health status ξ_t. We describe how we model the evolution of health status and its implications for health expenditures in sec. V.

REMARK 2. The GLTHI equilibrium premiums are recursively determined by equation (1). They do not depend on the policyholder's utility function or life-cycle income profile. Therefore, the GLTHI premiums do not depend on education or other determinants of life-cycle income profiles.

B. Comparison to the Optimal Dynamic Contract

Under the assumption of risk-averse and time-separable preferences for policyholders, one-sided commitment by insurers, and both having identical discount rates, the optimal dynamic health insurance contract as derived by Ghili et al. (2024) consists of consumption guarantees, $\bar{c}_t(\xi_t, \mathbf{y}_t^T)$. These depend not only on individuals' health but also on a vector of their current and future incomes $\mathbf{y}_t^T \equiv \{y_t, y_{t+1}, \ldots, y_T\}$.

Analogous to the GLTHI life-cycle premium calculation, $\bar{c}_t(\xi_t, \mathbf{y}_t^T)$ can be solved by backward induction. Specifically, the consumption guarantee in period T is given by $\bar{c}_T(\xi_T, y_T) = y_T - \mathbb{E}(m_T|\xi_T)$. For any $t < T$ and $\tau > t$, denote the set of future equilibrium consumption guarantees $\bar{\mathbf{c}}_{t+1}^\tau \equiv \{\bar{c}_{t+1}(.), \ldots, \bar{c}_\tau(.)\}$. An algebraic reformulation of lemma 2 in Ghili et al. (2024) implies that the equilibrium breakeven consumption guarantee under the optimal dynamic contract for an individual purchasing an optimal long-term contract at time t under health status ξ_t is recursively determined by

$$\bar{c}_t(\xi_t, \mathbf{y}_t^T) = \frac{y_t - \mathbb{E}(m_t|\xi_t) + \sum_{\tau>t}^T \sum_{z\in\Xi} \delta^{\tau-t}(y_\tau - \mathbb{E}(m_\tau|z)) \times q_\tau(z|\xi_t, \bar{\mathbf{c}}_{t+1}^\tau, \bar{c}_t(\xi_t, \mathbf{y}_t^T))}{1 + \sum_{\tau>t}^T \sum_{z\in\Xi} \delta^{\tau-t} \times q_\tau(z|\xi_t, \bar{\mathbf{c}}_{t+1}^\tau, \bar{c}_t(\xi_t, \mathbf{y}_t^T))},$$

(2)

where $q_\tau(z|\xi_t, \bar{\mathbf{c}}_{t+1}^\tau, \bar{c}_t(\xi_t, \mathbf{y}_t^T))$ is, with some slight abuse of notation, the probability that (i) $\xi_\tau = z$ and (ii) the individual does not lapse (or die) between periods t and τ, given the set of future equilibrium consumption guarantees $\bar{\mathbf{c}}_{t+1}^\tau$.[16]

The optimal and the GLTHI contract have several commonalities. Both contracts break even in expectation. Both contracts entail front-loading

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[16] This characterization of the optimal dynamic contract is independent of the curvature of the individual's utility function provided that it is concave and that the intertemporal preference is time separable. Section VI.D.1 discusses the case of non-time-separable preferences where the contract as characterized by Ghili et al. (2024) is no longer optimal. It is also important to note that, as shown in Krueger and Uhlig (2006), the optimal contract does depend on preferences if the discount rates differ between insurers and policyholders. They also show that the optimal contract in such case does not take the form of consumption guarantees. Investigating the welfare consequences of alternative contracts when the insured and the insurer differ in their discount factors is an interesting avenue for future research.

to limit (but not eliminate) reclassification risk. Both contracts are risk rated at inception and provide some form of renewable guarantee. But while the GLTHI establishes a constant premium, policyholders can switch to a lower one when they find a better offer in the market; similarly, the optimal contract offers a constant consumption guarantee that increases when individuals get a better consumption guarantee in the market.[17] Moreover, comparing equation (1) with equation (2), we find that, under flat incomes over the life cycle ($y_t = \bar{y} \ \forall \ t$), the premium guarantees under the GLTHI result in the optimal consumption guarantees (which, in the case of flat income over the life cycle, are independent of the income level). We highlight this important result in the following remark:

REMARK 3. In the special case of flat income profiles over the life cycle, the GLTHI contract coincides with the optimal contract.

C. Arrow Securities Implementation

Krueger and Uhlig (2006) note that the optimal dynamic long-term contract with one-sided commitment can be implemented through the trade of 1-period state-contingent Arrow securities. As such, long-term contracts can be turned into a sequence of short-term contracts. A main benefit of this alternative implementation is that it may enable competition between insurers rather than exposing the individual to the potential monopoly power of the insurer created by the lock-in effect embedded in long-term contracts. A main drawback is the added complexity relative to guaranteed premium (or consumption) profiles under long-term contracts.

Lemma 1 characterizes the quantity of securities traded to implement the GLTHI premium path:

LEMMA 1. The premium path of the GLTHI contract can be replicated by purchasing actuarially fair short-term insurance contracts supplemented by Arrow securities. The quantity of Arrow securities bought after history $\Xi_t \equiv (\xi_1, \xi_2, \ldots, \xi_t)$ that pay \$1 in state ξ_{t+1} is equal to

$$b_t(\xi_{t+1} \mid \Xi_t) = \begin{cases} 0 & \text{if } P_{t+1}(\xi_{t+1}) < \tilde{P}_t(\Xi_t), \\ E(m_{t+1}|\xi_{t+1}) - \tilde{P}_t(\Xi_t) + \\ \sum_{\tau>t+1}^{T}\sum_{z\in\Xi}\delta^{\tau-(t+1)}[E(m_\tau|z_\tau) - \tilde{P}_t(\Xi_t)]q_\tau(z \mid \xi_{t+1}, \mathbf{P}_{t+2}^\tau, \tilde{P}_t(\Xi_t)) & \text{otherwise,} \end{cases}$$

$$(3)$$

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[17] We note that guaranteed premium in the German system decreases when consumers switch to a contract with a lower premium guarantee. Although Ghili et al. (2024) derive the optimal contract under a no-lapsation constraint, they also note that the same outcome could be achieved by contracts that specify a guaranteed premium path that provides a constant consumption floor for as long as individuals decide to renew. As such, increases in consumption guarantees under the optimal contract are equivalent to premium decreases under the GLTHI when individuals lapse and sign a new contract with a lower premium.

where (*a*) $\widetilde{P}_t(\Xi_t)$ is the GLTHI premium in period *t* after history Ξ_t, and (*b*) $q_\tau(z \mid \xi_{t+1}, \mathbf{P}_{t+2}^\tau, \tilde{P}_t(\Xi_t))$ is the probability that (i) $\xi_\tau = z$, and (ii) the policyholder does not lapse (or die) between periods $t + 1$ and τ, given the subsequent equilibrium premiums $\mathbf{P}_{t+2}^\tau$ and $\tilde{P}_t(\Xi_t)$.

Proof.   See appendix section A3.

Lemma 1 states that the Arrow securities to replicate the GLTHI premiums pay either nothing (in the event of lapsing), or the net present value of the difference between the guaranteed-renewable GLTHI premium and the premium of a short-term contract (in the event of not lapsing). Appendix section A3.1 provides an analogous expression for the Arrow securities that replicate the optimal dynamic contract in Ghili et al. (2024). Appendix section A7 makes use of lemma 1 and our data to calculate the quantity of securities needed to replicate the GLTHI contract and the optimal dynamic contracts.

IV.   Claims and Survey Panel Data from Germany

This section describes the GLTHI claims panel data and the SOEP survey panel data. We use the claims data to estimate individual health transitions and expenditures over the life cycle. We use the SOEP data to estimate individual income dynamics over the life cycle. The evolution of health expenditures and income paths over the life cycle are the key inputs to assess welfare under the different health insurance contracts with analyze.[18]

A.   GLTHI Claims Panel Data

The claims panel data contain the universe of GLTHI contracts and claims between 2005 and 2011 from one of the largest German private health insurers. In total, our data include more than 2.6 million enrollee-year observations from 620,000 unique policyholders, along with detailed information on plan parameters such as premiums, claims, and diagnoses. The data also contain the age and gender of all policyholders, their occupational group, and the age when they first signed a contract with the insurer. We converted all monetary values to 2016 USD. Atal et al. (2019) provide more details about the dataset.

Sample selection.—We focus on primary policyholders. In other words, we disregard children and individuals under 25 years of age (555,690 enrollee-year observations).[19] Moreover, due to the 2009 portability reform (see

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[18] In one extension in sec. VI.D.1, we employ a claims dataset from one of the biggest German public insurers to assess the robustness of our results to using alternative initial health distributions. Further, we use the Panel Study of Income Dynamics (PSID) survey to assess the robustness of our results to using life-cycle income paths for the United States.

[19] The GLTHI market features only individual policies, not family policies; even children have their individual policy. However, if parents purchase the policy for their child within

app. sec. A2, n. A64), we disregard inflows after 2008 (253,325 enrollee-year observations). Our final sample consists of 1,867,465 enrollee-year observations from 362,783 individuals.

Descriptive statistics.—Table A1 shows that the mean age of the sample is 45.5 years and the oldest enrollee is 99 years old. Thirty-four percent of the sample are high-income employees, 49% are self-employed, and 13% are civil servants. The majority of policyholders (72%) are male because women are underrepresented among the self-employed and high-income earners in Germany.

On average, policyholders have been clients of the insurer for 13 years. They have been enrolled in their current health plan for 7 years. Ten percent of all policyholders remain clients for more than 28 years, with one policyholder staying for as long as 86 years, illustrating the existence of a truly long-term private health insurance system.[20] Figure A2 (figs. A1–A16 are available online) shows the distribution of policyholders' age at contract inception. The majority of individuals sign their first GLTHI contract at around 30 years old, an age when most Germans have fully entered the labor market but are still healthy and face affordable premiums.

The average annual premium is $4,749 and slightly lower than the average premium for a single plan in the US group market at the time (Kaiser Family Foundation 2019). Note that the annual premium is the total premium—including employer contributions for privately insured high-income earners.[21] The average deductible is $675 per year.

In terms of benefits covered, we simplify the rich data and focus on the plan generosity indicator provided by the insurer. It classifies plans into TOP, PLUS, and ECO plans. ECO plans lack coverage for services, such as single rooms in hospitals and treatments by a leading senior MD (*Chefarztbehandlung*), that TOP and PLUS plans offer. For ECO and PLUS plans, a 20% coinsurance rate applies if enrollees see a specialist without referral from their primary care physician, while such coinsurance does not apply for TOP plans. About 38% of all policyholders have a TOP plan, 34% a PLUS plan, and 29% an ECO plan. Because these plan characteristics have mechanical effects on claim sizes and correlate with policyholders' age, we control for them when modeling health transitions in section V.

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2 months of the birth, no risk-rating applies for the child. Under the age of 21, insurers do not have to budget and charge for old-age provisions.

[20] Our insurer doubled the number of clients between the 1980s and 1990s and thus has 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.

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

B.   Socio-Economic Panel

The German SOEP is a representative longitudinal survey. Since 1984, it annually surveys about 10,000 households and 20,000 individuals above the age of 17 (Goebel et al. 2019). We use SOEPlong and all existing waves from 1984 to 2016, to fully exploit the life-cycle dimension of this panel (SOEP 2018).

Our main income measure is equivalized posttax posttransfer annual income. It accounts for within-household redistribution and controls for economies of scale by assigning each individual a needs-adjusted income measure. Specially, equivalized posttax posttransfer annual income sums over all posttax monetary income flows at the household level, such as income from labor, capital, public and private retirement accounts, or social insurance programs.[22] Then, the total annual posttax household income is divided by the number of household members using the modified Organization for Economic Cooperation and Development (OECD) equivalence scale.[23]

Sample selection.—We leave the representative sample as unrestricted as possible, but exclude observations with missing data on core variables such as age, gender, employment, or the insurance status. Other than that, we only exclude respondents below the age of 25.

Descriptive statistics.—Table A2 provides summary statistics for our SOEP sample. From 1984 to 2016, the average annual income per household member was $26,433 (in 2016 USD). Note that this measure has positive values for all respondents.

In the SOEP sample, the average age is 47, and 52% are female. About 27% are white collar workers, 6% are self-employed, and 4% are civil servants. Forty-two percent work full-time and 14% part-time.

V.   Modeling Health Risks and Income over the Life Cycle

A.   Risk Classification

Risk classification is a key ingredient for calculating the premiums and welfare of short- and long-term insurance contracts. We rely on insights from actuarial science to produce an efficient risk classification. Our method aims to improve upon the state of the art literature by better representing skewed health expenditure distributions. We present below the features of our method and relegate the details to Appendix section A5.

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

[23] 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.
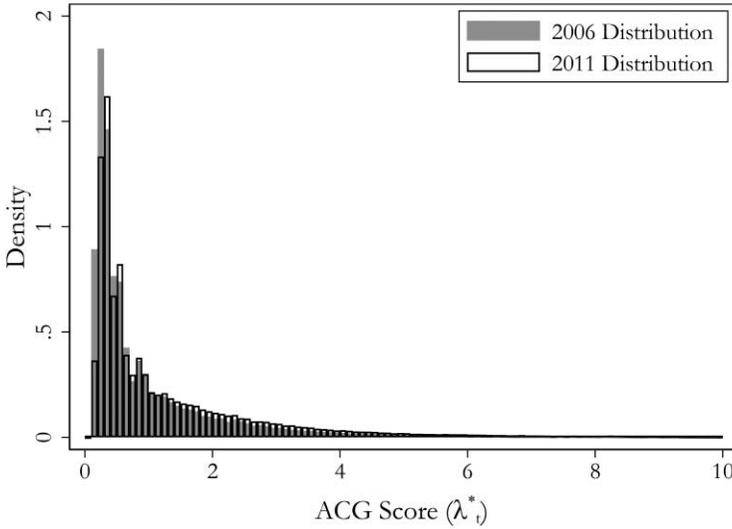
Fig. 1.—Distribution of λ_t^* in 2006 and 2011. The figure shows the distribution of ACG scores for years 2006 and 2011. The distribution of λ_t^* is truncated at 10; 0.7% of the sample have $\lambda_t^* > 10$. Source: own calculations using GLTHI claims data and ACG Software.

Following the economics literature (Einav et al. 2013; Handel, Hendel, and Whinston 2015; Ghili et al. 2024), we begin by constructing an individual measure for expected health care costs using the German version of the Johns Hopkins ACG software, which is routinely used by insurers for underwriting. For each individual, the ACG software provides a continuous risk score λ_t^* which represents the expected health care costs in year t relative to the mean in the reference population.[24] It is based on (*a*) diagnosis codes (preexisting conditions and claim diagnoses), (*b*) costs of treatments, (*c*) treatment episode dates, and (*d*) age and gender.

Figure 1 shows the empirical distributions of λ_t^* for our GLTHI claims data in 2006 (the first year in our sample) and 2011 (the last year in our sample). Both distributions are approximately unimodal and appear stable over time.[25] It also illustrates that the distribution of λ_t^* is heavily skewed and has a long right tail. For example, the top percentile of λ^* has expected health expenditures $\mathbb{E}(m|\lambda^* \geq \mathbb{P}_{99}) = \$63,422$, the second highest percentile has $\mathbb{E}(m|\mathbb{P}_{98} \leq \lambda^* < \mathbb{P}_{99}) = \$30,027$, and the following three percentiles have $\mathbb{E}(m|\mathbb{P}_{95} \leq \lambda^* < \mathbb{P}_{98}) = \$19,253$, where $\mathbb{P}_k$

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[24] In this case, the reference population are the publicly insured individuals in Germany.
[25] This also suggests that excluding inflows of new enrollees in 2010 and 2011 due to the portability reform (see sec. II) poses no major issue.

denotes the kth percentile of the distribution in figure 1. The distribution of expected expenditures thus mirrors the characteristic long right tail of health expenditure distributions (French and Kelly 2016).

Our method combines the continuous score λ_t^* and its lags, mapping them into K different discrete risk categories λ_t. Modeling risk types with discrete categories serves two specific purposes. First, as we allow the contract premiums to depend on the risk type, the granularity in our model should capture the granularity of the information used by the underwriters, in both the actual environment and counterfactual scenarios. Second, the model should be parsimonious enough to allow for modeling health dynamics with a reasonable number of parameters. The skewness in figure 1 implies that the amount of reclassification risk will strongly depend on the granularity of the risk classification.

Our main methodological contribution to risk-classification modeling is in how to discretize health risk. The commonly used approach would use an ad hoc criterion to partition λ_t^* into different discrete categories. We depart from the common approach in two key ways: First, we allow the health status to be a function of current and n lagged values of λ_t^*, where the number of lags n is determined within our procedure. Our approach can therefore allow for higher-order dependencies in the health dynamics in a parsimonious way. Second, we propose and implement a method to discretize the vector of scores $\{\lambda_{t-v}^*\}_{v=0}^n$ into an endogenously determined number of risk categories K. The method maximizes an efficiency criterion from the actuarial science literature (cf. Finger 2006).

We split the task of constructing discrete risk categories into two sequential problems: (1) For a given number of categories K, define the efficient partition of the scores vector $\{\lambda_{t-v}^*\}_{v=0}^n$ into K discrete categories. (2) Select the parameters K and n that lead to the best performance of the classification system. We expand on each step below.

Efficient partitioning.—According to the actuarial science literature (Finger 2006), an efficient risk classification system has two properties: *homogeneity*, meaning that individuals in the same risk category have similar risk, and *separation*, meaning that the categories have sufficiently different expected claims to justify distinct categories. For instance, in figure 1, 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. Appendix section A5 shows that applying k-means clustering to $\mathbb{E}(m_t|\{\lambda_{t-v}^*\}_{v=0}^n)$—that is, to the mean claims by an individual's ACG scores—yields an efficient classification. In the special case of no lags ($n = 0$), the clustering procedure may target the ACG score directly, as it represents an estimate of $\mathbb{E}(m_t \mid \cdot)$. When lags are included ($n > 0$),
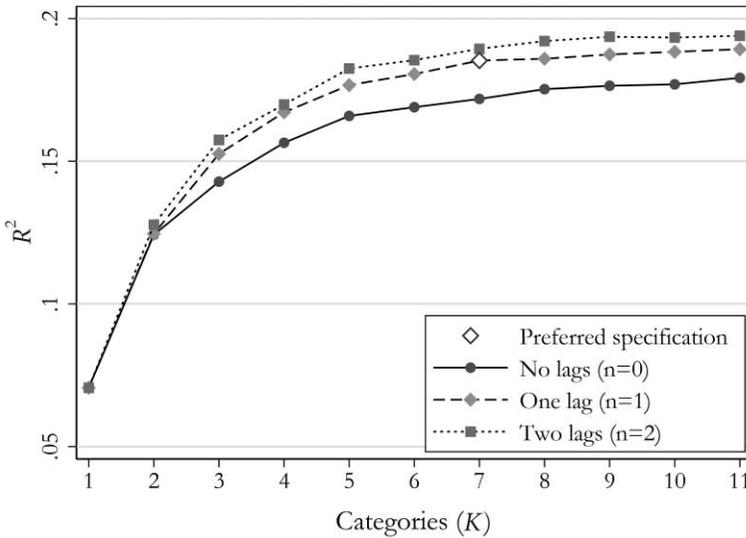
FIG. 2.—Performance of alternative risk classifications. The figure displays unadjusted R^2 of a regression of expenditures on risk category indicators. All results are robust to using adjusted R^2. Each specification includes 21 age-gender fixed effects, year fixed effects and 79 plan fixed effects. Source: own calculations using German claims panel data.

$\mathbb{E}(m_t \mid \cdot)$ must be estimated in an intermediate step; appendix section A5 outlines this process.

Parameter selection.—Next, we determine the number of lags n of ACG scores when computing the number of risk categories K.[26] k-means clustering is an unsupervised learning method; we assume that the overall objective applies also when selecting K and n. As shown in appendix section A5, this implies using the R^2 of a regression of expenditures on risk category indicators as our criterion for model selection.

Figure 2 shows how the performance depends on K and n. For all values of n, initially, the predictive power improves rapidly when we increase the number of categories K; however, this improvement levels out at around $K = 5$. Moreover, compared to only using the current year's score ($n = 0$), there is distinct improvement when adding one lag ($n = 1$) whenever $K \geq 3$. However, adding a second lag only marginally improves the predictive accuracy. Figure 2 shows that, beyond including one lag ($n = 1$) and seven distinct risk categories, increasing K or n further yields negligible improvement in performance. Thus as a compromise of predictive accuracy and model parsimony, we choose $K = 7$ and $n = 1$ (in the

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[26] Including lagged ACG scores is consistent with an underwriting process often covering a relatively long medical history of the applicant (e.g., all diseases of the past 5 years and all surgeries of the past 10 years in case of our insurer).

spirit of Heckman and Burton Singer [1984] and Keane and Wolpin [1997] in their choice of the number of unobserved types in the labor economics literature).[27]

B. Estimation of Transition Matrices and Mean Expenditures

We posit that the health status of individual i at age t, $\xi_{it} \equiv (A_{it}, \lambda_{it})$, depends on contemporaneous risk λ_{it} and age A_{it}, where A_{it} is one of 11 age groups (5-year bands from age 25 to age 75 and 75+).[28]

As our risk classification generates risk categories of very different sizes, we use a parametric yet flexible model for transition rates between discrete risk categories λ_t and for mean expenditures by risk category and age. Specifically, to estimate the transition matrices for health dynamics, we estimate a multinomial logit model:

$$\eta_{it}^{j} = A_{it}\beta_j + L_{it}\gamma_j + h\left(A_{it}, L_{it}; \theta_j\right) + \epsilon_{it}^{j}, \tag{4}$$

where η_{it}^{j} represents the log odds for $\lambda_{it+1} = j$, for $j \in \{2, \ldots, 8\}$ relative to the reference category $\lambda_{it+1} = 1$ ($\lambda_{it+1} = 8$ represents death); A_{it} represents i's age group, and L_{it} is a set of indicators for the categories of λ_{it}. $h(A_{it}, L_{it}; \theta_j)$ consists of pairwise interactions of A_{it} and L_{it} with the associated parameter vector θ_j.[29]

To model the expected claims based on risk category, we use predicted values from an ordinary least squares regression. In addition to the controls in equation (4), we control for Q_{it} representing health plan generosity dummies $q \in \{\text{ECO}, \text{PLUS}, \text{TOP}\}$. The base specification is

$$m_{it} = A_{it}\beta + L_{it}\gamma + Q_{it}\delta + h(A_{it}, L_{it}, Q_{it}; \theta) + \epsilon_{it}. \tag{5}$$

In an iterative process, we add pairwise interaction terms among A_{it}, L_{it}, and Q_{it} (represented by $h(A_{it}, L_{it}, Q_{it}; \theta)$) to equation (5) until no remaining term is statistically significant.[30]

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[27] Appendix sec. A5 provides additional robustness checks, including the role of outliers, including a longer history of claims, and sample changes when n changes. We also show that transition rates between risk categories satisfy first-order stochastic dominance as assumed in Ghili et al. (2024). Also see De Nardi, Pashchenko, and Porapakkarm (2024) for modeling of health types and health dynamics over the life cycle.

[28] Note that the ACG scores are based on an individual's age, so that, in principle, a risk category λ_{it} that uses ACG scores as input should contain all the information needed to predict mean expenditures. However, ACG scores are not designed to predict transitions so, in principle, transition matrices may depend on age even after conditioning on λ_{it}. As discussed below, our results confirm these predictions.

[29] We select the interaction 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.

[30] We use a subsample of policyholders with moderately-sized deductibles to estimate conditional expenditures given λ_t as policyholders with large deductibles may decide not to

TABLE 1
HEALTH RISK CATEGORY TRANSITIONS

λ_t	$\mathbb{E}\ (m_t \mid \lambda_t)$	λ_{t+1}							
		1	2	3	4	5	6	7	8[a]
1	1,473	.831	.158	.006	.003	.001	.001	.000	.001
2	3,559	.214	.523	.215	.036	.009	.001	.000	.002
3	6,019	.050	.179	.572	.164	.029	.003	.000	.003
4	9,302	.024	.053	.227	.541	.128	.013	.001	.013
5	14,600	.018	.027	.035	.330	.445	.104	.005	.036
6	24,554	.010	.018	.017	.096	.294	.409	.052	.104
7	54,930	.002	.005	.002	.027	.085	.200	.452	.226

SOURCE.—Own calculations based on German claims panel data.
NOTE.—The table shows expected health expenditures and average transition probabilities across the different health categories. The sample includes all years, all age groups, and uses the ACG scores to construct risk categories λ as explained in sec. V.A.
  [a] λ_{t+1} = 8 represents death.

Descriptive statistics for transition matrices.—Table 1 displays the 1-year transition rates between health risk categories for all age groups; the numbers are the predicted probabilities based on equation (4). Two facts emerge from table 1. First, we find strong persistence in health risk. For instance, an individual with $\lambda_t = 1$ has an 83% probability of $\lambda_{t+1} = 1$. The likelihood of staying in the same category between two consecutive years generally decreases over risk categories, but still, 45% of individuals in category 7 remain in category 7 in the next year. Second, despite high persistence, the likelihood of reclassification is nontrivial even when considering as few as two subsequent years. For example, the probability of ending up in a different risk category in $t + 1$ (with very different mean expenditures as shown below) is more than 50% for category 2 in year t.

The transition rates are highly dependent on age. Tables A3 and A4 show the transition matrices separately for each of the 11 age groups. For example, the probability of remaining in category 1 decreases from 89% among 25-year-olds to 18% among individuals over 75. Also the probability of recovering, that is, transitioning from a higher to a lower risk category, declines with age. Moreover, the mortality rates increase rapidly with age—in particular for states below 7. All these differences are statistically significant. Therefore, allowing for age-dependent transition rates is necessary.

Descriptive statistics for expenditures.—Table 2 shows the mean expenditures m by age group, and the distribution of risk categories within each group. As expected, the mean expenditures strongly increase in age: they almost double from $1,996 in the age group 25 to 30, to $3,719 in the

submit their claims, leading to downward biased estimates. In app. sec. A5, we provide some descriptive statistics for this subsample, which generally confirm that this assumption is reasonable.

TABLE 2
HEALTH EXPENDITURES AND RISK CATEGORIES λ BY AGE GROUP

Age	Mean	SD ($\mathbb{E}\,(m \mid \lambda)$)	λ_t						
			1	2	3	4	5	6	7
25–30	1,996	1,782	.789	.154	.039	.013	.004	.001	.000
30–35	2,619	1,938	.740	.178	.054	.020	.006	.001	.000
35–40	2,840	2,086	.652	.225	.085	.027	.009	.002	.000
40–45	3,119	2,411	.622	.227	.103	.034	.012	.003	.000
45–50	3,719	2,946	.539	.258	.136	.046	.016	.004	.001
50–55	4,880	3,544	.463	.263	.174	.068	.024	.007	.001
55–60	6,517	4,573	.291	.319	.232	.108	.036	.011	.002
60–65	7,635	4,299	.184	.313	.269	.155	.058	.019	.003
65–70	7,151	4,421	.069	.291	.337	.217	.069	.014	.002
70–75	8,355	5,026	.019	.203	.347	.309	.105	.015	.002
75+	10,020	4,490	.000	.092	.267	.422	.188	.029	.003

SOURCE.—Own calculations based on German claims panel data.
NOTE.—The table shows average claims and the standard deviation of claims within each risk category and age group for the different health categories (values in 2016 USD). It also shows the fraction of individuals in each category by age group. The sample includes all years, all age groups, and uses the ACG scores to construct risk categories λ as explained in sec. V.A.

age group 45 to 50, and almost double again to $7,151 in the age group 65 to 70. For those above 75 years, the average is $10,020 (all values in 2016 USD). This age gradient is, however, accounted for by our risk classification.[31]

There is also a clear age gradient in health risk. The probability of λ = 1 declines progressively with age, whereas the share of enrollees in the five highest categories increases with age. Only 1.7% of those in the age group 25 to 30 are in categories λ = 4 and λ = 5. This share almost quadruples to 6.2% for the age group 45 to 50, and then more than quadruples again to 28.6% for the age group 65 to 70. It is 61% for enrollees above 75 years. Risk category λ = 7 clearly represents catastrophic risk and covers at most 0.3% in any age group in a given year. Section VI.E discusses how catastrophic risk affects welfare under the different contracts.

C. Life-Cycle Income Paths

Next, we estimate the life-cycle income paths using 33 years of the SOEP (1984–2016). We estimate income over the entire life cycle as we are interested in assessing the performance of long-term contracts that are

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[31] As the ACG score depends on age, age group indicators A_{it} should not have predictive power in the model for expected expenditures if our risk classification based on ACG scores is rich and flexible enough. Even though a few age-related parameters in eq. (5) turn out statistically significant, the deviations from mean expenditure within each risk category are economically insignificant. Figure A6 illustrates this point. We interpret it as evidence that our preferred risk classification is rich enough. Therefore, we restrict all age effects to zero.

guaranteed renewable until death. Our income measure is equivalized posttax posttransfer annual income, which sums over all posttax income flows at the household level and then normalizes by the number of household members. We estimate the following individual fixed effects model:

$$\log(y_{it}) = \theta_i + f(\text{age}_{it}) + \epsilon_{it}, \tag{6}$$

where y_{it} is our income measure in 2016 USD for individual i in year t and θ_i's are individual fixed effects that net out persistent individual time-invariant income determinants, such as gender, preferences, or work productivity. The flexible function $f(\text{age}_{it})$ represents a series of age fixed effects and identifies the main coefficients of interest.

Because life-cycle profiles differ substantially by educational degree (Becker and Chiswick 1966; Bhuller, Mogstad, and Salvanes 2017), we estimate the income process by education for (*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).[32]

The two dashed curves in figure 3 show the estimated age fixed effects for Ed 10 and Ed 13, respectively. Income rises sharply between age 25 and age 57 and then it decreases substantially until around age 70, from which point it remains relatively flat until death.[33] There exists a level difference in income paths between the two educational groups over the entire life cycle. We accommodate these patterns by fitting $f(\text{age}_{it})$ as a piecewise squared polynomial of age, where we allow the parameters of age and age[2] to differ by education and across three different age bins: [25, 56], [56, 70], and 70+. This is illustrated by the two solid lines in figure 3. Note that the piecewise squared polynomials fit the empirical life-cycle profiles very well.

Several factors can explain these life-cycle income patterns. First, the labor market entry and subsequent careers significantly increase the posttax income between the main working ages 25 and 55. Second, our income measure includes social insurance benefits, and the German welfare state is known for its generosity. Third, equivalized household income starts to decrease after age 57 until around age 70. Especially in the 1980s and 1990s—but 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

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[32] Germany has three different schooling tracks where the majority of students complete school after 10 years and then start a 3-year apprenticeship (cf. Dustmann, Puhani, and Schönberg 2017).

[33] The German life-cycle pattern for wealth is similar; see Mahler and Yum (2024) for evidence on wealth-health gaps.
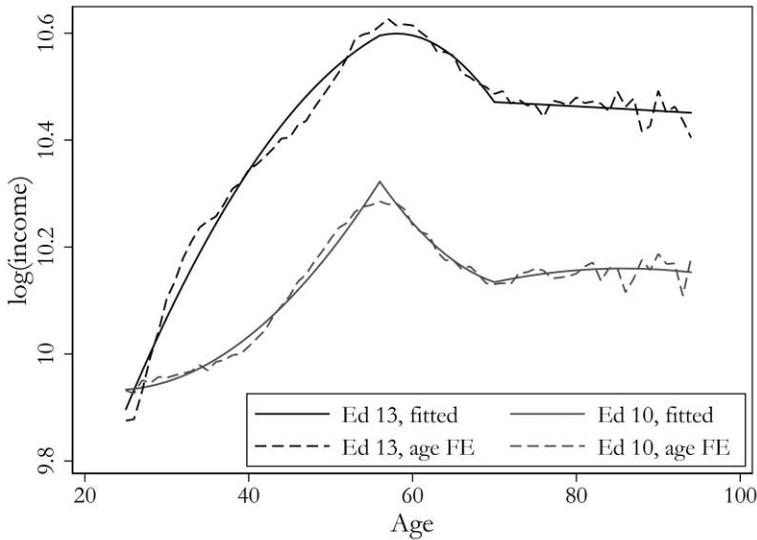
F𝗜𝗚. 3.—Life-cycle income paths for Germany, nonparametric and fitted. The figure shows the predicted income using equation (6), and the fitted, piecewise squared polynomial. All values in 2016 USD. Source: own calculations using SOEP (2018) for the years 1984 to 2016.

income measure primarily includes statutory pensions, employer-based pensions, and private pensions (Geyer and Steiner 2014; Kluth and Gasche 2016).

VI. Main Results

A. Equilibrium Life-Cycle GLTHI Premiums

After estimating the health risk process, we can calculate the equilibrium GLTHI life-cycle premiums by solving equation (1) using backward induction. We use an annual discount factor $\delta = 0.966$, which corresponds to an annual discount rate of 3.5%. Note that $P_t(\xi_t)$ in equation (1) is the guaranteed-renewable premium that an individual with health status ξ_t would be offered if she entered a contract in period t in the GLTHI market. Therefore, the equilibrium GLTHI premiums correspond to 490 values: premiums depend on an individual's current risk category $\lambda_t \in \{1, 2, ... , 7\}$ and age $t \in \{25, ... , 94\}$.

Figure 4 plots the resulting premiums calculated using equation (1) for a handful of the most relevant combinations: $\lambda_t = 1$ and $t \in \{25, ... , 59\}$; $\lambda_t = 2$ and $t \in \{25, ... , 74\}$; $\lambda_t = 3$ and $t \in \{25, ... , 94\}$; $\lambda_t = 4$ and $t \in \{60, ... , 74\}$; $\lambda_t = 5$ and $t \in \{75, ... , 94\}$. These combinations
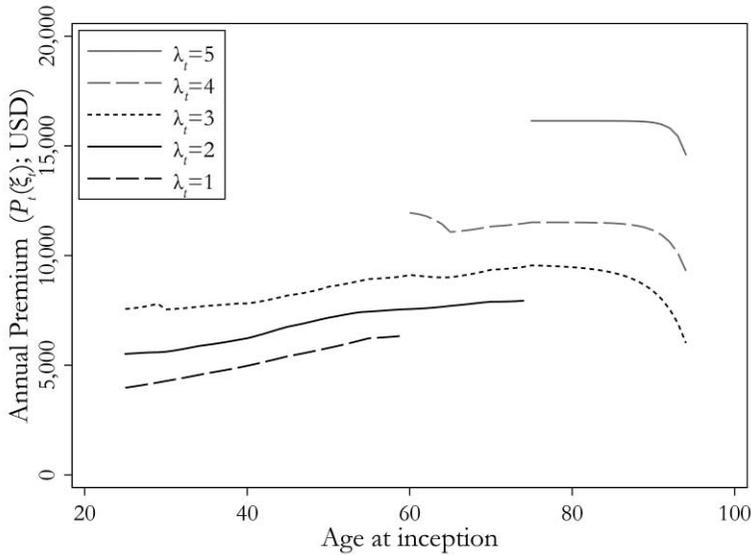
Fig. 4.—Calibrated starting premiums $P_t(\xi_t)$ in the GLTHI. Calibrated GLTHI premiums at inception, calculated using equation (1) and the estimated health status process. Health status ξ is comprised of age and health category λ, as explained in the text. Source: own calculations using German claims panel data.

represent the most common health categories for each corresponding age interval.

Three forces determine the life-cycle profile of $P_t(\xi_t)$ in figure 4. First, $P_t(\xi_t)$ is an increasing function of ξ_t because for any age, a higher risk category is associated with higher current and future health care claims.

Second, starting premiums increase with age for most age ranges. This is because health transitions depend strongly on age (through the A_t component of ξ_t, see equation [4]). As a consequence, the annualized net present value of health care claims of an individual with a given λ_t increases with age for most of the age ranges.

Third, starting premiums decrease with age in very old age ranges. The reason is that the probability of ever transitioning to a worse category in the future diminishes as one approaches the end of life. Therefore, the need to front-load premiums to fund future negative health shocks decreases over the life-cycle. This force explains why $P_t(\xi_t)$ decreases with t when t is sufficiently large.

Appendix section A6 compares the calibrated and the observed premiums by age at inception for ages between 25 and 75.[34] Both are very

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[34] For those health categories with enough observations of new policies being issued.

similar in the key aspects that determine welfare over the life cycle. Calibrated premiums for 25-year-olds starting in categories 1 and 2 (99.35% of the sample) are very similar to the observed ones (and somewhat smaller than observed premiums for sicker individuals). We also observe positively sloped starting premiums by age over this entire age range, both for the calibrated and the observed premiums. Also, the rank ordering of premiums by health status persists over the entire life cycle.[35]

B. Comparison between the GLTHI and the Optimal Dynamic Contract

This subsection compares the life-cycle premiums and the amount of front-loading between the flat-income–optimal GLTHI design and the optimal dynamic (GHHW) contract (Ghili et al. 2024). Using our empirical health status transitions and income dynamics, table 3 illustrates the differences between the flat-income–optimal GLTHI and the optimal contract by comparing the contract terms at age 25. Panel A shows the GLTHI premium and the front-loading amounts for a 25-year-old by the health risk category $\lambda_{25} \in \{1, \dots, 7\}$. If $\lambda_{25} = 1$, she pays a premium of $3,973, which is $2,499 in excess of expected claims. Individuals with higher λ's pay higher premiums, but the amount of front-loading decreases. For example, for $\lambda_{25} = 3$, the premium is $7,563, which includes $1,545 in front-loading. The reason is that when the current health status worsens, the likelihood of a further health deterioration also decreases.

Panel B of table 3 shows the premiums and the front-loading amounts for the optimal dynamic contract for Ed 10 by initial health at age 25. For all health categories (except the worst), the initial premiums and front-loading amounts are lower in the optimal dynamic contract than in GLTHI. As income is low at early ages, the optimal contract entails less front-loading than GLTHI would to improve the degree of intertemporal consumption smoothing. However, the differences in premiums between the GLTHI and the optimal dynamic contract decrease as the health status

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[35] Although we could, in principle, use the observed premiums to evaluate welfare under the GLTHI, there are two reasons to use the calibrated premiums instead: First, our analysis of the market equilibrium under different assumptions requires knowing the premiums for all possible combinations of ξ and t. Many of these are either completely absent or represented by only a small number of individuals in our data. Second, as we compare the welfare properties of GLTHI to counterfactual model-based contracts, we prefer to conduct welfare comparisons based on premiums that were generated in an analogous manner. Note also that the similarities between the observed and theoretical premiums highlighted in the text imply that the welfare under the GLTHI contracts evaluated with the observed premiums should be very close to our results derived from the calibrated premiums. Calibrated starting premiums for the vast majority of individuals are very similar to the observed ones and most people lock in this premium for their entire life cycle. Also, note that lapsation rates depend on the rank-order of premiums but not the magnitude of the premium differences.

TABLE 3
COMPARING THE GLTHI CONTRACT TO OPTIMAL CONTRACT TERMS AT INCEPTION, AGE 25

λ_{25}	1	2	3	4	5	6	7
Expected claims	1,473	3,559	6,019	9,302	14,600	24,554	54,930
				A. GLTHI			
Premium	3,973	5,517	7,563	10,363	15,291	24,561	54,930
Front-loading	2,499	1,957	1,545	1,062	691	7	0
				B. Optimal Contract (Ed 10)			
Premium	2,571	5,366	7,489	10,307	15,273	24,554	54,930
Front-loading	1,097	1,807	1,471	1,006	673	0	0
				C. Optimal Contract (Ed 13)			
Premium	1,895	4,578	6,988	10,103	15,187	24,554	54,930
Front-loading	421	1,019	970	801	586	0	0

SOURCE.—German claims panel data; SOEP (2018).
NOTE.—The table shows expected health care claims, starting premiums, and the amount of front-loading by health risk category at age 25, $\lambda_{25} \in \{1, \dots, 7\}$. All values are in 2016 USD.

at contract inception worsens. For $\lambda_{25} = 1$ the optimal premium is \$2,571 (vs. \$3,973 for GLTHI), and for $\lambda_{25} = 4$, the optimal premium is \$10,307 (vs. \$10,363 for GLTHI). Note, however, in contrast to the constant guaranteed premiums under the GLTHI, the premiums under the optimal contracts need to adjust as income evolves to maintain any given level of consumption guarantee.

Panel C of table 3 shows the premiums and the front-loading amounts for the optimal dynamic contract for Ed 13 by initial health at age 25. This individual has a steeper income profile over her life cycle (see fig. 3), which is why the optimal contract entails less front-loading than it does for Ed 10, especially for healthy individuals. Again, the sicker the individual is at inception, the lower the front-loading amount.

Equivalent Arrow securities.—As discussed in section III.C, it is possible to replicate the dynamic contracts with 1-period Arrow securities. Appendix section A7 provides numerical examples for the terms of such contracts for the GLTHI contract and the optimal contract. As expected, the quantity of securities needed to replicate the optimal contract is smaller than that to replicate the GLTHI contract. This reflects the lower degree of front-loading required under the optimal contract.

C.   Consumption Profiles over the Life Cycle

Life-cycle consumption and intertemporal consumption smoothing.—We now explore how the short-term contract, the (flat-income–optimal) GLTHI contract, and the optimal contract affect intertemporal consumption smoothing and reclassification risk over the life cycle. To do so, we simulate the

consumption life-cycle profiles, from age 25 to age 94, for $N = 500,000$ individuals. Figure 5 plots the average consumption for these three contracts over the life cycle for Ed 10 (fig. 5*B*) and for Ed 13 (fig. 5*A*).

Under a series of short-term contracts, average consumption is simply income minus expected health expenditures. As shown by the gray solid lines, the average consumption profile under short-term contracts is therefore hump-shaped over the life cycle for both education groups. Under the GLTHI contract, average consumption (dashed lines) has a similar shape but starts at a lower level and is higher at older ages. This reflects the heavy front-loading of GLTHI up to the early 50s. Compared to GLTHI, the average consumption under the optimal dynamic contract (solid lines) would start at a higher level, particularly for the highly educated, who have steeper income profiles and for whom front-loading is costlier.

On top of the lower front-loading in the initial periods, studying income profiles over the life cycle highlights an additional important advantage of optimal long-term contracts. In our setting, with hump-shaped income profiles, the optimal contract allows for fully smooth intertemporal consumption after some age, as the flat solid consumption line after around age 40 illustrates. The optimal contract prescribes higher premiums in the middle ages, not only to finance reclassification risk insurance but also to shift resources toward later years when income is low.

Reclassification risk.—To illustrate the degree of reclassification risk over the life cycle, figure 6 displays the standard deviations of consumption changes over the life cycle. That is, figure 6 plots for each age t the standard deviation of $\Delta C_{i,t} \equiv C_{i,t+1} - C_{i,t}$ across individuals i.

As the figure illustrates, the GLTHI contract imposes very little reclassification risk as most individuals lock in $P_{25}(\cdot)$ in the first period. The few

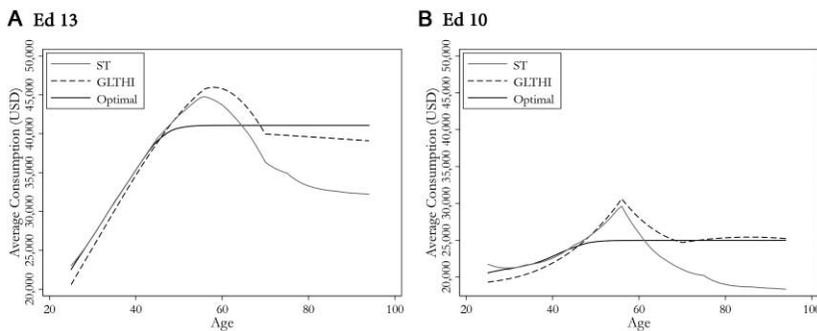Fɪɢ. 5.—Simulated average consumption over the life cycle by education. The figure displays average simulated consumption under short-term contracts, the GLTHI contract, and the optimal contracts. Results for the steeper income profile, Ed 13 (*A*), and for the flatter income profile, Ed 10 (*B*). Source: own calculations using German claims panel data and SOEP (2018).
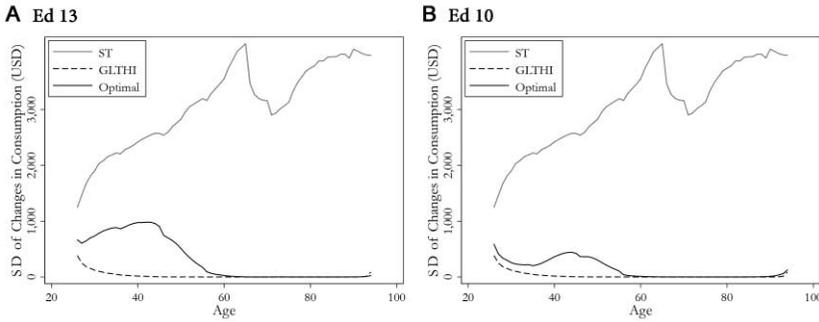
FIG. 6.—Simulated standard deviation of consumption changes over the life cycle by education. The figure displays the simulated standard deviation of consumption changes under short-term contracts, the GLTHI contract, and the optimal contracts. Results for the steeper income profile, Ed 13 (A), and for the flatter income profile, Ed 10 (B). Source: own calculations using German claims panel data and SOEP (2018).

individuals who switch contracts are those who start with $\lambda_{25} > 1$ and become sufficiently healthier over time (such that $P_t(\xi_t) < P_{25}(\xi_{25})$ for some $t > 25$). However, this is a rare event, especially after age 40. On the other hand, the optimal dynamic contract entails consumption bumps early in life. For instance, the consumption guarantee under the optimal contract increases for individuals who start at $\lambda_{25} = 1$ and remain at $\lambda_{26} = 1$ in the following year. The reason is that a competing insurer, taking into account the good news regarding future health reflected by the event $\lambda_{25} = 1$ and $\lambda_{26} = 1$, can offer the individual a higher consumption guarantee and still break even in expectation. Finally, the standard deviation of consumption changes increases strongly between age 25 and 60 for a series of short-term contracts, decreases slightly up to age 70, and then increases again until death. Reladtely, figure A12 shows lapsation rates under each contract.

D. Baseline Welfare Results

We now calculate how the differences in consumption profiles over the life cycle translate into welfare differences across the different contracts. We summarize lifetime utility under each contract with the Consumption Certainty Equivalent (CE). In this section, we focus on the relative welfare difference between the GLTHI contract and the optimal dynamic contract. We also compare the CE of each long-term contract with welfare under short-term contracts and with the first-best consumption level, which is equal to the annualized present discounted value of net income $y_t - \mathbb{E}(m_t)$, taking into account mortality risk. Details on these welfare measures are in appendix section A9.

So far, we have not specified the utility function because the premiums in the long-term contracts do not hinge on a specific utility function. For welfare comparisons, we use a constant absolute risk aversion (CARA) utility function of the form[36]

$$u(c) = -\frac{1}{\gamma} e^{-\gamma c}. \tag{7}$$

In our main results, we use a risk aversion parameter $\gamma = 0.0004$ (Ghili et al. 2024). In section VI.D.1, we explore the robustness to (i) the level of risk aversion, (ii) using a constant relative risk aversion (CRRA) utility function, and (iii) using non-time-separable Epstein-Zin preferences, among other robustness tests.

We provide eight sets of results in table 4, stratifying the findings by the two education groups with different life-cycle income paths. Each corresponds to a different probability simplex that determines the initial category, $\Delta_0 \in \Delta^7$. For instance, panel A assumes that everyone starts in the healthiest category, such that $\Delta_0 = (1/100)[100, 0, 0, 0, 0, 0, 0]$. Panel H shows our baseline results, which assume that λ_{25} is drawn from the distribution implied by the transition matrix at age 25, given $\lambda_{24} = 1$ (see table A3). By doing so, we accurately replicate the distribution of ξ among the 25 to 30 age group. In panel H, we also assume that individuals cannot start in the worst health category. This assumption is motivated by the fact that individuals starting in category 7 are unable to afford actuarially fair premiums. One possibility is a fallback option for the very sick, such as a co-existing public health insurance system.

Column 1 shows welfare under the first-best contract, C^*; column 2 shows welfare under the optimal contracts, C_{GHHW}. Column 3 shows welfare under the GLTHI contract, C_{GLTHI}. Column 4 shows welfare under a series of short-term contracts, C_{ST}. Finally, column 5 shows the percentage welfare difference between the GLTHI and the optimal contract $(C_{\text{GHHW}} - C_{\text{GLTHI}})/C_{\text{GHHW}}$.

Several findings emerge from table 4. First, comparing column 1 to column 4, we find that a series of short-term contracts can produce large welfare losses relative to the first-best. For all initial health categories at age 25 and for both life-cycle income profiles, the CEs are negative. This highlights the significant negative welfare consequences of one-sided commitment, that is, the inability of policyholders to commit to long-term contracts, together with the inability of consumers to borrow.[37] It

[36] The CARA utility function has the convenience of allowing for negative consumption, which occurs when income is lower than the required premium payments. However, it also implies that the consumption equivalent may be negative under some contracts (see table 4).

[37] As is well known, if consumers can borrow, they can "manufacture" commitment power by posting a "bond" with the insurer that equates the discounted sum of expected

TABLE 4
Welfare under Different Contracts

	C^* (1)	C_{GHHW} (2)	C_{GLTHI} (3)	C_{ST} (4)	$\frac{C_{\text{GHHW}} - C_{\text{GLTHI}}}{C_{\text{GHHW}}}$ (5)
A. $\Delta_0 = \frac{1}{100}[100, 0, 0, 0, 0, 0, 0]$					
Ed 10	23,029	22,489	21,537	−10,156	4.2%
Ed 13	34,210	27,727	26,025	−2,396	6.1%
B. $\Delta_0 = \frac{1}{100}[0, 100, 0, 0, 0, 0, 0]$					
Ed 10	22,598	21,374	20,841	−10,771	2.5%
Ed 13	33,775	25,572	24,899	−3,921	2.6%
C. $\Delta_0 = \frac{1}{100}[0, 0, 100, 0, 0, 0, 0]$					
Ed 10	22,244	20,167	19,853	−10,693	1.6%
Ed 13	33,418	23,616	23,271	−2,339	1.5%
D. $\Delta_0 = \frac{1}{100}[0, 0, 0, 100, 0, 0, 0]$					
Ed 10	21,911	18,413	18,256	−10,807	.8%
Ed 13	33,085	21,102	20,946	−2,342	.7%
E. $\Delta_0 = \frac{1}{100}[0, 0, 0, 0, 100, 0, 0]$					
Ed 10	21,475	14,716	14,680	−10,921	.2%
Ed 13	32,648	16,649	16,600	−2,332	.3%
F. $\Delta_0 = \frac{1}{100}[0, 0, 0, 0, 0, 100, 0]$					
Ed 10	20,631	5,962	5,960	−11,243	.0%
Ed 13	31,801	7,570	7,564	−2,617	.1%
G. $\Delta_0 = \frac{1}{100}[0, 0, 0, 0, 0, 0, 100]$					
Ed 10	11,591	−27,069	−27,069	−27,084	.0%
Ed 13	22,329	−24,629	−24,629	−24,630	.0%
H. $\Delta_0 = \frac{1}{100}[89.10, 10.25, .47, .11, .04, .03, 0]$					
Ed 10	22,980	21,945	21,168	−10,119	3.5%
Ed 13	34,159	26,093	25,088	−2,223	3.9%

Source.—German claims panel data.

Note.—The table shows welfare measured by the CE in 2016 USD per capita per year, separately for two income profiles (see fig. 3). Panels A–G differentiate by initial health status $\lambda_{25} \in \{1, \ldots, 7\}$. In panel H, we do not allow 25-year-olds to be in the worst health risk category. Columns 1–4 show welfare according to the first-best (C^*; col. 1), the optimal contract (C_{GHHW}; col. 2), the GLTHI (C_{GLTHI}; col. 3), and a series of short-term contracts (C_{ST}; col. 4). Column 5 shows the percentage of welfare loss under GLTHI relative to the optimal contract.

is important to note, however, that the performance of short-term contracts is sensitive to catastrophic risk. Under the baseline scenario, individuals would pay $54,930 whenever they reach category 7 under short-term contracts. This event, even if unlikely in a given year, has highly detrimental effects on welfare. We come back to this issue in section VI.D.1.

medical claims and restore first-best outcomes (see, e.g., Cochrane 1995; Hendel and Lizzeri 2003).

Long-term contracts can produce substantial welfare gains compared to short-term contracts. Consider panel A for the case where $\lambda_{25} = 1$ at inception. Column 2 shows that, under the optimal contract, the CE is $22,489 for Ed 10 and $27,727 for Ed 13. Column 4 shows that, under the GLTHI contract, the CE is $21,537 for Ed 10 and $26,025 for Ed 13.

The welfare difference between the optimal and the GLTHI contracts shrinks as health at inception worsens. Column 5 shows that, for those starting in the healthiest risk category ($\lambda_{25} = 1$), the CE under the GLTHI contract is 4.2% lower for Ed 10 and 6.1% lower for Ed 13 when compared to the optimal contract. Comparing columns 5 across panels A–G, we find that this difference becomes almost negligible for individuals starting in health category 5 or worse. Welfare under both long-term contracts (GLTHI and GHHW) is highly driven by the large degree of front-loading when health status at inception deteriorates (see table 3). In this case, both long-term contracts are ineffective in dealing with reclassification risk.

The welfare difference between the GLTHI and the optimal contract is close to 4%. Panel H provides our baseline results using the initial health distribution that correspond to the observed distribution at age 25 in our sample. As most individuals start healthy (99.35% have $\lambda_{25} \in \{1, 2\}$), both long-term contracts produce substantial gains relative to short-term contracts and recoup a large fraction of the welfare loss from short-term contracting. This highlights the large benefits of long-term contracts in providing insurance against reclassification risk.

1. Robustness: Preferences, Initial Health Status, Savings, and Income Profiles

We investigate the robustness of our previous result in various dimensions. First, we consider different levels of risk aversion. Second, we use a CRRA utility function instead of CARA. Third, we use Epstein and Zin's (1989) recursive preferences, where risk aversion and intertemporal elasticity of substitution are separately parameterized. Fourth, we use claims data from one of the biggest German public insurers to replicate our main findings for an initial health status representative of the population of Germany, and we further investigate the sensitivity of the results to the initial distribution of health status. Fifth, we allow for savings. Finally, we use US income profiles. We provide details of each robustness analysis below.

Risk aversion.—Our baseline results assume risk aversion $\gamma = 4 \times 10^{-4}$. The solid lines in figure 7 show the percentage point difference in CEs between each long-term contract as we vary the value for γ over the interval $\gamma \in [7.5 \times 10^{-5}, 8 \times 10^{-4}]$. Panel A shows the results for the flatter income profile (Ed 10), panel B for the steeper income profile (Ed 13).

We find that the percentage difference in welfare between the GHHW and GLTHI contracts is robust to the degree of risk aversion. The solid
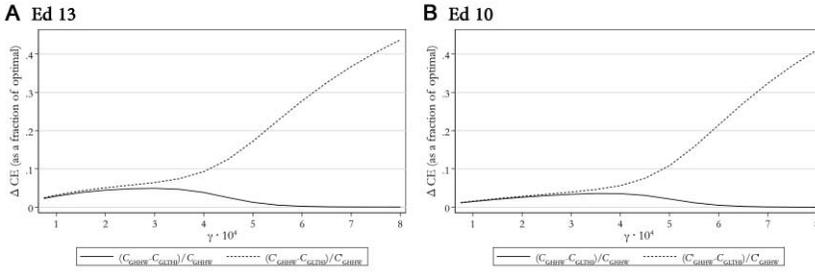
FIG. 7.—Welfare difference (GLTHI vs. GHHW) by risk aversion. The figure shows the differences in CE between GLTHI and the GHHW contract as a fraction of welfare under the GHHW contract, for different levels of risk aversion (γ). Results for the steeper income profile, Ed 13 (*A*), and for the flatter income profile, Ed 10 (*B*). Source: own calculations based on German claims panel data and SOEP (2018).

curves in the two panels show that the maximal welfare difference between the two contracts across all values of γ is 4.4% for Ed 10 and 5% for Ed 13, when $\gamma = 3.7 \times 10^{-4}$ or $\gamma = 3 \times 10^{-4}$, respectively. As expected, the welfare gap is small when γ is small, as reclassification risk and lack of intertemporal consumption smoothing are less relevant with less curvature in the utility function. However, the welfare gap is also small when γ is high.

To understand the mechanisms behind this pattern, we compute welfare under the life-cycle path of expected consumption under the GHHW contract—which we denote by C'_{GHHW}—and compare it to welfare under the GLTHI contract. In other words, we eliminate the welfare differences due to differences in reclassification risk and quantify only the welfare differences arising from the better intertemporal consumption smoothing in the optimal contract. The dashed lines in figure 7 plots $(C'_{\text{GHHW}} - C_{\text{GLTHI}})/C'_{\text{GHHW}}$.[38]

For relatively low levels of γ, C'_{GHHW} is very close to C_{GHHW}, implying that the difference in CE between GLTHI and GHHW are almost exclusively determined by their differences in intertemporal consumption smoothing.[39] However, the role of reclassification risk in explaining the differences across contracts comes to dominate at high values of γ. For instance, for $\gamma = 0.0004$ and for Ed 13, the average life-cycle consumption path under the optimal contracts produces welfare (C'_{GHHW}) that is 9.3% higher

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[38] In principle, one could also eliminate reclassification risk from the consumption path under GLTHI. However, the reclassification risk component of GLTHI is negligible.

[39] Note that even at these relatively low levels of γ, the lack of intertemporal consumption smoothing decreases welfare substantially, relative to risk neutrality. However, welfare decreases with γ by a similar amount when we eliminate reclassification risk. For instance, for Ed 13, CE_{GHHW} and $\text{CE}_{\text{GHHW}'}$ decrease by 14% and 13% compared to risk neutrality when $\gamma = 3 \times 10^{-4}$.

than welfare under GLTHI (compared to 3.9% higher when considering consumption volatility as in panel H of table 4). Overall, when γ is large, the welfare benefits of less reclassification risk under GLTHI largely compensate the welfare losses due to worse intertemporal consumption smoothing.

In summary, varying the level of risk aversion affects the performance of the GLTHI relative to the optimal contract via two underlying channels. The first is due to differences in intertemporal consumption smoothing, where GLTHI clearly falls short. The larger γ, the bigger this effect. The second is due to differences in reclassification risk, where GLTHI outperforms the optimal contract. Again, the larger γ, the bigger this effect, and the closer is the welfare under GLTHI to the welfare under the optimal contract.

CRRA preferences.—Our main analysis assumes CARA preferences. We investigate the robustness of the findings to using CRRA preferences, that is, $u(c) = u^{1-\sigma}/(1 - \sigma)$. Previous research has suggested that CRRA might represent choices well (see, e.g., Chiappori and Paiella 2011). Following Dohmen et al. (2011), we use a coefficient of risk aversion of $\sigma = 4$. We find welfare differences of 2.4% for Ed 10 and 3.8% for Ed 13.[40]

Epstein-Zin recursive preferences.—Our main specification assumes that a single parameter governs both risk aversion and intertemporal elasticity of substitution. Here we break the parametric link between risk aversion, γ, and intertemporal elasticity of substitution, ψ. As in Epstein and Zin (1989), preferences are defined recursively as $V_t = F(c_t, R_t(V_{t+1}))$ with $R_t(V_{t+1}) = G^{-1}(\mathbb{E}_t G(V_{t+1}))$, and we consider the constant elasticity of substitution (CES) aggregator $F(c, z) = ((1 - \delta)c^{1-1/\psi} + \delta z^{1-1/\psi})^{1/(1-1/\psi)}$.

We embed the same CARA specification used in our main analysis into the Epstein-Zin preferences by assuming $G(c) = u(c) = (1/\gamma)e^{-\gamma c}$. Appendix section A10.1 provides the details of the derivations.

Varying γ and ψ, figure 8 shows differences in CEs between the GLTHI and the optimal GHHW contract. Each panel corresponds to a different income profile. We show results for both extremes of the risk aversion interval in figure 7 ($\gamma = 7.5 \times 10^{-5}$ and $\gamma = 8.0 \times 10^{-4}$), as well as our baseline risk aversion parameter ($\gamma = 4 \times 10^{-4}$). As expected, the welfare differences are larger with low levels of risk aversion and low intertemporal elasticity of substitution. The maximum welfare difference is 0.7%, which occurs for the steeper income profile. We also find that the GLTHI can even outperform the optimal contract when the intertemporal elasticity of substitution is relatively high.[41]

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[40] To avoid negative consumption, we impose a consumption floor of $10,000. This is a binding constraint in approximately 10 out of 10,000 simulated consumption levels.

[41] This can occur because the GHHW contract in Ghili et al. (2024) is not necessarily the optimal contract under recursive preferences; recall that the theoretical characterization in Ghili et al. (2024) requires that preferences are time separable, a requirement that Epstein and Zin's (1989) recursive preferences do not satisfy.
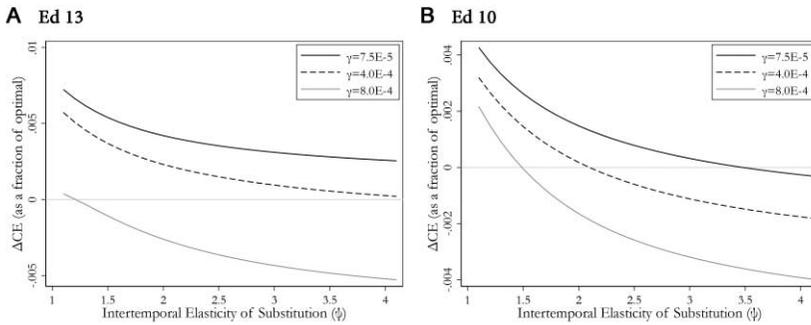
Fig. 8.—Welfare differences (GHLTI vs. GHHW) with Epstein-Zin preferences. The figure shows the differences in CE between GLTHI and GHHW contracts as a fraction of welfare under the GHHW contract with recursive (Epstein-Zin) preferences, for different levels of intertemporal elasticity of substitution ψ and for different levels of risk aversion (γ). Results for the steeper income profile, Ed 13 (A), and for the flatter income profile, Ed 10 (B). Source: own calculations based on German claims panel data and SOEP (2018).

Initial health status representative of Germany.—Our results so far use the estimates of health status for the population of GLTHI policyholders. However, several institutional features imply that this population is not representative of the German population, and likely healthier (see sec. II). This section studies the robustness of our results to using a health risk profile that is more representative of the German population as a whole. To do so, we use claims data from one of the biggest public insurers, with more than 5 million enrollees.

Overall, the claims data confirm that the privately insured are healthier. Figure A14 compares ACG risk score distributions across the publicly insured and the publicly insured; table A9 compares average raw scores, and table A10 shows the distribution by age over risk classes within the sample of publicly insured.[42]

Using the risk scores and estimated initial probabilities at age 25 for the publicly insured, we find a welfare difference (GLTHI vs. GHHW) of 1.5% and 0.9% for Ed 10 and Ed 13, respectively. Appendix section A10.2 provides additional details.[43]

Different starting states.—We further study the robustness of the results to the initial health status by considering a large number of draws of distributions over the initial health categories for the privately insured.

[42] Furthermore, using the representative SOEP, table A8 shows that privately insured are less likely to smoke, have lower body-mass indexes, and use fewer health care services.

[43] Another question is whether risk tolerance differs between the publicly and privately insured. At least in West Germany, there is evidence that civil servants are more risk averse than the rest of the population (Fuchs-Schündeln and Schündeln 2005). Table A8 confirms this. Using the SOEP, fig. A13 plots very similar risk tolerance distributions for both populations. If anything, the privately insured are a bit less risk averse, mostly stemming from more mass between 6 and 8 on the 1–10 Likert scale.

Specifically, we sampled 20 million probability simplices $\tilde{\Delta}_r \in \Delta^7$ from a Dirichlet distribution with concentration parameters equal to the baseline probabilities for the privately insured.

We find that the welfare loss of the GLTHI relative to the optimal contract is bounded at around 6% for Ed 13 and at around 4% for Ed 10. This exercise also confirms that the welfare differences between the GLTHI and the optimal contract is smaller when the population is less healthy at inception, which alleviates the concern that our findings might be driven by a relatively healthy subsample of the overall population. Appendix section A10.3 provides the details.

Savings.—Our main welfare calculations assume that individuals cannot save. Savings could improve welfare under the GLTHI contract, particularly in settings with hump-shaped life-cycle income profiles like the ones we find in the SOEP. Here, we allow for savings by solving the dynamic programming problem of optimal savings with mortality risk, as in Yaari (1965). The details are in appendix section A10.4.

We find that the relative gap between GLTHI and the optimal contract is almost unaffected by savings. Intuitively, the GLTHI contract already forces more savings than desired through highly front-loaded premiums. Moreover, under the optimal contract, individuals have no incentives to save additionally as shown in Ghili et al. (2024). Thus, savings do not affect welfare under the optimal contract.

Income profiles.—Finally, to test the robustness with respect to the life-cycle income profile, we now employ the representative PSID for the United States.[44] To extract life-cycle income profiles, we use the exact same income concept as in our main analysis for German income profiles. Moreover, we use the same estimation process. That is, we exclude respondents under 25, focus on the years 1984 to 2015, and estimate equation (6) for high school and college educated respondents. Figure A16 shows the estimated life-cycle income profiles.

In the United States, the increase in posttax equivalized income between ages 25 and 60 is very close to the pattern in Germany. However, the decrease in income after age 60 is much steeper in the United States for both educational groups. This effect amplifies the beneficial effects of optimal contracts in allowing for consumption smoothing at old ages, as shown in figure 5. Overall, the GLTHI contract would achieve welfare that would fall 5.9% and 3.5% short of the optimal dynamic long-term contract for Americans with high school and college degrees, respectively. To illustrate the role of the hump-shaped income, we calculate the welfare gap between the GLTHI and the GHHW contracts under the PSID

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[44] The PSID is the oldest and longest-running panel survey in the world. From 1968 to 1996, it surveyed US families annually, and from 1997, biannually (PSID 2018). We use the Cross National Equivalence Files, which harmonizes survey measures across years (Frick et al. 2007).

income for long-term contracts that would expire at age 65.[45] In such case, the welfare gap between the GLTHI and GHHW contracts is 2.3% and 2.0% for high school and college income profiles, respectively. Also, allowing for savings in life-long contracts, the welfare gap is 3.7% and 3.0% for high school and college income profiles, respectively.

E. Benchmarking the Loss from Using Flat-Income Optimal Contracts

In our setting, a flat-income–optimal GLTHI contract provides welfare that is around 4% lower than the optimal contract. Here we put this welfare difference in perspective, and provide additional lessons regarding when and why the flat-income–optimal GHTHI contract can approximate the welfare gains from the optimal contract.

The benefits of replacing short-term contacts with each long-term contract provide a natural benchmark to compare the welfare differences across both long-term contracts. Panel A of table 5 expands our main results by providing additional metrics to assess the welfare gains of long-term over short-term contracts. Columns 1–4 replicate the main results for CE under each contract. Columns 5 and 6 show what fraction of the welfare difference between the first-best and the short-term contract is recouped by the optimal contract and the GLTHI, $(C_{GHHW} - C_{ST})/(C^* - C_{ST})$ and $(C_{GLTHI} - C_{ST})/(C^* - C_{ST})$, respectively. Column 7 shows the fraction of the gains from replacing short-term contracts with optimal (GHHW) contracts that is achieved by replacing short-term contracts with GLTHI contracts, $(C_{GLTHI} - C_{ST})/(C_{GHHW} - C_{ST})$. Finally, column 8 shows again the percentage welfare difference between the GLTHI and the optimal contract.

Under our baseline results, the optimal contracts are very effective. They close either 96.9% or 77.8% of the welfare gap between short-term contracts and the first-best for each income profile, respectively (col. 5). This highlights the large benefits of optimal long-term contracts in providing insurance against reclassification risk. Similarly, the GLTHI contract is able to close either 94.5% or 75.1% of that gap (col. 6). As a consequence, for both income profiles, the GLTHI contract achieves close to 97% of the welfare gains from optimal long-term contracting (col. 7). Even though the GLTHI contract is only optimal when income is constant over the life cycle, its ability to insure large reclassification risk, and its particular balance between front-loading and reclassification risk insurance still achieves much of the benefits from optimal long-term contracting.

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[45] This exercise is also interesting from a policy perspective, e.g., if long-term contracts were considered for the US working population while keeping the Medicare program intact.

TABLE 5
Benchmarking Welfare under GLTHI

	C^*	C_{GHHW}	C_{GLTHI}	C_{ST}	$\frac{C_{GHHW}-C_{ST}}{C^*-C_{ST}}$	$\frac{C_{GLTHI}-C_{ST}}{C^*-C_{ST}}$	$\frac{C_{GLTHI}-C_{ST}}{C_{GHHW}-C_{ST}}$	$\frac{C_{GHHW}-C_{GLTHI}}{C_{GHHW}}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	A. Baseline Results							
Ed 10	22,980	21,945	21,168	−10,119	96.9%	94.5%	97.6%	3.5%
Ed 13	34,159	26,093	25,088	−2,223	77.8%	75.1%	96.5%	3.9%
	B. Without Catastrophic Losses							
Ed 10	22,979	21,930	21,164	14,504	87.6%	78.6%	89.7%	3.5%
Ed 13	34,159	26,064	25,079	22,123	32.7%	24.6%	75.0%	3.8%

Source.—German claims panel data; SOEP (2018).
Note.—The table shows welfare measured by CE in 2016 USD per capita per year, separately for two income profiles (see fig. 3). Panel A uses the baseline contracts as in table 4. Panel B assumes that catastrophic risk is insured by an alternative contract, as explained in the text. Columns 1–4 show welfare according to the first-best (C^*; col. 1), the optimal contract (C_{GHHW}; col. 2), the GLTHI (C_{GLTHI}; col. 3), and a series of short-term contracts (C_{ST}; col. 4). Columns 5 and 6 show how much of the welfare gap between col. 2 and col. 1 is closed by the optimal contract and the GLTHI, respectively. Column 7 shows the fraction of the potential benefits from long-term contracting achieved by GLTHI. Column 8 shows the percentage of welfare loss under GLTHI relative to the optimal contract.

The role of catastrophic risk.—As previously noted, welfare under short-term contracts is very low in our baseline scenario. Our risk classification method accommodates the heavily skewed distribution of expenditures with a high-cost but low-probability risk category 7 (sec. V.A). Even though we observe large health expenditures in our data, the assumption that individuals would be subject to such large losses in the counterfactual scenario with short-term contracts may be unrealistic, for instance, due to public safety net programs, or other forms of protection against catastrophic risks. Relatedly, one may wonder whether any mechanism that provides insurance against this catastrophic risk would perform close to the optimal dynamic contract.

We now evaluate the welfare effects under different contracts when catastrophic losses are bounded. Specifically, we recompute welfare under each contract by capping the expenditures of category 7 at those of category 6. To finance that cap, individuals starting at age 25 in $\lambda_{25} = k_0$ pay a yearly fee $\tilde{P}(k_0)$ such that the insurance company breaks even ex ante.[46] In particular, premiums under this modified short-term contract are now $P_t(\lambda_t|\lambda_{25} = k_0) = \tilde{P}(k_0) + \mathbb{E}(m_t|\min\{\lambda_t, 6\}$. The long-term contracts are also computed as before, but now with capped health expenditures and

[46] That is,

$$\tilde{P}(k_0) = \frac{\mathbb{E}\left(\sum_{t=25}^{T} S_t \delta^{t-25} \mathbf{1}[\lambda_t = 7](\mathbb{E}(m_t|\lambda_t = 7) - \mathbb{E}(m_t|\lambda_t = 6))\right)|\lambda_{25} = k_0)}{\mathbb{E}\left(\sum_{t=25}^{T} S_t \delta^{t-25}|\lambda_{25} = k_0\right)},$$

where $\mathbf{1}[]$ is the indicator function.

the additional yearly fee.[47] Panel B of table 5 provides the results under this alternative set of contracts.

We find that the gap between the two long-term contracts (GLTHI and GHHW) is robust to catastrophic expenditures (col. 8 of table 5). It remains below 4% after we eliminate the risk of category-7 expenditures. In fact, welfare under both long-term contracts changes little under this alternative scenario. This is because long-term contracts have the virtue of preventing individuals from paying higher premiums when they transition to high-cost categories. In particular, health expenditures of category 7 only affect welfare by slightly affecting the contract terms (as state 7 only arises with very low probability in the data and the contract terms are set by the risk-neutral insurer). This result highlights that long-term contracts can be very effective in dealing with the risk of future catastrophic losses.[48]

As expected, welfare under short-term contracts increases substantially when we limit the size of the catastrophic risk. As a consequence, bounding catastrophic losses generally results in smaller gains from the optimal GHHW contracts. In particular, column 5 shows that for the steeper income profile (Ed 13), optimal long-term contracts close 32.7% of the gap between the first-best and short-term contracts, as opposed to 77.8% in our baseline scenario.

Naturally, capping catastrophic losses increases the welfare gap from using the GLTHI instead of the optimal GHHW when measured as a fraction of the gains from optimal long-term contracting relative to short-term contracting. The reason is simple: the welfare gap between the GLTHI and GHHW long-term contracts stays almost unaltered in absolute terms, but the gains from optimal long-term contracts relative to short-term contracting shrinks. In our baseline scenario with large catastrophic losses, GLTHI recoups 97.6% (for Ed 10) and 96.5% (for Ed 13) of the gains from replacing short-term contracts with optimal long-term contracts (table 5, panel A, col. 7). However, after bounding category-7 expenses, the gains from optimal long-term contracting are more limited, and GLTHI recoups 89.7% (for Ed 10) and 75.0% (for Ed 13) of those (smaller) gains (table 5, col. 7).

Both long-term contracts still bring sizable gains beyond those that come from capping catastrophic risk, particularly for flatter income profiles (CE increases from $14,504 to $21,164 under the GLTHI contract and to $21,930 under the GHHW contract). It is also worthwhile noting

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[47] We note that these alternative contracts are not incentive compatible, as individuals who become healthier than expected over time could switch to an alternative contract with a lower fee. The proposed contracts assume commitment in the payment of $P_t(\lambda_t | \lambda_{25} = k_0)$.

[48] It is also interesting to note that welfare under both long-term contracts decreases (slightly) in this alternative scenario, even if we assume that individuals can commit to paying the premium $P_0(\lambda_{25})$ over time, regardless of the evolution of their health status.

that, in our empirical setting, both long-term contracts improve welfare substantially relative to the guaranteed-renewable contracts of Pauly, Kunreuther, and Hirth (1995), which fully eliminate reclassification risk at the expense of even higher front-loading.[49] These results highlight the virtue of optimal long-term contracting, in that their welfare gains do depend on the intricate trade-offs between intertemporal consumption smoothing and reclassification risk insurance. The particular way in which GLTHI balances this trade-off, and its commonalities with the optimal contract, are important to explain its performance.

The results from eliminating the catastrophic risk are tightly connected to the fact that the German contract provides more reclassification risk insurance at the expense of more front-loading than the optimal dynamic contract. In our setting, much of the welfare loss from short-term contracting would be due to reclassification risk.[50] Under such situations, both the GLTHI and the optimal GHHW contracts are very effective as they are designed to mitigate reclassification risk using front-loaded premiums. By virtue of practically eliminating reclassification risk, the GLTHI contract achieves much of the benefits of long-term contracting, even though it introduces more front-loading than optimal. In contrast, when the size of the catastrophic risk is bounded, a smaller fraction of the losses from short-term contracting is due to reclassification risk (and a larger fraction is due to the lack of intertemporal consumption smoothing).

The difference across income groups in the relative performance of each contract also relates directly to the source of welfare losses under short-term contracting. For relatively flat income profiles (Ed 10), most of the welfare loss from short-term contracting is due to reclassification risk, even when the size of the catastrophic risk is bounded. As a consequence, the GLTHI contract achieves a large fraction of the potential gains from optimal long-term contracting. For steeper income profiles, however, a larger fraction of the welfare gap comes from poor intertemporal consumption smoothing, especially when catastrophic risk is bounded. In these cases, long-term contracts are in general less effective; and the GLTHI contract achieves a smaller fraction of the potential gains from optimal long-term relative to short-term contracting.

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[49] Results are available from the authors upon request.

[50] To make this point more precisely, we can quantify the relative importance of reclassification risk under our benchmark scenario as well as under the alternative assumptions regarding catastrophic losses by computing the certainty consumption equivalent under a benchmark of no borrowing and no savings (C_{NBNS}) and calculating $(C_{NBNS} - C_{ST})/(C^* - C_{ST})$. This metric quantifies what fraction of the overall welfare losses from short-term contracts ($C^* - C_{ST}$) are due to reclassification risk ($C_{NBNS} - C_{ST}$). The remainder is due to the lack of intertemporal consumption smoothing. We find that in our baseline scenario, for Ed 10 (Ed 13), this metric is equal to 97.3% (82.7%), whereas after bounding the category-7 catastrophic losses it is 89.8% (47.4%).

F.   Summary

In our setting, we find that the flat-income–optimal (GLTHI) design achieves welfare that is close to 96% of the welfare under the optimal contract. This result is robust to several assumptions.

When reclassification risk is high, long-term contracts are very effective and provide large welfare gains relative to short-term contracts. In such cases, the welfare gains of replacing short-term contracts with the flat-income–optimal design represent most of the gains from optimal long-term contracting. However, when catastrophic losses are more limited, the gains from optimal long-term contracting are also more limited, and it is also the case that the flat-income–optimal recoups a smaller share of the gains. This pattern is tightly linked to the fact that the flat-income–optimal contract provides more reclassification risk insurance at the expense of worse intertemporal consumption smoothing.

VII.   Conclusion

Regulated private markets for comprehensive health insurance have an important role in several OECD countries—including the United States, Chile, Switzerland, and Germany. A central goal of premium rating regulation in such markets is to prevent reclassification risk, which is often achieved through community-rated pricing. For example, Switzerland has a private health insurance market with tight community rating regulations to provide reclassification risk insurance for all citizens. Several large markets and programs in the United States also feature community rating, most notably the individual market after the enactment of the ACA. However, community rating regulations, unless combined with individual mandates, tend to exacerbate adverse selection (Geruso and Layton 2017).

A fundamental, but empirically understudied alternative to regulated short-term contracts are individual long-term contracts. They provide policyholders with reclassification risk insurance without necessarily triggering adverse selection. This paper bridges between the theoretical literature on long-term contracts and its most important real-world application—the GLTHI.

We show that contracts in Germany's private health insurance market share several features with the optimal dynamic contract, as recently derived by Ghili et al. (2024). Moreover, we highlight that the two contracts coincide for individuals with a flat life-cycle income profile. More generally, the GLTHI contract almost fully eliminates reclassification risk over a policyholder's life cycle. However, the elimination of reclassification risk comes at the expense of higher premium front-loading, which, compared to the optimal contract, results in less intertemporal consumption smoothing.

We assess welfare under the GLTHI contracts and compare it to optimal contracts leveraging unique claims panel data from GLTHI policyholders, along with household panel data. Key to this analysis, we propose a novel risk classification method based on principles of actuarial science. We find that welfare under the GLTHI design—as measured by certainty-equivalent yearly consumption—is 96% of what the income-dependent optimal contract achieves. This result is robust to the degree of risk aversion, to using non-time-separable recursive preferences after Epstein and Zin (1989), to using the initial health status of the publicly insured in Germany, to using US life-cycle income profiles, and to the extent of catastrophic risk. Overall, the welfare loss due to reduced consumption smoothing from ignoring income dynamics is partly compensated by lower reclassification risk.

We also provide further insights regarding the workings of the flat-income–optimal GLTHI contract relative to the income-dependent optimal dynamic contracts. In our empirical setting, a large share of the welfare loss under the counterfactual scenario of short-term contracts comes from reclassification risk. The flat-income–optimal and optimal contracts are very effective at improving upon short-term contracts: they mitigate the large reclassification risk with premium front-loading, resulting in large welfare gains relative to short-term contracts. However, in scenarios with more limited catastrophic risk—for example, if long-term contracts were to coexist with government programs that already insure catastrophic expenses—the additional gains from optimal long-term contracting would be smaller, and the GLTHI design would recoup a smaller share of those incremental gains.

A practical advantage of the GLTHI contract is its simplicity, in that, after an initial risk rating, policies are guaranteed renewable with constant and income-independent premiums for as long as the policyholder does not lapse. This simplicity may explain its proliferation and stable existence in Germany for decades. We see the performance of long-term contracts under this particular design as a virtue of the theory of optimal long-term contracts, which strengthens their case as an appealing policy option. Alternative designs with premium profiles tailored to rising life-cycle income profiles as, for instance, those observed in life insurance, should also be considered (Hendel and Lizzeri 2003). In the United States, the debate has so far focused on either incremental adjustments to the community-rated short-term contracts under the ACA or a transition to a "single payer for all" system.

Finally, we acknowledge two important and general caveats of long-term contracts. First, neither the GLTHI nor the optimal dynamic contracts are affordable for those who are sick in young ages. From a policy perspective, societies that implement long-term contracts must offer public insurance for these individuals. Second, our discussion abstracts

from a couple of key features that may have implications for welfare under the long-term contracts. First, our model assumes time-consistent individuals. From the perspective of a present-biased consumer, front-loading may render long-term contracts undesirable, particularly when front-loading is high.[51] Furthermore, our model abstracts from moral hazard. In the presence of moral hazard, the use of long-term contracts to protect against reclassification risks could also induce inefficiencies in health spending and health investment, similar to what is studied in Cole, Kim, and Krueger (2019) for the case of community rating. Quantifying the role of moral hazard in long-term contracts is an important avenue for future research.

Data Availability

Code replicating the tables and figures in this article can be found in the Harvard Dataverse, https://doi.org/10.7910/DVN/AX0LQS (Atal et al. 2024).

References

Aizawa, N., and H. Fang. 2020. "Equilibrium Labor Market Search and Health Insurance Reform." *J.P.E.* 128 (11): 4258–336.

Akerlof, G. A. 1970. "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." *Q.J.E.* 84 (3): 488–500.

Atal, J. P. 2019. "Lock-in in Dynamic Health Insurance Contracts: Evidence from Chile." PIER Working Paper Archive 19-020, Penn Inst. Econ. Res., Dept. Econ., Univ. Pennsylvania.

Atal, J. P., H. Fang, M. Karlsson, and N. R. Ziebarth. 2019. "Exit, Voice or Loyalty? An Investigation into Mandated Portability of Front-loaded Private Health Plans." *J. Risk and Insurance* 86 (3): 697–727.

———. 2024. "Replication Data for: 'German Long-Term Health Insurance: Theory Meets Evidence.'" Harvard Dataverse. https://doi.org/10.7910/DVN/AX0LQS.

Avdic, D., S. Decker, M. Karlsson, and M. Salm. 2024. "No-Claim Refunds and Healthcare Use." *J. Public Econ.* 230:105061.

Baumann, F., V. Meier, and M. Werding. 2008. "Transferable Ageing Provisions in Individual Health Insurance Contracts." *German Econ. Rev.* 9 (3): 287–311.

Becker, G. S., and B. R. Chiswick. 1966. "Education and the Distribution of Earnings." *A.E.R.* 56 (1/2): 358–69.

Bhuller, M., M. Mogstad, and K. G. Salvanes. 2017. "Life-Cycle Earnings, Education Premiums, and Internal Rates of Return." *J. Labor Econ.* 35 (4): 993–1030.

Börsch-Supan, A., and H. Jürges. 2012. "Disability, Pension Reform, and Early Retirement in Germany." In *Social Security Programs and Retirement around the World: Historical Trends in Mortality and Health, Employment, and Disability Insurance*

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[51] Still, Gottlieb and Zhang (2021) show that with a sufficiently large number of periods, the inefficiencies arising from time inconsistency vanish. With the long-term contract that emerges in equilibrium with time-inconsistent agents, time-inconsistent agents may achieve the same level of welfare as time-consistent agents.

Participation, edited by David A. Wise, 277–300. Chicago: Univ. Chicago Press (for NBER).

Bundesministerium für Gesundheit. 2024. *Die Pflegeversicherung*. https://www .bundesgesundheitsministerium.de/themen/pflege/online-ratgeber-pflege/die -pflegeversicherung.html, retrieved April 20, 2024.

Bünnings, C., H. Schmitz, H. Tauchmann, and N. R. Ziebarth. 2019. "How Health Plan Enrollees Value Prices Relative to Supplemental Benefits and Service Quality." *J. Risk and Insurance* 86 (2): 415–49.

Chiappori, P.-A., and M. Paiella. 2011. "Relative Risk Aversion Is Constant: Evidence from Panel Data." *J. European Econ. Assoc.* 9 (6): 1021–52.

Christiansen, M., M. Eling, J.-P. Schmidt, and L. Zirkelbach. 2016. "Who Is Changing Health Insurance Coverage? Empirical Evidence on Policyholder Dynamics." *J. Risk and Insurance* 83 (2): 269–300.

Claxton, G., L. Levitt, and K. Pollitz. 2017. *Pre-ACA Market Practices Provide Lessons for ACA Replacement Approaches*. Kaiser Family Foundation. https://www.kff .org/health-costs/issue-brief/pre-aca-market-practices-provide-lessons-for -aca-replacement-approaches/, retrieved on September 14, 2018.

Cochrane, J. H. 1995. "Time-Consistent Health Insurance." *J.P.E.* 103 (3): 445–73.

Cole, H. L., S. Kim, and D. Krueger. 2019. "Analysing the Effects of Insuring Health Risks: On the Trade-Off between Short-Run Insurance Benefits versus Long-Run Incentive Costs." *Rev. Econ. Studies* 86 (3): 1123–69.

De Nardi, M., S. Pashchenko, and P. Porapakkarm. 2024. "The Lifetime Costs of Bad Health." *Rev. Econ. Studies*, forthcoming.

Diamond, P. 1992. "Organizing the Health Insurance Market." *Econometrica* 60 (6): 1233–54.

Dohmen, T., A. Falk, D. Huffman, U. Sunde, J. Schupp, and G. G. Wagner. 2011. "Individual Risk Attitudes: Measurement, Determinants, and Behavioral Consequences." *J. European Econ. Assoc.* 9 (3): 522–50.

Dustmann, C., P. A. Puhani, and U. Schönberg. 2017. "The Long-Term Effects of Early Track Choice." *Econ. J.* 127 (603): 1348–80.

Eekhoff, J., M. Jankowski, and A. Zimmermann. 2006. "Risk-Adjustment in Long-Term Health Insurance Contracts in Germany." *Geneva Papers on Risk and Insurance: Issues and Practice* 31 (4): 692–704.

Einav, L., A. Finkelstein, S. P. Ryan, P. Schrimpf, and M. R. Cullen. 2013. "Selection on Moral Hazard in Health Insurance." *A.E.R.* 103 (1): 178–219.

Epstein, L. G., and S. E. Zin. 1989. "Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: A Theoretical Framework." *Econometrica* 57 (4): 937–69.

Fang, H., and E. Kung. 2020. "Life Insurance and Life Settlements: The Case for Health-Contingent Cash Surrender Values." *J. Risk and Insurance* 87 (1): 7–39.

Finger, R. J. 2006. "Risk Classification." In *Foundations of Casualty Actuarial Science*, 5th ed., edited by the Casualty Actuarial Society, 231–76. Arlington, VA: CAS Books.

Finkelstein, A., K. McGarry, and A. Sufi. 2005. "Dynamic Inefficiencies in Insurance Markets: Evidence from Long-Term Care Insurance." *A.E.R.* 95 (2): 224–28.

Fleitas, S., G. Gowrisankaran, and A. L. Sasso. 2018. "Reclassification Risk in the Small Group Health Insurance Market." Working Paper no. 24663 (May), NBER, Cambridge, MA.

French, E., and E. Kelly. 2016. "Medical Spending around the Developed World." *Fiscal Studies* 37 (3–4): 327–44.

Frick, J. R., S. P. Jenkins, D. R. Lillard, O. Lipps, and M. Wooden. 2007. "The Cross-National Equivalent File (CNEF) and Its Member Country Household Panel Studies." *Schmollers Jahrbuch: J. Appl. Soc. Sci.* 127 (4): 626–54.

Fuchs-Schündeln, N., and M. Schündeln. 2005. "Precautionary Savings and Self-Selection: Evidence from the German Reunification 'Experiment.'" *Q.J.E.* 120 (3): 1085–120.

Geruso, M., and T. J. Layton. 2017. "Selection in Health Insurance Markets and Its Policy Remedies." *J. Econ. Perspectives* 31 (4): 23–50.

Geyer, J., and V. Steiner. 2014. "Future Public Pensions and Changing Employment Patterns across Birth Cohorts." *J. Pension Econ. and Finance* 13 (02): 172–209.

Ghili, S., B. Handel, I. Hendel, and M. D. Whinston. 2024. "Optimal Long-Term Health Insurance Contracts: Characterization, Computation, and Welfare Effect." *Rev. Econ. Studies* 91 (2): 1085–121.

GKV-Spitzenverband. 2024. "Die gesetzlichen Krankenkassen." https://www.gkv -spitzenverband.de/krankenversicherung/kv_grundprinzipien/alle_gesetzli chen_krankenkassen/alle_gesetzlichen_krankenkassen.jsp.

Goebel, J., M. M. Grabka, S. Liebig, M. Kroh, D. Richter, C. Schröder, and J. Schupp. 2019. "The German Socio-Economic Panel (SOEP)." *Jahrbücher für Nationalökonomie und Statistik* 239:345–60.

Gotthold, K., and B. Gräber. 2015. "So kommen Sie zurück in die gesetzliche Kasse." *Die Welt*, June 3. https://www.welt.de/finanzen/verbraucher/article 138148142/So-kommen-Sie-zurueck-in-die-gesetzliche-Kasse.html.

Gottlieb, D., and X. Zhang. 2021. "Long-Term Contracting with Time-Inconsistent Agents." *Econometrica* 89 (2): 793–824.

Handel, B., I. Hendel, and M. D. Whinston. 2015. "Equilibria in Health Exchanges: Adverse Selection vs. Reclassification Risk." *Econometrica* 83 (4): 1261–313.

Harris, M., and B. Holmstrom. 1982. "A Theory of Wage Dynamics." *Rev. Econ. Studies* 49 (3): 315–33.

Heckman, J., and B. Burton Singer. 1984. "A Method for Minimizing the Impact of Distributional Assumptions in Econometric Models for Duration Data." *Econometrica* 52 (2): 271–320.

Hendel, I., and A. Lizzeri. 2003. "The Role of Commitment in Dynamic Contracts: Evidence from Life Insurance." *Q.J.E.* 118 (1): 299–328.

Henke, K. D. 2007. "Zur Dualität von GKV und PKV / The Future of Private and Public Health Insurance in Germany." *Jahrbücher für Nationalökonomie und Statistik* 227 (5–6): 502–28.

Herring, B., and M. V. Pauly. 2006. "Incentive-Compatible Guaranteed Renewable Health Insurance Premiums." *J. Health Econ.* 25 (3): 395–417.

Hofmann, A., and M. Browne. 2013. "One-Sided Commitment in Dynamic Insurance Contracts: Evidence from Private Health Insurance in Germany." *J. Risk and Uncertainty* 46 (1): 81–112.

Hullegie, P., and T. J. Klein. 2010. "The Effect of Private Health Insurance on Medical Care Utilization and Self-Assessed Health in Germany." *Health Econ.* 19 (9): 1048–62.

IKKBB (Innungskrankenkasse Berlin Brandenburg). 2018. "IKK oder privat versichert: Wichtige Infos zur Entscheidung." Brochure, IKKBB, Berlin.

Jacobs, K., F. Breyer, J. Wasem, A. Walendzik, and K.-D. Henke. 2012. "Dualität aus gesetzlicher und privater Krankenversicherung überholt?" *Wirtschaftsdienst* 92 (10): 651–66.

Kaiser Family Foundation. 2019. "2019 Employer Health Benefits Survey." Technical report. Kaiser Family Found. https://www.kff.org/health-costs/report /2019-employer-health-benefits-survey/.

Keane, M. P., and K. I. Wolpin. 1997. "The Career Decisions of Young Men." *J.P.E.* 105 (3): 473–522.

Kluth, S., and M. Gasche. 2016. "Ersatzraten in der Gesetzlichen Rentenversicherung / Replacement Rates in the German Statutory Pension System." *Jahrbücher für Nationalökonomie und Statistik* 235 (6): 553–83.

Koch, P. 1971. *Von der Zunftlade zum rationellen Grossbetrieb: Kleine Geschichte der privaten Krankenversicherung in Deutschland.* Karlsruhe: Versicherungswirtschaft.

Koijen, R. S. J., T. J. Philipson, and H. Uhlig. 2016. "Financial Health Economics." *Econometrica* 84:195–242.

Krueger, D., and H. Uhlig. 2006. "Competitive Risk Sharing Contracts with One-Sided Commitment." *J. Monetary Econ.* 53 (7): 1661–91.

Mahler, L., and M. Yum. 2024. "Lifestyle Behaviors and Wealth-Health Gaps in Germany." *Econometrica* 92 (5): 1697–733.

Panthöfer, S. 2016. "Risk Selection under Public Health Insurance with Opt-Out." *Health Econ.* 25 (9): 1163–81.

Patel, V., and M. V. Pauly. 2002. "Guaranteed Renewability and the Problem of Risk Variation in Individual Health Insurance Markets." *Health Affairs* 21 (suppl.): W280–W289.

Pauly, M. V., H. Kunreuther, and R. Hirth. 1995. "Guaranteed Renewability in Insurance." *J. Risk and Uncertainty* 10 (2): 143–56.

Pauly, M. V., and R. D. Lieberthal. 2008. "How Risky Is Individual Health Insurance?" *Health Affairs* 27 (suppl.): W242–W249.

Pauly, M., A. Percy, and B. Herring. 1999. "Individual versus Job-Based Health Insurance: Weighing the Pros and Cons." *Health Affairs* 18 (6): 28–44.

Polyakova, M. 2016. "Risk Selection and Heterogeneous Preferences in Health Insurance Markets with a Public Option." *J. Health Econ.* 49:153–68.

PSID (Panel Study of Income Dynamics). 2018. "Public Use Dataset." Survey data, Inst. Soc. Res., Univ. Michigan. https://psidonline.isr.umich.edu/.

Schencking, F. 1999. *Entwicklungsmöglishkeiten privater Krankenversicherung.* Wiesbaden: Springer.

Schmitz, H., and M. Westphal. 2017. "Informal Care and Long-Term Labor Market Outcomes." *J. Health Econ.* 56:1–18.

Schmitz, H., and N. R. Ziebarth. 2017. "Does Framing Prices Affect the Consumer Price Sensitivity of Health Plan Choice?" *J. Human Resources* 52 (1): 89–128.

SOEP (German Socio-Economic Panel). 2018. *Socio-Economic Panel (SOEP); Data from 1984-2016.* Dataset, German Inst. Econ. Res. https:/doi.org/10.5684/soep.v33.

Statistisches Bundesamt. 2020. "Sozialleistungen: Angaben zur Krankenversicherung (Ergebnisse des Mikrozensus) 2019." Dataset, Statistisches Bundesamt. https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Gesundheit/Gesundheitszustand-Relevantes-Verhalten/Publikationen/Downloads-Gesundheitszustand/krankenversicherung-mikrozensus-2130110199004.html.

TK (Die Techniker Krankenkasse). 2024. "Wann Beschäftigte in die gesetzliche Krankenversicherung zurückkehren können." https://www.tk.de/firmenkunden/service/fachthemen/versicherung-fachthema/wann-rueckkehr-in-die-gkv-moeglich-ist-2117276?tkcm=aaus.

VPK (Association of German Private Healthcare Insurers). 2020. *Zahlenbericht der privaten Krankenversicherung 2019.* https://www.pkv.de/fileadmin/user_upload/PKV/3_PDFs/Publikationen/Zahlenbericht_2019.pdf.

———. 2023. *PKV in Zahlen 2022.* Report. VPK. https://www.pkv.de/fileadmin/user_upload/PKV/3_PDFs/Publikationen/Zahlenbericht_2022.pdf.

———. 2024. *So funktioniert die Pflegeversicherung.* Report. Verband der Privaten Krankenversicherung. https://www.pkv.de/wissen/pflegeversicherung/so-funktioniert-die-pflegeversicherung/.

Werbeck, A., A. Wübker, and N. R. Ziebarth. 2021. "Cream Skimming by Health Care Providers and Inequality in Health Care Access: Evidence from a Randomized Field Experiment." *J. Econ. Behavior and Organization* 188:1325–50.

Yaari, M. E. 1965. "Uncertain Lifetime, Life Insurance, and the Theory of the Consumer." *Rev. Econ. Studies* 32 (2): 137–50.