One-Sided Commitment in Dynamic Insurance Contracts: Evidence from Private Health Insurance in Germany

Annette Hofmann · **Mark Browne**

Abstract This paper studies long-term private health insurance (PHI) in Germany. It describes the main actuarial principles of premium calculation and relates these to existing theory. In the German PHI policyholders do not commit to renewing their insurance contracts, but insurers commit to offering renewal at a premium rate that does not reflect revealed future information about the insured risk. We show that empirical results are consistent with theoretical predictions from one-sided commitment models: front-loading in premiums generates a lock-in of consumers, and more front-loading is generally associated with lower lapsation. Due to a lack of consumer commitment, dynamic information revelation about risk type implies that high-risk policyholders are more likely to retain their PHI contracts than are low-risk types.

Keywords Private health insurance · One-sided commitment · Guaranteed renewable insurance.

JEL Classification G22 · I11 · I18

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In many European countries, health insurance is offered by government-sponsored social insurance funds. These funds are subject to mounting problems of financing the welfare state, and do not offer much, if any, consumer choice. In contrast, freely competitive health insurance markets do not seem to work efficiently either. In these markets, policy-makers are often concerned about selection, equity, and access issues. Leading policy-makers look for alternative strategies for creating incentives to increase efficiency. Creating an environment that can overcome current inefficiencies in health insurance markets appears to be a challenging task though.

The present paper addresses the issue of long-term insurance contracts in a world where risk types evolve over time. This issue is especially important in the health and life insurance industries. The first-best insurance policy in this world would fully insure against both the short-term sickness risk and the long-term reclassification risk (premium risk).[1] In a private health insurance market, it is far from easy to design long-term contracts that protect consumers from premium risk in the long run. The premium risk mainly emerges because contracts tend to be incomplete, i.e., they do not specify a price for every possible state of the world. To date, the insurance economics literature offers two solutions to this problem. On the one hand, Pauly et al. (1995) propose solving the premium risk problem via guaranteed renewable insurance contracts. Since policyholders initially prepay guaranteed renewable premiums to cover losses of everyone in the pool who (will) become high risk, the leaving of a low-risk policyholder has no impact on the insurer's profits while the leaving of a high-risk policyholder is profitable to the insurer. Yet the technical design of long-term guaranteed renewable contracts seems sophisticated. On the other hand, Cochrane (1995) argues that the premium risk problem could be solved via separate "premium insurance" which pays an indemnity in the event an individual becomes a high risk.

We study the German private health insurance market, a regulated market exhibiting guaranteed renewable premiums. Our study summarizes the main actuarial principles of premium calculation and discusses some of the major issues. The objective of the paper is threefold. First, it describes the German private health insurance experience (insurance contracts, actuarial premium calculation model, regulation, and market structure). Second, it relates this experience to existing theory (it shows how the offered contracts and the way they are priced relates to theoretical predictions). Third, it provides evidence on the relevance of the theory through individual data. In particular, we aim to investigate whether one-sided commitment contracts can solve well-known issues in health insurance. Using individual-level data, our study contributes to the literature on dynamic contract theory in two ways. First, it confirms theoretical findings on dynamic contracts and one-sided commitment. Second, private health insurance in Germany is significantly different from that in other countries which makes Germany interesting for a study of one-sided commitment. The German market environment is unique in several aspects.

One of these aspects is that Germany has a social health insurance (SHI) system as well as a private health insurance (PHI) system coexisting side by side.[2] Dependent workers are mandated by law to purchase health insurance coverage. In the statutory SHI system, nonprofit insurers (called sickness funds) collect premiums from their policyholders and pay health care providers according to negotiated agreements. Consumers who are not insured through these funds, mostly civil servants and the self-employed, usually have private insurance. Given that insurance is compulsory in Germany, "no insurance" is not really an

[1] In a competitive market environment where premiums are risk-based, individuals face reclassification risk. Reclassification risk is the risk of an increase in the health insurance premium when the policyholder's health deteriorates. In health economics, reclassification risk is often referred to as premium risk. See Arrow (1963), Pauly et al. (1995) and Cochrance (1995).

[2] A similar structure can only be found in Chile, which also has public and private options. For a theoretical model and more information on the determinants of the choice of health insurance in Chile, we refer to Sapelli and Torche (2001).

option. Indeed, less than 0.2 per cent of the German population has no health insurance of any kind.[3] These consumers are generally the very rich who do not need it, and the very poor who receive health care through social assistance. SHI premiums are not risk-based but depend on an individual's annual labor income. Children and spouses without labor income are insured without surcharge. Premiums are shared between the insured and his or her employer. Sickness funds are required by law to set a uniform premium for all their policyholders. The most important features of the German SHI system are community rating and open enrollment, i.e., to ensure coverage for all risk types, sickness funds are required to accept any individual who applies without making a risk assessment.[4]

Another unique aspect of the German health insurance market environment is its high degree of government regulation. Both the social as well as the private system are highly regulated. About ninety per cent of all Germans have social health insurance coverage. An upper-income group, the self-employed, and civil servants are eligible for the private health insurance system, which offers more extensive coverage, and in which premium calculation is regulated in a unique way: insurers must offer long-term contracts at a guaranteed renewable rate involving front-loading of premiums and insurance of premium risk. The insurer accumulates aging provisions to smooth premiums over time. If policyholders want to switch private health insurers, they can do so, but they cannot take any fraction of this accumulated capital stock with them. As a result, this form of regulation creates a lock-in effect implying that switching becomes especially unattractive for high risk policyholders. The important features of the PHI system, the system of interest in this study, are explained in more detail below.

As predicted by the theory on symmetric learning and dynamic contracting, our private health insurance data confirm that front-loading of premiums generates a lock-in of consumers. We provide evidence suggesting that low-risk policyholders are more likely to drop their coverage, and that dropping coverage seems at least partly a response to learning over time. While symmetric learning has no effect on informational asymmetries between policyholders and insurers, some information may be private to policyholders who then may be able to more accurately estimate the severity and future consequences of their impaired health. Hence, in a world where reclassification risk is insured, given a specific mechanism, risk selection may become an issue.

The remainder of the paper proceeds as follows. The next section reviews related literature. The basic structure of the German private health insurance system and its functioning is explained in Section 3. We derive our main hypotheses according to the theory of one-sided commitment in Section 4. Section 4 also contains the empirical analysis. Section 5 discusses policy implications and concludes.

1 Related Literature

The paper is related to two strands of literature. The first strand is the vast literature on dynamic contracts, learning and commitment. This theoretical literature has received relatively little empirical attention. Hendel and Lizzeri (2003), following Harris and Holm-

[3]See Thomson, Busse, and Mossialos (2002), p. 426.

[4]Government regulation is an alternative way to insure premium risk. When community rating is required, health insurers must impose a somewhat uniform price for all individuals who enroll in their health insurance plans. Community rating is then necessarily associated with (a) open enrollment and (b) compulsory insurance. Open enrollment is necessary to avoid cherry picking by insurers. Compulsory insurance is necessary to ensure cross-subsidization between high and low risks. This is because, if insurance were not compulsory, low risks would prefer to purchase risk-based insurance (or remain uninsured) to avoid cross-subsidizing high risks. Government regulation in this form - a combination of community rating, open enrollment and compulsory insurance - is implemented in Belgium, the Netherlands, and Switzerland, and is part of Enthoven's (1988) proposal to reform the U.S. health care system. See Kifmann (2002), p. 15. Since our focus is on private health insurance in Germany, we do not further discuss Germany's SHI system. For a more detailed discussion, the reader is referred to Breyer (2004).

strom (1982), develop and test a theory of dynamic contracting in the U.S. life insurance market. They provide strong evidence of the existence and significance of learning over time. The "incentive-compatible" life insurance contracts involve front-loading (meaning that the premiums in the initial time period are higher than current-period expected expenses) resulting from a lack of bilateral commitment to contracts. The "extra" premium can be used by the insurer to cover the subsequent above-average expenses in case an individual becomes a high risk between the first and the second period. As Hendel and Lizzeri (2003) show, this front-loading creates a partial lock-in for consumers and more front-loaded contracts generally involve lower lapsation. Herring and Pauly (2006) extend the work of Hendel and Lizzeri (2003) by showing that essentially the same results can be obtained with guaranteed renewability and single-year individual health insurance policies. The optimal incentive-compatible lifetime premium path is one that sets the premium in every period just low enough to retain participation by low risks, while collecting enough premium income in advance to cover the higher expected expenses of those policyholder who become high risks. Herring and Pauly (2006) also provide direct comparisons of the extent of front-loading in actual premiums paid with estimates of the optimal incentive-compatible age-path of premiums. They show that health insurance premiums in the U.S. follow this optimal premium path. The optimal premium path increases with age (because expected expenses tend to increase with age), but has modest front-loading and is less steep than the plot of expected expenses for the initially insured population. Private health insurers in Germany are not allowed to charge such incentive-compatible premiums, but are required by law to charge a level lifetime premium. This may imply undesirable effects because, compared to the optimal premium path, premiums in Germany involve more front-loading and a larger deviation in older years between the level premium and even the expected expenses of the healthiest older people. Finkelstein, McGarry and Sufi (2005) support Hendel and Lizzeri's findings using data on the U.S. long-term care insurance market where mortality risks are learned over time. However, there are several important differences between life insurance contracts and health insurance contracts. A life insurance contract mainly insures an income stream; a health insurance contract insures health care treatment. Learning about health is an important phenomenon. Yet life insurance contracts are comparatively simple and explicit when compared to health insurance contracts, and therefore asymmetric information is not an important issue.[5] When we look at more sophisticated health insurance contracts evolving over time, risk selection may be more important as distortions due to dynamic information revelation on health status can be large. Using data on employment-based health insurance plans, Crocker and Moran (2003) provide empirical evidence on the importance of precommitment in the design of health insurance contracts.

The second strand of literature this paper contributes to is the theory of adverse selection in insurance markets.[6] Following this theory, high-risk agents can be expected to purchase more (comprehensive) insurance coverage. This prediction, the coverage-risk correlation, can also be expected to manifest itself in a greater tendency of high-risk agents to purchase insurance.[7] A high-risk individual is one who generates higher expected insurance payouts

[5]See Hendel and Lizzeri (2003), p. 299.

[6]The theory of adverse selection in insurance markets was introduced by Rothschild and Stiglitz (1976) and has been extended in many ways. For a survey and discussion of theoretical adverse selection models, see Dionne, Doherty and Fombaron (2001).

[7]The existence of a coverage-risk correlation itself is viewed as necessary for adverse selection to be present (and its absence as sufficient for rejecting adverse selection). See, for instance, Chiappori and Salanié (2000). However, it may not always be sufficient to confirm the existence of adverse selection given that this correlation is also suggested by moral hazard theory. See, for instance, the discussion in Cohen and Siegelman (2010), pp. 71-74. To test for adverse selection, individuals facing the same set of choices should be examined. To test for moral hazard, similar individuals facing different coinsurance rates should be examined, where price sensitivity can be measured by using the coinsurance variability across individuals. See, e.g., Cardon and Hendel (2001). A detailed discussion can be found in Cohen and Siegelman (2010).

due to a larger number of expected claims, a higher expected payout in the event of a claim, or both. Empirical evidence on adverse selection in insurance markets varies across markets and pools of policies. A significant amount of empirical work finds evidence of adverse selection in insurance markets.[8] Early research by Phelps (1976) reports no evidence of a significant relationship between predicted illness of individuals and their choice of insurance coverage. Although Cardon and Hendel (2001) suggest that informational asymmetry in the U.S. health insurance market may be unimportant, Browne (1992) provides statistical evidence that adverse selection is present in the market for individual health insurance in the U.S.. His analysis confirms that cross-subsidization of high risks by low risks occurs in this market. Browne and Doerpinghaus (1993) also focus on the U.S. market for individual health insurance. They find that the characteristics of the insurance policies purchased by high and low risks and the premiums paid by high and low risks are similar, but that high risks derive more indemnity benefits from their insurance contract than do low risks. This finding suggests that adverse selection in the market for individual health insurance results in a pooling of risk types. Browne and Doerpinghaus (1994) report similar results in a study of the Medicare supplemental insurance market in the United States. Cutler and Reber (1998) study different health insurance plans offered by Harvard University, which switched from subsidizing the most generous plans to offering a fixed-dollar subsidy, thus increasing the annual cost of the most generous plan. The coverage-risk correlation was strongly confirmed by their analysis: the most generous plan was abandoned by the best risks.

Finkelstein and McGarry (2006) find no statistically significant evidence of a positive correlation between insurance coverage and (ex post) realizations of loss in the long-term care insurance market in the United States; however, Browne (2006) shows that high-risk types are more likely to retain their insurance coverage, an indication of the presence of adverse selection in this market.

Although there is a significant body of empirical work addressing adverse selection in health insurance markets, the main focus of this literature has been on testing predictions of *static* insurance models.[9] An exception is Dionne and Doherty (1994), who study a two-period competitive insurance market with one-sided commitment and renegotiation. They show that an optimal renegotiation-proof contract may entail semi-pooling in the first, and separation of risk types in the second period. More importantly, they show that optimal contracts will exhibit "highballing" features, i.e., the insurer will typically make positive profits in the first period, compensated by below-cost second period contracts. This study contributes to the smaller literature on *dynamic* contract theory, learning, and one-sided commitment. We empirically investigate contract dynamics in a world where consumers cannot commit to renewing a contract but insurers commit to offering renewal at a premium rate that does not reflect revealed future information about the insured risk.[10] We combine the two strands of literature, that on one-sided commitment and learning with that on adverse selection.

[8] For a detailed review, see Cutler and Zeckhauser (2000). They review a substantial amount of empirical adverse selection studies in health insurance. Virtually all of these studies support the hypothesis of informational asymmetry in favor of policyholders. While our focus is on health, adverse selection is shown to be present in several other insurance markets. See, for instance, Makki and Somwaru (2001) or Cohen (2005).

[9] See the seminal theoretical work by Akerlof (1970), Rothschild and Stiglitz (1976) and Wilson (1977).

[10] To our knowledge, there is no empirical study on adverse selection in the private health insurance market in Germany to date, but Nuscheler and Knaus (2005) examine risk selection within the German social health insurance system. They look at why company-based sickness funds were able to attract many new customers during 1995-2000 and study potential determinants of switching behavior. They find no evidence for selection by sickness funds in German SHI.

2 Private Health Insurance in Germany

2.1 The PHI market environment

About ten per cent of all Germans have private health insurance. Only an upper-income group as well as the self-employed and civil servants are eligible for the private system.[11] Employees can purchase PHI only if their annual labor income exceeds a certain threshold.[12] If annual income is below this social security ceiling, they must remain within the compulsory community-rated public health insurance system. There are exceptions for learners and students who can more easily choose between both systems due to the absence of income restrictions.[13] In case a policyholder retires, the income ceiling does no longer apply and he or she stays in the private system even though his or her income may have fallen below the ceiling.[14]

The German PHI market is oligopolistic. The German Association of Private Health Insurers (PKV Verband) reported 45 members by the end of 2009.[15] The legal form of private health insurers is either a stock company or a mutual. There were 26 stock companies and 19 mutuals insuring approximately 8.8 million people by the end of 2009. Overall premium income was 22564.2 million Euros for individual private health insurance coverage. Women have a lower share of private health insurance coverage than men. This is because women tend to have a lower annual labor income and thus do not cross the income threshold to be eligible for private health insurance as often as men do.[16]

There is migration within and between these two health insurance systems. However, switching possibilities from the private to the social system and vice versa are somewhat restricted. Individuals aged 55 or older are not allowed to switch to the SHI system in any case. Despite regular increases in the contribution ceiling, ever since 1975, the number of people switching to substitutive private health insurance has been higher every year than the number of people lost to the statutory social system. Since 1997, however, the number of people switching from social to private health insurance has seen a substantial increase. The German Association of Private Health Insurers argues that this is partly due to cutbacks in the statutory SHI system. There are no data available on the extent of migration within the PHI system. However, inefficiencies from the lack of bilateral commitment may involve migration-inducing distortions. In view of many countries' current health insurance reform debate, it is of interest to study and evaluate these potential distortions.

2.2 PHI premium calculation

The private health insurance system in Germany is a system that offers comprehensive health insurance (including the cost of outpatient, hospital, and dental treatment) for the whole life. This is important since it means that an insurer, when calculating premiums,

[11] Self-employed and civil servants are not compulsorily insured in the SHI system. For the latter, there is an entirely tax-financed plan for civil servants (called "Beihilfe"). Depending on marital status and the number of children, this plan covers 50-70 % of health care expenditures with the remainder being covered by an additionally purchased PHI contract. As civil servants would lose these entitlements while staying in the public system, there is a strong incentive to (partially) join the PHI system.

[12] In 2012, for instance, annual income before taxes must exceed 50,850 Euros.

[13] Most children are insured via their parents' PHI or SHI contract. However, they might change this status and switch systems or contracts when they enter the job market. For instance, it is possible to pause a PHI contract, when a 16-year-old decides to enter an apprenticeship or other work during which he will be insured in the SHI system. Therefore, there is a choice even for young people in choosing between systems or different PHI contracts.

[14] Note that once a policyholder has entered a PHI contract, he or she cannot simply drop out and reenter the SHI system, regardless of how attractive this seems. The policyholder must stay in the PHI system as long as annual income is above the ceiling. However, it is possible to switch within the system and to choose any other PHI contract offered by either the same or another private health insurer.

[15] Taking also into account 31 comparably very small non-members, the overall number of companies in the market amounts to 76.

[16] See German Association of Private Health Insurers (2009/2010), pp. 17,29.

needs to take into account all different life periods of the individual who applies for coverage. In contrast to the SHI system where premiums depend on income, PHI premiums are risk-based, unrelated to income, and individually calculated using a funding principle. Policyholders accumulate funding capital to compensate for higher expected health expenditures in the future. From an actuarial viewpoint, a constant net premium is calculated such that accumulated aging provisions in early contract years are sufficient to compensate high health care costs in later years.[17] Therefore, as health expenses increase with age, premiums necessarily exceed expected cost in early years and fall below expected cost in older years. German law requires, however, that private health insurers calculate premiums in such a way that they are constant over the insured's life-time.[18] The precautionary savings element used to smooth premiums over time is called the *aging provision* or aging reserve.

Since premiums are risk-based at contract entry, some risk assessment is needed. The insurer conducts such a risk assessment at initial enrollment. The resulting premium then depends on overall health status, sex, age at entry as well as on the extent of PHI coverage chosen. In particular, when a policyholder enters into a new PHI contract, the risk assessment can lead the insurer to imposing some risk loading on the net premium due to the individual's poor health status. Health impairments are usually assessed by a health questionnaire and/or doctor's report. However, there is no reassessment of risk type over time and the premium loading generally stays constant.[19] As a consequence, PHI premiums are not adjusted over time according to risk type and policyholders face no reclassification risk. Indeed, they only face this risk if they decide to switch their insurer. Then, again, the new insurer conducts an individual risk assessment and may impose some risk loading in the premium due to poor health at contract entry. When a policy lapses (when the insured dies or switches insurers) the aging provisions accumulated up to that point is forfeited in favor of the remaining insured community. So if policyholders wish to switch insurers, they cannot take any fraction of the aging provision with them.[20] It is important to note that the aging provision is defined as a collective reserve and does not belong to an individual policyholder. The insured is thus not entitled to the surrender value. As a result, there is implicit partial cross-subsidization between policies over time and some benefit of survivorship. However, since there is always an individual risk assessment at contract entry with a new insurer, switching is more attractive for lower-risk types.

The funding principle used to calculate PHI premiums is implemented via a basic actuarial rule, the so-called *principle of equivalence*. This principle states that over the entire policy duration (generally life-long) the total of the premiums must match the total of the benefits, including expenses caused by writing and administration of the policy, for each category of equivalent risk. The magnitude of the individual health risk is determined by the benefits under the contract, the policyholder's age (at contract entry) and the policyholder's sex. Theoretically, the premium remains constant throughout the policyholder's life time as long as the actual benefits match those used to calculate the premium. In reality, cost increases in health care cause the benefits and thus the premiums to change throughout the insured period. As a result, the principle of equivalence is static and only fulfilled at the moment of calculation.[21]

[17] Insurers calculate with a maximum life expectancy of 102. Since life expectancy depends on age and risk type of a policyholder, premiums vary for different ages at entry.

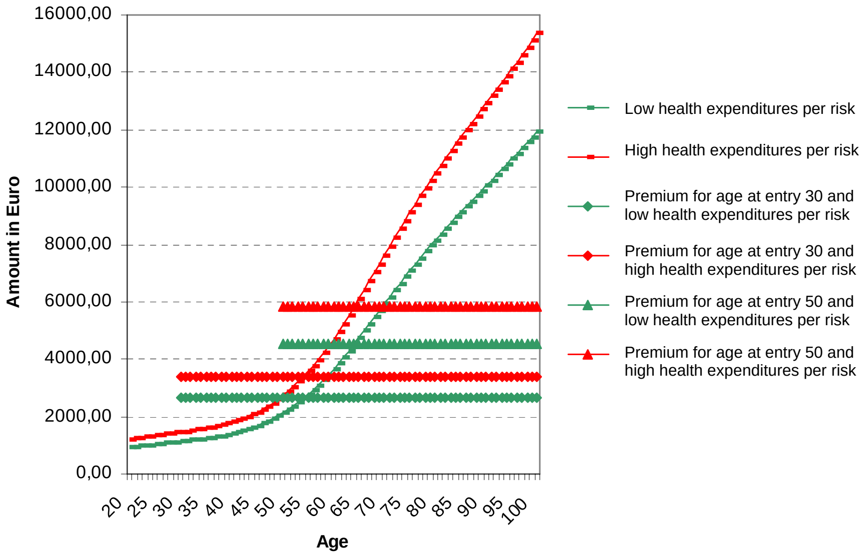
[18] In practice, premiums are not constant but depend on external factors. Premiums would be constant if, for instance, the insurer's insured community and treatment cost did not change. See Milbrodt (2005).

[19] If the policyholder can prove that the precondition(s) that led the insurer to impose a risk loading is no longer present or has become unimportant, the risk loading can be reduced.

[20] It should be noted that this fact has partly changed since 2009. Since January 2009 private health insurers offer an additional base rate ("Basistarif"). Under certain circumstances, switching into such a contract is possible without losing accumulated aging provisions. Since our empirical study is based on data that were collected before 2009, this new law has no impact on our study and we thus neglect it.

[21] See Fuerhaupter and Brechtmann (2002).

Figure 1 Health expenditures per risk and net premiums. Source: Rosenbrock (2010).



More formally, the principle of equivalence states that a lifetime constant net premium is calculated such that the present value of expected premium income (P) is equivalent to the present value (PV) of expected claims per capita (CpC). In other words, CpC represents average health expenditures per risk. It is shown in the *equivalence equation*:

$$E[PV(P)] = E[PV(CpC)] \tag{1}$$

In this equivalence equation, the present values are determined by making use of

- mortality tables,
- an actuarial interest rate,
- health expenditures (claims per capita),
- other patterns of lapses except death.

Following legislation, the technical interest rate must not exceed 3.5%. Using some exemplified progression data, Figure 1 illustrates how premiums are determined.[22] As can be seen from the figure, higher health expenditures per risk imply higher premiums over the insured's life-time. Premiums are based on the gender and the age at entry of the policyholder, so that, for a higher age at contract entry, premiums are increased because there is less time remaining for pre-financing health expenditures in the future. As a result, policies exhibit different degrees of front-loading, where the variation in front-loading is due to differences in a policyholder's risk type, gender, and age at contract entry.

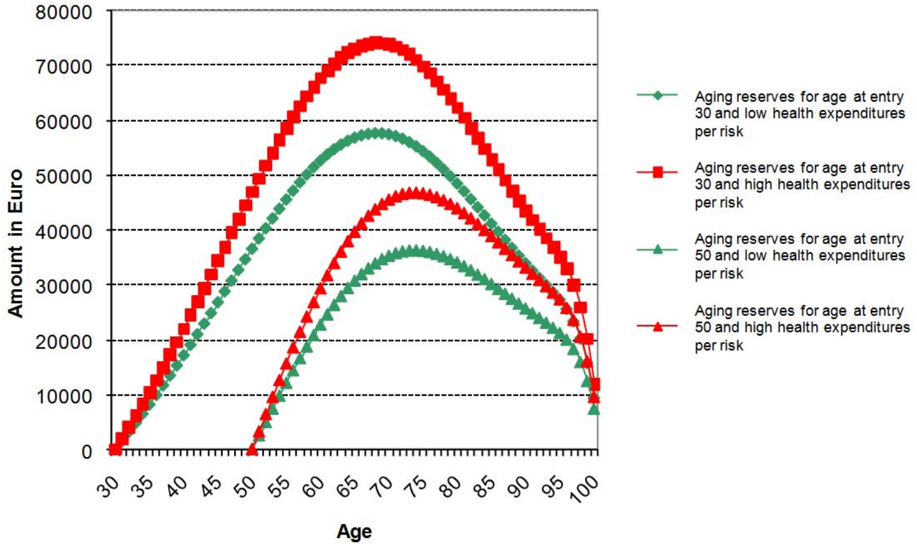
Remember that parts of the premium not used for indemnity payments due to lower health expenditures per risk in younger years are accumulated by the insurer in the form of actuarial aging provisions. Due to interest effects, aging provisions tend to increase until policyholders reach a high age (see Figure 2) even though the health expenditures per risk curve crosses the premium curve significantly before this time (see Figure 1). The accumulation of aging provisions ensures that at each point in time the equivalence equation holds, i.e., the present value of expected premium income and existing aging provisions (AP) is equivalent to the present value of expected calculated health expenditures

$$E[PV(P)] = E[PV(CpC)] - AP. \tag{2}$$

which constitutes the *generalized equivalence equation*. This equation is the actuarial basis

[22]The calculations in Figure 1 are notional and follow Milbrodt (2005). Calculations include exit and mortality risk as well as an actuarial interest rate.

Figure 2 Aging provisions for different ages of entry and health expenditures per risk. Source: Rosenbrock (2010).



of individual premium calculation.[23] AP depends only on age, sex, policy duration, and extent of coverage chosen. Individual reclassification risk is insured because equation (2) does not include any individual health information: it follows directly from the actuarial calculation principle. Thus, when the policyholder's state of health deteriorates, the premium stays constant. The basic mechanism is as follows. After a few periods (theoretically, after each period), CpC and mortality rates used for calculating present values generally differ and need to be recalculated. Then, if necessary, aging provisions are adjusted.[24] Together with new mortality tables, the new premium P is calculated and a new equivalence equation as shown in equation (2) is obtained. Individual reclassification risk is insured because CpC and mortality tables apply to *all* policyholders in the insurer's collective, and adjustment of aging provisions is regulated so that individual premiums do not vary according to individual health status.

In contrast to *individual* reclassification risk, we use the term *collective* reclassification risk to mean the risk that collective health expenditures exceed collective costs. This risk is borne by policyholders via premium loadings since it follows the development of health expenditures in the insurer's collective. Premiums need to be adjusted if overall premium income does not suffice to cover overall health expenditures. While individual reclassification risk can be insured via partial risk pooling, i.e., using a collective actuarial calculation method, collective reclassification risk cannot be insured.

In a long-term perspective, dynamic information revelation as to health status informs policyholders about their individual risk. Since the equivalence principle is based on collective actuarial calculation, and aging provisions do not include any information on individual health status, the system appears prone to risk selection. This is because aging provisions are objectively "too high" for low risks and "too low" for high risks. It seems likely that lower-risk types, once they discover that they are low risks, will be inclined to cancel their policy and look for cheaper and less comprehensive coverage elsewhere. Therefore, reclassification risk constitutes some implicit switching cost and partial risk pooling seems likely to entail risk selection in the German PHI market.

There are five possible reasons a policyholder may opt out of a PHI contract. Individuals

[23]Note that for a new policyholder, equation (2) corresponds to equation (1) with $AP = 0$. Thus, equation (1) is a special case of equation (2).

[24]Methods for adjusting aging provisions are regulated. Financial resources for this adjustment stem from separate sources or insurers' financial surplus.

opt out over time (a) because their incomes have fallen below the contribution ceiling and so they must rejoin the social health insurance system, (b) because they find out they are low risk and switch to another more favorable health insurance contract involving less extensive coverage and lower prices, (c) because their work status changes from self-employed to wage earner,[25] (d) because they expatriate themselves, or (e) because they die. Of course, we cannot differentiate between these causes for lapsation, but we may draw conclusions about relationships. In this view, our focus will mainly be on the (b), the second reason.

3 Model Framework and Empirical Analysis

German PHI premiums involve front-loading (prepayment of premiums). As a consequence, policyholders transfer income from early contract years to later years, during which they generally have worse health. Contracts are unilateral in the sense that policyholders can cancel their PHI policies, whereas insurers commit to the terms of the contract as long as the contract is in force. These contract characteristics are consistent with a dynamic model of one-sided commitment. To make theoretical predictions, it seems fruitful to adapt such a model framework, which we accomplish by relying heavily on Hendel and Lizzeri (2003). The key features of the model are (1) symmetric learning, i.e., information about risk type is revealed over time; (2) one-sided commitment of insurance companies; (3) buyer heterogeneity as to front-loading, i.e., consumers vary in income (growth); and (4) guarantee of full insurance against reclassification risk, i.e., premiums are independent of health status revealed over time.

The following predictions about the competitive market equilibrium set of contracts, which can be found in the Appendix, are an adaptation of Hendel and Lizzeri (2003) to our environment:

- All consumers obtain full insurance in all possible states of the world.
- In the second period, premiums involve a cap so that the actual premium is below the fair premium in this period. Consumers transfer income from the first period, when they enjoy comparatively good health, to future states involving worse health. The initial overpayment in the premium creates a lock-in or commitment to the PHI contract. This renders switching to a rival insurer unattractive for policyholders.
- Contracts are front-loaded as long as income growth is below a certain threshold. Less front-loaded contracts appeal to buyers with lower first-period income.

It should be noted that these predictions are drawn from equilibrium allocations via fully contingent contracts that involve no lapsation. However, there are comparable non-contingent contracts that allows us to derive comparative statics predictions.

- Non-contingent contracts with higher first-period premiums (i.e., higher front-loading) are chosen by consumers with lower income growth and have a lower rate of lapsation.

The PHI market we study is different from the life insurance market studied by Hendel and Lizzeri (2003). However, the basic mechanism behind the market forces is very similar. German PHI contracts insure individual reclassification risk. A policyholder faces reclassification risk only when he or she considers entering a PHI contract with a different

[25] In this case, individuals can either cancel or pause their PHI contract. Pausing may be attractive if the work status may change again in the future. Then, the individual can reenter the PHI contract at the same conditions. If, however, the person feels that he or she is a low risk and that the SHI system can do equally well, the person may cancel the PHI contract. We take this effect into account in our empirical analysis below.

insurer. In summary, we predict the following two key hypotheses for the German PHI market.[26]

1. Front-loading creates a lock-in of consumers, i.e., contracts with higher front-loading have lower rates of lapsation due to a more severe lock-in, other things equal.

2. Since high-risk types have a lower incentive to lapse for any given contract, ceteris paribus, the risk pool worsens over time.

An important characteristic of German PHI premiums is that they are flat. This coincides with the most front-loaded life insurance contracts observed in the US and Canada. Interestingly, another implication of the model is that the most front-loaded contracts are flat.

3.1 Data

We study enrollment in a comprehensive private health insurance contract over a period of five years, 2001 through 2005, using a large sample data set from a German private health insurer. To analyze potential inefficiencies resulting from the lack of bilateral commitment in this market, it is of interest to discover which individuals drop their PHI contract over time. Therefore, we create a subsample consisting of those $5,681$ individuals who were enrolled with the insurer in 2001, and then study the characteristics of those individuals over the following five sample periods. The subsample used for our statistical analysis contains $28,405$ (i.e., $5,681 \cdot 5$) consumer-year observations. The sample includes information on gender, age, tenure, pausation, individual health expenditures, and insurance premiums paid, but information on other characteristics of interest, such as marital status of a policyholder, race, and income, is not collected by the insurer. A short sample overview is shown in Table 1.

Table 1 Data overview 2001–2005.

	2001	**2002**	**2003**	**2004**	**2005**
Total enrollment	5,681	4,871	4,256	3,859	3,627
Enrollment male	4,143	3,558	3,110	2,830	2,651
Enrollment female	1,538	1,313	1,146	1,029	976
Average premium	1,935.14	2,511.01	2,565.22	2,600.55	2,613.86
Average premium male	1,817.13	2,377.74	2,433.83	2,473.67	2,492.16
Average premium female	2,253.01	2,872.15	2,921.80	2,949.50	2,944.42
Average loss	1,582.23	1,701.09	1,740.17	2,192.57	2,191.12
Average loss male	1,453.63	1,434.96	1,538.95	2,171.81	2,170.74
Average loss female	1,724.10	1,968.27	2,134.63	2,238.52	2,236.50

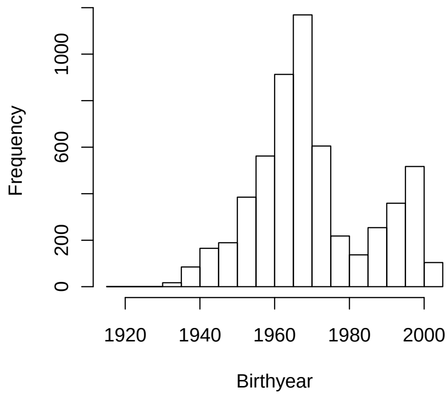
Women are higher risk type than men on average. In terms of loss frequency, over the five periods observed, 88.62 per cent of women made health insurance claims, whereas only 80.71 per cent of men did so. Women are also higher risk type in terms of loss severity. The average annual treatment cost for a woman in our sample is 2,017.37 Euros; for men, the average health care cost is 1,646.58 Euros. As a consequence of their being a higher risk type, women pay, on average, about 20 per cent more for their health insurance premium than do men.

Figure 3 displays the distribution of birth year for the policyholders in our sample. Most policyholders were born between 1965 and 1970, meaning that most were in their early thirties in the study period 2001–2005. The average age of a policyholder in our sample is 32.6. Since the regulatory framework of German PHI requires employed individuals to stay within the social health insurance system as long as their earnings do not exceed the PHI

[26]Note that we observe a given number of policyholders over time. In practice, new policyholders joining the collective tend to dilute these effects.

income threshold, the majority of PHI participants are around 30 years old.[27] However, given that newborn children tend to enter via their parents' PHI contract, this average is lower when children are taken into account. We include children in our study (this is useful for predicting claims in the prediction model, and results of the test model are not very different without children). The average age at entry is 23.84.

Figure 3 Year of birth of policyholders.



We are interested in the characteristics of policyholders who cancel their policy. We conduct our analysis in two steps. The first step involves using an estimation model to obtain a proxy for risk type in our sample. We refer to this model as the "Prediction Model". We obtain this proxy before we test our theoretical predictions, which is the second part of our analysis. We refer to the second model as the "Test Model". In the first-step modeling approach, we use a two-part model to predict expected medical expenditure, which is our proxy for a policyholder's risk type. In the second step, we use logistic regression to test our hypotheses. Each statistical method is explained in more detail below.

3.2 Predicting Risk Type via Expected Medical Expenses

To test our hypotheses, it is necessary to classify all policyholders in the sample by their risk type. Although individual risk type is unobservable, claims, along with their frequency and severity, can be observed. We will use (predicted) medical expenses as a proxy for risk type. Having identified risk types, we then look at which policyholders drop their coverage using this risk type proxy.

Since the distribution of actual expenses has a large mass at zero and is heavily skewed, we estimate individual-level medical expenses using a two-part regression model for health expenditures. Compared with ordinary regression, which ignores the special pattern of a large share of zeros in the dependent variable, a two-part model can provide an unbiased estimation. In a two-part model, the frequency component and severity component are modeled separately. Following the traditional actuarial literature based on the *individual risk model*, the response, i.e., the insurance claim, can be decomposed into two components: a frequency (number) component and a severity (amount) component.[28] More formally, let r_i be a binary variable indicating whether the ith individual had an insurance claim and let y_i describe the amount of the claim given there was a claim. Indeed, the mechanism that determines zero or nonzero expenditures might not be the same as the mechanism that determines the amount of positive expenditures. Then, the claim can be modeled as

$$(\text{Claim recorded})_i = r_i \times y_i \tag{3}$$

[27] See Baumann et al. (2006), p. 16.
[28] See Bowers et al. (1997), ch. 2.

constituting the two-part or frequency-severity model.[29] The first part is a logit model predicting for the likelihood of having any nonzero medical expenses, the second part is a linear regression for the logarithm of annual medical expenses for the sub-sample with nonzero expenses.[30] Our aim is to predict logarithmic medical expenses which is our proxy for policyholder risk type.[31]

Specifically, our first equation is a logit equation for the dichotomous event of zero versus positive annual medical expenditure. Following Manning et al. (1987), we express the expectation of the response as a function of explanatory variables to be the probability of a claim, i.e.,

$$Prob(Claim_i = 1) = \frac{exp(\boldsymbol{x}_i'\boldsymbol{\beta})}{1 + exp(\boldsymbol{x}_i'\boldsymbol{\beta})} \tag{4}$$

where $Claim_i$ is a binary variable equal to one if there is a claim for a given insured individual i; zero otherwise. The unknown parameters β_j are estimated by using maximum likelihood techniques.

Similarly, our second equation is a linear regression on the log scale for positive medical expenditure given that the policyholder receives any medical services:

$$Lnloss_i | Loss_i > 0 = \boldsymbol{x}_i'\boldsymbol{\delta} + \epsilon_i. \tag{5}$$

Assuming that $\boldsymbol{\beta}$ and $\boldsymbol{\delta}$ are not related, i.e., under independence, the two parts of our model are estimated separately to result in a prediction of expected medical expenditures per policyholder in a given period. The list of variables we use for our analysis is in Table 2, and the resulting estimates for loss frequency and severity, respectively, are shown in Table 3.

Claim is a dichotomous variable equal to one if there has been a claim in period t; zero otherwise. *Lnloss* is a numerical variable indicating the size of medical expenditures on the log scale for a given period. It is defined only in the event of a claim. *Female* is a dichotomous variable equal to one if the policyholder is female; zero otherwise. *Age* indicates the age in years of a policyholder in a given period. *Agesquare* is the square of *Age*. *Claims per Capita* or short *CpC* was explained in section 2.2 above. It is a numerical variable indicating average health expenditures per insured risk for a given tariff in a given year. In other words, *CpC* is what the insurer expects to spend in t on a given policyholder taking into account the policyholder's age and sex.[32] *CpC_Female* represents an interaction term with *Female*. *Contractyear* is a numerical variable indicating the policy duration. For instance, at contract entry, *Contractyear* is equal to one, meaning that the contract is in its first duration period. *Year* is a count variable indicating the period, i.e., 2001 through 2005. *Risk Loading* is a numerical variable representing the premium loading for a high-risk policy, that is, *Risk Loading* is positive when the insurer conducts a risk

[29]See Frees (2010), p. 424.

[30]The logarithmic transformation nearly eliminates the typical undesirable skewness in the distribution of medical expenditures, making the model more robust. In particular, it yields nearly symmetric and roughly normal error distributions, for which the least squares estimate is efficient. See Duan et al. (1983).

[31]Note that we could also predict medical expenditures (without the log scale) but this would require a retransformation to the normal scale. A shortcoming of this procedure is that the error terms in the log expenditures equation are often not normally distributed but still skewed so that normal retransformation estimates are biased. Therefore, the "smearing estimate", developed by Duan (1983), is often used to estimate the retransformation factor. The smearing estimate is given by the sample average of the exponentiated least squares residuals. Yet estimating expected expenditures in this way complicates our analysis without providing further insights: since there is a positive relationship between expected losses and expected logarithmic losses (and since we only need a risk classification proxy here) we can use predicted expenses on the log scale as a proxy for risk type.

[32]According to §6 of the Order of Premium Calculation Methods in Private Health Insurance in Germany (Kalkulationsverordnung - KalV), *CpC* is defined as average benefits per insured. It needs to be calculated based on age and sex of the policyholder for a given period (a year) and tariff. The calculation of *CpC* must take into account former claims and actuarial methods must be used in order to smooth random fluctuation.

Table 2 Response and explanatory variables in the empirical models.

Variables in the Prediction Model		Type	Min.	Max.	Mean	Std.Dev.
Prediction	Claim (Claim=1)	Binary	0	1	0.55	0.50
Variables	Lnloss	Numerical	0.92	12.35	6.82	1.25
	Female	Dummy	0	1	0.27	0.44
Control	Age	Numerical	0	86	32.58	15.75
Variables	Agesquare (Age*Age)	Numerical	0	7396	1309.85	985.26
	Claims per Capita (CpC)	Numerical	0	7764.9	1168.61	1013.96
	CpC_Fem. (CpC*Fem.)	Numerical	0	7764.9	413.51	974.23
	Contractyear	Numerical	1	66	9.75	10.04
	Risk Loading	Numerical	0	3212.76	62.63	25.56
	Exposure	Numerical	0	12	10.02	3.55
	Year	Numerical	1	5	3	1.41
Variables in the Test Model						
Response	Enrolment (Enrolment=1)	Binary	0	1	0.785	0.411
	Female	Dummy	0	1	0.27	0.44
Control	Age category 0	(dropped)	0	1	0.22	0.41
Variables	Age Category 1	(omitted)	0	1	0.04	0.21
	Age Category 2	Dummy	0	1	0.25	0.43
	Age Category 3	Dummy	0	1	0.31	0.46
	Age Category 4	Dummy	0	1	0.12	0.33
	Age Category 5	Dummy	0	1	0.06	0.23
	Short Duration	Dummy	0	1	0.82	0.38
	Middle Duration	(omitted)	0	1	0.11	0.31
	Long Duration	Dummy	0	1	0.07	0.259
	Age at Entry	Numerical	0	62	23.84	15.09
	Risk Type	Numerical	0.21	9.03	4.12	1.77

assessment at contract entry and finds that the policyholder is high risk. The size of *Risk Loading* depends on the specific precondition or illness of the policyholder. *Exposure* is a numerical variable indicating the number of months a PHI contract was actually in force for a given period. This variable takes into account that (1) a contract may be paused for some time and thus there is no insurance coverage in case of a loss, and (2) an individual may have joined the pool later in the year. *Enrolment* is a dichotomous variable equal to one if a policyholder is enrolled with the insurer in a given period; zero otherwise. *Age at Entry* is a numerical variable indicating the age at entry of the policyholder. *Short Duration*, *Middle Duration*, and *Long Duration* are dummy variables dividing policyholders into three groups: those with short contract duration of 0-14 years, those with middle contract duraction of 15-30 years, and finally those with long contract duration of over 30 years. *Risk Type* is the resulting proxy estimated via the Prediction Model.

We group individuals according to their age. Age category 0 includes children (individuals with age below 18). Category 1 includes young adults of age $18-24$. Age category 2 includes individuals aged 25 to 34. Age category 3 includes individuals aged 35 to 44, category 4 includes ages $45-54$. Finally, age category 5 includes all individuals older than 55.[33] According to these categories, *Age Category 1* is a dummy variable equal to one if the age of a policyholder falls within age category 1 for a given period; zero otherwise. *Age Category 2* through *Age Category 5* are similarly defined.

The two-part model estimations confirm that women are altogether higher risk than men. The coefficient of *Female* on loss probability (*Claim*) is positive and significant at the 5 per cent level. The coefficient on loss severity (*Lnloss*) is positive but not significant.

[33] Note that this final age category makes sense when taking into account that, at the age above 55, switching is no longer possible (following German law).

Table 3 Loss frequency (1) and severity (2) estimations (Prediction Model).

	(1) Claim	(2) Lnloss
Female	0.206*	0.0426
	(0.0910)	(0.0434)
Age	-0.0851***	0.0246***
	(0.00445)	(0.00198)
Agesquare	0.000429***	-0.000406***
	(0.0000826)	(0.0000425)
Claims per Capita (CpC)	0.00116***	0.000561***
	(0.0000566)	(0.0000363)
CpC_Fem. (CpC*Female)	-0.000229***	-0.000132***
	(0.0000569)	(0.0000258)
Contractyear	0.0109***	0.00260*
	(0.00183)	(0.00102)
Exposure	0.100***	0.0140***
	(0.00495)	(0.00333)
Risk Loading	0.000734***	0.000388***
	(0.0000866)	(0.0000325)
Year	-0.0271*	0.0303***
	(0.0117)	(0.00687)
N	22294	15632
Pseudo R^2	0.131	
R^2		0.141

(Robust) Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Higher age tends to have a positive (but decreasing) effect on loss severity and a negative (but increasing) effect on loss probability. This suggests that treatment cost increases with age but policyholders tend to visit physicians less often. Our estimations confirm the intuition that the insurer's calculated expected claims per capita are positively correlated with both loss probability and loss severity. A higher exposure during a given period, that is, a longer policy duration, is associated with higher loss probability and severity. Finally, a higher risk loading due to bad health status has a positive effect on both loss probability and loss severity.[34] It is also clear from the estimated parameters of the two–part model for loss probability and severity prediction that the R^2 does not explain very much of the variation in loss probability and severity. This is not surprising as insured losses are largely random events and thus a considerable amount of unexplained variation is expected. Note that we are not using the prediction model equation to test any hypotheses. Therefore, collinearity is not a concern at this point of our analysis.

Using these estimates and combining them in a new single estimate, *Risk Type*, which is simply the product of the frequency and the severity components, we obtain an estimate for expected medical expenditures (on the log scale) for each policyholder. We will use this estimate as an independent variable in the second part of our analysis when we test our hypotheses regarding the German PHI market.

[34]Note that we do not have any information on a policyholder's chronic conditions and his or her chance of developing such, but we do know whether a policyholder is charged a risk loading on his or her premium at contract entry. The risk loading is taken into account in our Prediction Model which therefore uses this available information on policyholders' potential decline in future health status.

3.3 Testing the Implications of the Model

We consider the individual's decision to enroll in a PHI contract as a discrete choice. An individual may either stay with the original contract or enter a new PHI contract with some other (private or public) insurer.[35] The net expected utility of being enrolled in the PHI contract as compared to switching to some other contract is assumed to be given by some linear index function

$$EU_i = \boldsymbol{x}_i'\boldsymbol{\phi} + \epsilon_i, \tag{6}$$

where $\boldsymbol{x}_i$ denotes individual i's characteristics, $\boldsymbol{\phi}$ is the vector of parameters to be estimated and represents the impact of these characteristics on the decision to stay enrolled in the private health insurance contract, and ϵ_i is a random error term. We do not observe the net expected utility of being enrolled in the private health insurance contract in a given period, but we do observe whether the net expected utility is positive, meaning that the individual decided to be enrolled in the contract in a given period. Thus, using logistic regression analysis, the probability that an individual is enrolled in a given period t can be modeled as:

$$Prob(Enrolment_{i,t} = 1) = Prob(EU_{i,t} > 0) = \frac{exp(\boldsymbol{x}_i'\boldsymbol{\phi})}{1 + exp(\boldsymbol{x}_i'\boldsymbol{\phi})}, \tag{7}$$

where $Enrolment_{i,t}$ is a dummy variable equal to one if individual i is insured in period t; zero otherwise. The logit modeling approach here consists in estimating the probability that a policyholder drops out of his or her PHI contract in period t, depending on individual characteristics. We use average medical expenditure (on the log scale), which we estimated using the Prediction Model and called *Risk Type*, as a proxy for a policyholder's risk type.

Logistic regression results for the test equation are shown in Table 4. The test equation is estimated four times for each data period in the sample based on 100 per cent enrollment in the previous period, i.e., we evaluate lapsation for every period from 2002 through 2005. Therefore, in our test equation, the number of observations available for testing in period t will correspond to enrollment in *t-1*. Young policyholders aged up to 18 (Age category 0) are dropped from the analysis since we only consider adults. Age category 1 is the reference age category and left out of regression. Interpretations will thus refer to age category 1 as the reference age group.[36] Estimation results use robust standard errors. Mean variance inflation factors range from 2.87 to 4.11 for all test periods.

We now address the hypotheses derived above. Theoretical predictions concerning one-sided commitment in a market environment such as German PHI insurance suggest the following. (1) Front-loading creates a lock-in of consumers: contracts with higher front-loading suffer lower rates of lapsation due to a more severe lock-in. (2) Low-risk policyholders have a higher incentive to lapse. Since low-risk types have higher lapsation, the risk pool worsens over time.

In regard to the *first hypothesis*, we expect that more front-loaded contracts will experience lower rates of lapsation. Since we do not have information about prepayments (aging provisions) for policyholders, we need a proxy for front-loading. We use age at entry, i.e., the variable *Age at Entry* for this purpose. This is reasonable because for a given risk type, a higher entry age is associated with a higher premium. The premium is higher due to the fact that the insurer needs higher annual prepayments to account for increased health care cost in old age (see Figure 1). As a consequence, a higher entry age is associated with a more severe lock-in. Therefore, we would expect lapsation to be lower for higher entry

[35] Note that this is true for over 99.8 per cent of all Germans since the proportion of uninsured people in Germany is below 0.2 per cent. Therefore, we ignore the decision to drop health insurance coverage.

[36] Since we look at the policyholders' switching behavior, it seems intuitive to consider only adults for the analysis, i.e., policyholders with a minimum age of 18. Therefore, the number of observations differs from Table 1. Children can be dropped in the Test Model without substantially changing our results. We present the results without children here.

Table 4 Enrollment choice estimation results (Test Model).

	(2002) Enrolment02	(2003) Enrolment03	(2004) Enrolment04	(2005) Enrolment05
Female	-1.723***	-1.117***	-1.225***	-0.556
	(-5.74)	(-3.92)	(-4.17)	(-1.69)
Age Category 2	5.480***	3.913***	4.002***	3.288***
	(8.57)	(7.31)	(6.48)	(5.01)
Age Category 3	8.285***	5.796***	5.752***	4.243***
	(9.76)	(8.41)	(7.76)	(5.59)
Age Category 4	10.89***	7.556***	7.490***	5.433***
	(10.61)	(8.98)	(8.10)	(6.20)
Age Category 5	10.56***	8.121***	7.630***	4.454***
	(6.99)	(8.53)	(7.20)	(3.71)
Age at Entry	0.0302*	0.0197	0.0118	0.000814
	(2.01)	(1.73)	(0.90)	(0.07)
Risk Type	10.57***	7.599***	7.094***	4.801***
	(11.84)	(11.34)	(8.99)	(8.08)
_cons	-17.03***	-12.19***	-11.14***	-7.626***
	(-11.00)	(-10.90)	(-8.68)	(-6.97)
N	4411	3792	3320	3022
pseudo R^2	0.834	0.795	0.785	0.742

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

ages in our sample. As can be seen from the test model results above, our data confirm this relationship, i.e., the coefficient of *Age at Entry* is positive and statistically significant in 2002 (at the 5 per cent level) and 2003 (at the 10 per cent level) indicating a higher tendency of a given risk type to retain coverage when he or she enters the contract in older age.

The *second hypothesis* is that low-risk policyholders have a higher incentive to lapse. Our results confirm this hypothesis. The coefficient of *Risk Type* is positive and highly significant in all tested periods. As a result, high-risk policyholders – those with higher predicted medical expenditure or *Risk Type* – are more likely to retain their PHI contract (which implies that low-risk types have a higher tendency to lapse). As a consequence, the risk pool worsens over time.

In the theoretical section of this paper, we assumed perfect information. The insurer can observe individual health status via loss frequency and loss severity. Even if there was no important informational asymmetry between the parties, partial risk pooling and a lack of consumer commitment would distort efficient behavior. The positive and highly significant coefficient of *Risk Type* implies that high risks are more likely to retain their PHI contract than are low-risk types. Such a worsening of the collective over time is indicative of adverse selection.

Finally, it is interesting that the impact of gender in the form of *Female* is negative. There are two possible explanations for this finding. Women might be higher risk since the cost of pregnancy is covered by the contract and included in the premium. This would be reflected in higher premium differences between men and women for age in the range of mid twenties to late thirties. Indeed, in our sample, age categories 2 and 3 exhibit a stronger average premium difference between genders. Women have a significantly lower tendency to stay with the insurer when they are aged 20 to 35. Another probable explanation is that the coefficient represents an income effect. Since women tend to have lower income than men on average, and, as shown by our two-part model estimations, are also a higher risk type, their premiums are higher. Note that in our sample, women do indeed pay higher premiums (see Table 1). Interpreting *Female* as a proxy for income, we would generally expect females to be more likely to cancel their PHI contract because their incomes are more likely to have fallen below the PHI contribution ceiling. This may be why their probability to retain a PHI contract is less than that of males. Second, if a woman drops out of employment to stay at home, she generally will be insured via her husband's insurance contract. This might have an impact on females' tendency to retain, or not, PHI coverage, too.

One of the theoretical predictions we made earlier is that in a dynamic one-sided commitment market where contracts are not contingent on future health state, the equilibrium will be such that the contract with higher first-period premium is chosen by consumers with lower income growth, and that this contract has lower lapsation. Given the structure of the German PHI market, premiums tend to increase with age at contract entry. Given that income growth is generally higher in age categories 1 and 2 compared to age categories 3 and 4, we would expect that age categories 3 and 4 (with lower income growth) will be required to pay higher prices (compared to age categories 1 and 2), and will exhibit a higher tendency to retain the high-priced contract (implying lower lapsation). This is exactly what we observe in the data: the coefficients of age categories are positive and highly significant, and they tend to increase from age category 2 up to age category 4 (see Table 4).

It should be noted that we are not able to directly test the theoretical finding of Hendel and Lizzeri that contracts with higher first-period premiums are chosen by consumers with lower income growth and that these contracts have lower lapsation. The reason is that we do not have a measure of income growth in our data set. However, the average monthly net income of a German male tends to increase with age, and income growth tends to decrease in higher age groups.[37] In our data analysis in Table 4, we do observe that the variables Age Category 2, Age Category 3 and Age Category 4 are all highly significant and positively signed in all models. Further, the coefficients of theses variables increase monotonically in each model. This indicates that the likelihood of lapsing decreases with age. This is consistent with the model of Hendel and Lizzeri to the degree that age proxies income growth.[38]

Finally, we consider an alternative model to test enrollment choice in German PHI. In this alternative model, we only look at the behavior of adults. Naturally, there is a high correlation between contract duration (*Contract Duration*) and age at entry (*Age at Entry*), i.e., a low age at contract entry is associated with a long contract duration in a given period. To avoid a multicollinearity problem when using *Age at Entry* and *Contract Duration* , we divide policyholders into three groups: *Short Duration*, *Middle Duration*, and *Long Duration* are Dummy variables dividing policyholders into those with short contract duration of 0-14 years, those with middle contract duration of 15-30 years, and finally those with long contract duration of over 30 years. *Middle Duration* is the reference category. The new regression results are shown in Table 5. Mean variance inflation factors range from 4.83 to 5.98 for all test periods.

Using *Short Duration* as a proxy for contracts exhibiting high front-loading, the results show that those contract owners, i.e., those with short contract duration below 15 years, have a significantly lower probability to keep their PHI contract than the reference group. Lapsation is higher within this group. We also find that the group with long contract duration and thus relatively low (if not negative) front-loading has a significantly higher probability to stay with their contract. These results confirm our hypotheses.

[37] See Rostocker Zentrum fuer demographischen Wandel (2005), p. 78.

[38] Remember that by German law individuals in Age Category 5 are not permittd to switch policies. The seemingly anomalous result that the size of the Age Category 5 coefficients is less that the size of the Age Category 4 coefficients is likely attributable to the higher rate of death in Age Category 5 relative to the other Age Categories.

Table 5 Alternative enrollment choice estimation results (Test Model).

	(2002) Enrolment02	(2003) Enrolment03	(2004) Enrolment04	(2005) Enrolment05
Female	-2.020***	-1.350***	-1.357***	-0.581
	(-5.77)	(-4.36)	(-4.61)	(-1.78)
Age Category 2	5.048***	3.154***	3.894***	3.054***
	(6.32)	(5.42)	(5.45)	(4.23)
Age Category 3	6.838***	4.287***	5.038***	3.541***
	(6.59)	(5.36)	(5.68)	(4.04)
Age Category 4	7.667***	4.784***	5.813***	4.160***
	(6.06)	(4.44)	(5.28)	(3.91)
Age Category 5	5.369**	4.144**	4.638**	2.475
	(2.86)	(3.03)	(3.23)	(1.66)
Short Duration	-5.097***	-2.970***	-2.743***	-1.492*
	(-5.01)	(-4.06)	(-4.26)	(-2.52)
Long Duration	2.196**	1.594**	1.360	0.732
	(2.89)	(2.64)	(1.67)	(0.99)
Age at Entry	0.266***	0.164***	0.132***	0.0684*
	(5.60)	(4.70)	(4.11)	(2.28)
Risk Type	13.62***	8.816***	8.557***	5.318***
	(10.11)	(10.65)	(8.86)	(7.36)
_cons	-20.81***	-13.53***	-12.72***	-8.095***
	(-9.47)	(-10.37)	(-8.25)	(-6.46)
N	4411	3792	3320	3022
pseudo R^2	0.847	0.804	0.794	0.747

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4 Conclusion

This paper addresses the issue of long-term insurance contracts in a world where risk types evolve over time, an especially important feature of the health and life insurance industries. The first-best insurance policy in this world would fully insure against both short-term sickness risk and long-term reclassification risk. Theoretical models of guaranteed renewable insurance display front-loaded premium schedules. The paper contributes to the literature on one-sided commitment by studying properties of long-term private health insurance contracts in Germany. Private health insurance in Germany is regulated in such a way that insurers must offer long-term contracts at a guaranteed renewable rate involving front-loading of premiums and insurance of premium risk. The insurer accumulates aging provisions to smooth premiums over time. If policyholders want to switch insurers, they cannot take any fraction of this accumulated capital stock with them. As a result, this form of regulation creates a lock-in effect implying that switching is unattractive for policyholders who would bear a financial loss even at early contract stages.

As predicted by the theory on symmetric learning and dynamic contracting (Hendel and Lizzeri (2003)), our private health insurance data confirm that front-loading generates a lock-in of consumers, and more front-loading is generally associated with lower lapsation. Our results shed light on the nature of possible dynamic inefficiencies in markets under one-sided commitment. We provide evidence suggesting that low-risk policyholders are more likely to drop their coverage, and that dropping coverage seems at least partly a response to learning over time (i.e., low-risk policyholders discover positive information about their health status over time). Our analysis also supports evidence found by Finkelstein, McGarry and Sufi (2005) who studied long-term care insurance in the United States, a market that also involves learning (about mortality risk) over time. While symmetric learning has no effect on informational asymmetries between policyholders and insurers, some information may be private to policyholders who then may be able to more accurately estimate the severity and future consequences of their impaired health. Hence, in a world where reclassification risk is insured, given a specific mechanism, risk selection may be an issue.[39] Indeed, insuring reclassification risk may introduce a new problem: the stability of the pool must be ensured by new (better risk type) policyholders constantly entering the collective. This is due to the lack of bilateral commitment. Therefore, given imperfect commitment it seems necessary to collect enough funds upfront so as to enhance consumer commitment and minimize selection problems in the long run.

The current study has several limitations that may be overcome by future analysis. First, the proxy *Risk Type* may not properly identify a policyholder's actual risk type in a relevant way. The relevant health conditions for a policyholder's renewal include those discovered after enrollment, but these are not included in the expense model. Of course, we do not have this information, but it seems critical for lapsing behavior. Second, our empirical model cannot include a measure of income, which is important as a general control and for the interaction with public health insurers. However, the insurer does not collect this sensible information from its policyholders, and the only information we have is that all policyholders in our empirical test model tend to dispose of annual income above the PHI income threshold in Germany. We we also not able to test the prediction that lapse rates should be very low at older ages in gher German system because higher (than optimal) front-loading produces lower premiums in older age. This would require a comparison with a premium schedule closer to the optimal one in the sense of Herring and Pauly (2006). Another limitation of our study is that the data from this one private health insurer may not be representative of other German PHI insurers. Finally, neglecting German legislation, one might conceive of a model of a competitive insurance market in which the insurers offer premiums with positive slope over time so that the lock-in would be more "elastic". But such a framework would not apply to Germany.

While the solutions to the premium risk problem proposed by Cochrane (1995) as well as Pauly et al. (1995) produce an incentive-compatible premium schedule preferable to facing single-period risk-rated insurance in theory, there is considerable disagreement on whether this feature may work well in practice. In a multi-period setting, front-loading of premiums would be rather large, and so young consumers who are credit constrained may not be able to afford such insurance.[40] Although our focus is on the German private health insurance market, dynamic inefficiencies generated by a lack of consumer commitment have ramifications beyond the German PHI market. For example, the non-availability of renewable insurance is considered a common market failure in many health and life insurance markets. The results of this study may thus be of relevance to insurance policy-makers in other countries where private health insurance covers a large part of the population or in countries in which no private health insurance yet exists but such a system is being contemplated. A challenge will be to construct a system that can address these dynamic inefficiencies.

[39] Life insurance contracts are comparatively simple and explicit; health insurance is more sophisticated, and thus asymmetric information seems a more important issue. In contrast to Hendel and Lizzeri (2003), we look at these more sophisticated contracts evolving over time. In this context, asymmetric information seems an important problem since distortions due to dynamic information revelation on health status can be large. Compared to Hendel and Lizzeri, who found that asymmetric information is not important in the case of life insurance, our results suggest that dynamic information revelation in health insurance may involve significant risk selection. This may be particularly the case when premiums include partial risk pooling as in the case of Germany.

[40] See Frick (1998).

Appendix

Consider a competitive two-period health insurance market with a high number of buyers and sellers. Buyers wish to insure potentially worse health states in the future. A health status can be described as a certain probability of suffering medical loss and a certain severity of the loss in the event the individual experiences medical loss. In the first period, individuals are identical with regard to loss probability and severity, i.e., they face identical medical expenses m in case of illness, and they have identical probability p of suffering an illness.[41] In period 2, multiple health statuses are possible so that policyholders differ in both their probability p_i of experiencing some medical loss and the severity or size of the loss. If an individual is in health status i in period 2, he or she faces potential medical loss m_2^i, which may represent physician visits, time and money invested in obtaining treatment, etc. We order health states so that $p_1 < p_2 < ... < p_N$ and $m_2^1 < m_2^2 < .... < m_2^N$ and assume $p \leq p_1$ and $m \leq m_2^1$, i.e., health worsens over time in both frequency and severity. The probability of being in health state i is given by π_i. Individuals' utility function is $u(c)$ when they consume $c \geq 0$ in each period. Individuals are risk-averse: the utility function is strictly concave and twice continuously differentiable.

Period 1 involves three stages: first, insurers offer contracts, second, buyers choose a contract, third, uncertainty about medical loss is revealed and consumption takes place. Period 2 involves four stages: first, uncertainty about a policyholder's health status is revealed. The realized health status of a policyholder can be observed by the insurer. The following stages are equivalent to stages 1 to 3 in the first period.

A first-period premium consists of a first-period premium P_1 and coverage amount C_1, and a vector of premiums and coverage amounts $(P_2^1, C_2^1)...(P_2^N, C_2^N)$ indexed by the second-period health states. Thus a first-period contract is a long-term contract to which the insurer unilaterally commits. In contrast, the second-period contract is a short-term contract. Note that a short-term contract may depend on information revealed at the beginning of the second period. It consists of a premium and coverage amount (P_2^i, C_2^i) indexed by second-period health status. There is one-sided commitment: insurers can commit to future premiums while consumers freely choose between staying with their period 1 contract and switching to a competitor offering a short-term spot contract in period 2.

Consumer heterogeneity is given by differences in the income process. We assume that consumers differ in income growth. While some minimum income $\tilde{y}$ is needed in order to enter into a PHI contract, consumers with minimum income $\tilde{y}$ may differ in income growth. To capture this, we assume that a consumer receives an income of $y - g \geq \tilde{y}$ in the first period and $y + g$ in the second period, and the variation in consumers' income growth is represented by $g > 0$. In our model, $\tilde{y}$ represents the minimum income needed in order to enter the PHI market.[42]

In competitive equilibrium, allocations maximize individuals' expected utility subject to a zero expected profit constraint and a set of no-lapsation constraints that capture individuals' inability to commit to the PHI contract. Solving this constrained maximization problem gives the set of prices and coverage amounts that must be available to individuals in a competitive PHI market.[43]

In equilibrium, premiums and coverage amounts that are fully contingent on health states, (P_1, C_1), and $(P_2^1, C_2^1)...(P_2^N, C_2^N)$ must maximize individuals' expected utility:

$$EU = (1-p)u(y-g-P_1) + pu(y-g-P_1-m+C_1) \tag{8}$$

[41]Note that the model easily extends to different risk categories captured by different values of p.

[42]For simplicity, we assume there are no capital markets and that the borrowing rate is higher than the lending rate. Therefore, consumers with higher g are more tightly constrained since their income in period 1 is lower.

[43]As a reference point, we assume that the constrained maximization problem is constructed via fully contingent contracts, i.e., the contracts are fully contingent on future health states. As a result, there is no lapsation. However, the argument can be extended to non-contingent contracts.

$$+\sum_{i=1}^{N}\pi_i\left[(1-p_i)u(y+g-P_2^i)+p_iu(y+g-P_2^i-m_2^i+C_2^i)\right]$$

subject to a zero profit constraint (i.e., contracts break even on average)

$$P_1-pC_1+\sum_{i=1}^{N}\pi_i\left[P_2^i-p_iC_2^i\right]=0 \tag{9}$$

and no-lapsation constraints imposed by lack of consumer commitment: for all possible future health states, $i=1,...N$, and for all $\tilde{P}_2^i,\tilde{C}_2^i$ such that $\tilde{P}_2^i-p_i\tilde{C}_2^i>0$, we must have $EU(P_2^i,C_2^i)\geq EU(\tilde{P}_2^i,\tilde{C}_2^i)$ or equivalently

$$\begin{aligned}(1-p_i)u(y+g-P_2^i)+p_iu(y+g-P_2^i-m_2^i+C_2^i) \\ \geq(1-p_i)u(y+g-\tilde{P}_2^i)+p_iu(y+g-\tilde{P}_2^i-\tilde{m}_2^i+\tilde{C}_2^i).\end{aligned} \tag{10}$$

The no-lapsation constraints imply that an equilibrium contract is such that there is no other contract that is profitable and offers potential buyers higher expected utility in any state of period 2. We refer to the actuarially fair premium that guarantees full insurance in health state i and guarantees zero expected profits as $P_2^i(FI)$.

Proposition 1. *In the equilibrium set of contracts:*
(i) All consumers obtain full insurance in period 1 and for all health states of period 2.
(ii) For health states s and worse, premiums are capped at a price that is below the fair price for each of these states, i.e. for every g there is an s such that $P_2^i=P_2^i(FI)$ for $i=1,...,s-1$ and $P_2^i<P_2^i(FI)$ for $i=s+1,...,N$.
(iii) Insurance contracts are front-loaded as long as g is not 'too high'. That is, there is a $\hat{g}$ such that, if $g<\hat{g}$, then PHI contracts involve front-loading.
(iv) More front-loaded contracts appeal to buyers with higher first-period income (i.e. consumers with lower g who find front-loading less costly). Contracts with higher P_1 involve a lower cutoff s. Policyholders with higher income growth g choose PHI contracts with less front-loading.
(v) Consumers are eligible for PHI as long as g is not "too high". That is, there is a $\tilde{g}$ so that $y-\tilde{g}<\tilde{y}$ and the consumer drops out of the PHI market.

Proof of Proposition 1:

We can replace the set of constraints (10) with the following simpler set

$$P_2^i-p_iC_2^i\leq 0\ \forall\ i \tag{11}$$

This is because if P_1, C_1, $(P_2^1,C_2^1)...(P_2^N,C_2^N)$ maximize (8) subject to (9) and (11) then there is no state i and no $(\tilde{P}_2^i,\tilde{C}_2^i)$ that results in positive expected profits and offers consumers a higher expected utility in state i. Hence, (10) is satisfied. Conversely, if (P_2^i,C_2^i) are such that (11) is violated, then (10) is violated as well since a competing company may offer terms slightly better for consumers than (P_2^i,C_2^i) while still making positive expected profits.

Let μ be the Lagrange multiplier for the constraint in (9) and λ_i be the multiplier for the ith constraint in (11). Then the Lagrangian is

$$\mathcal{L}=(1-p)u(y-g-P_1)+pu(y-g-P_1-m+C_1)$$

$$+\sum_{i=1}^{N}\pi_i\left[(1-p_i)u(y+g-P_2^i)+p_iu(y+g-P_2^i-m_2+C_2^i)\right]$$

$$+\mu \cdot \left[P_1 - pC_1 + \sum_{i=1}^{N} \pi_i (P_2^i - p_i C_2^i) \right]$$
$$+\lambda_i \cdot \left[P_2^i - p_i C_2^i \right]$$

and the first-order conditions for an optimum are given by

$$\mu = (1-p)u'(y - g - P_1) + pu'(y - g - P_1 - m + C_1) \tag{12}$$

$$\mu = u'(y - g - P_1 - m + C_1) \tag{13}$$

$$\pi_i \left[-p_i u'(y + g - P_2^i - m_2 + C_2^i) - (1-p_i)u'(y + g - P_2^i) \right] + \pi_i \mu + \lambda_i = 0 \; \forall \; i \tag{14}$$

$$\pi_i u'(y + g - P_2^i - m_2 + C_2^i) - \pi_i \mu - \lambda_i = 0 \tag{15}$$

$$(P_2^i - p_i C_2^i)\lambda_i = 0 \; \forall \; i; \; \lambda_i \leq 0. \tag{16}$$

Combining first-order conditions (12) and (13) gives $C_1 = m$ which implies full insurance in period 1. Combining conditions (14) and (15) results in $m_2^i = C_2^i \; \forall \; i$ which implies full insurance in all states of period 2. This proves part (i) of proposition 1.

To prove part (ii), note that if constraint i in (11) is binding, then $P_2^i = p_i C_2^i$ which implies actuarially fair insurance. It follows that if i and j are two binding constraints and $i > j$ (and thus $p_i > p_j$ and $m_2^i > m_2^j$) then it must be that $P_2^i > P_2^j$. In contrast, if k in (11) is non-binding, then $P_2^k < p_k C_2^k$ and thus $\lambda_k = 0$. Then equation (14) reduces to

$$u'(y + g - P_2^k) = \mu \tag{17}$$

As a result, if constraints k and l are non-binding, then $P_2^k = P_2^l$. If in contrast constraint i in equation (11) is binding, then (14) becomes

$$u'(y + g - P_2^i) = \mu + \frac{\lambda_i}{\pi_i} < \mu \tag{18}$$

where the inequality on the RHS holds because $\lambda_i < 0$ if constraint i in equation (11) is binding. As a consequence, if constraint i is binding and k is not, it follows that $P_2^i < P_2^k$. Finally, we show that if i is binding and k is not, then $i < k$. To see this, note that since k is non-binding, we have $P_2^k < p_k C_2^k$, which, together with $P_2^i < P_2^k$, leads to

$$p_i C_2^i < p_k C_2^k. \tag{19}$$

Assume $i > k$. Then $C_2^i > C_2^k$ (due to $m_2^i > m_2^k$) and $p_i > p_k$. This would render $P_2^i < P_2^k$ impossible and so we must have $i < k$. This proves part (ii).

To show that part (iii) holds, we need to show that the first-period premium P_1 is larger than the actuarially fair premium $P_1(FI)$. If any of the no-lapsation constraints (11) is nonbinding, then $P_1 > P_1(FI)$ is immediate from the zero expected profit condition (9) above. Assume instead that all no-lapsation constraints in (11) are binding. Keeping in mind full insurance in optimum and then substituting equation (12) into (14), we obtain

$$u'(y + g - P_2^i) = u'(y - g - P_1) + \frac{\lambda_i}{\pi_i} \tag{20}$$

which, since $\lambda_i < 0$ if all no-lapsation constraints are binding, gives $P_1 > P_2^N(FI) - 2g = p_N \cdot m_2^N - 2g$. This inequality requires that $P_1 > P_1(FI)$ if g is small enough since $p_N > p$ and $m_2^N > m$.

To prove part (iv), note that as g increases, more and more of the no-lapsation constraints become binding and thus as g grows so does the cutoff s. When s becomes larger, P_1

decreases.

Finally, part (v) is obvious from our assumptions.

Following Hendel and Lizzeri (2003), proposition 1 can be extended to non-contingent contracts.[44] A non-contingent contract is also an equilibrium contract if a consumer for whom the contingent contract is optimal can obtain the same utility from the noncontingent contract (in each state), and insurance companies earn the same profits. In states $i = 1, ..., s-1$, premiums and coverage amounts of the contingent contract equal those offered on the spot market. Fixing the terms of the non-contingent contract to be the same as those of the contingent contract in the first period and in the bad states of the second period (i.e. states $s, ..., N$), both contracts are equivalent except for states $1, ..., s-1$, in which the contingent contract offers better terms. Note, however, that a consumer can drop out of the alternative non-contingent contract and purchase spot contracts. As a result, the alternative contracts are equivalent.[45] Taking into account equivalence of contingent and non-contingent contracts, we state:

Proposition 2. *Consider two PHI contracts that are offered in period 1 and not contingent on the health state in period 2. In competitive equilibrium, the contract with the higher first-period premium is chosen by those consumers with lower income growth (i.e., higher first-period income $y - g$), and has lower lapsation.*

Proof of Proposition 2:

The proof follows Hendel and Lizzeri (2003). The contract with the higher first-period premium must involve a lower second-period premium, otherwise no consumer would choose it. Thus, in the second period this contract retains a healthier pool of consumers (since a higher P_1 involves a lower cutoff s). This implies that the average cost of this contract is lower. Under competition (and due to the equivalence principle used in German PHI premium calculations), the present value of the premiums must be lower. Proposition 1 implies that the contract with the higher first-period premium is chosen by consumers with lower income growth.

[44]See Hendel and Lizzeri (2003), p. 311-312.

[45]The alternative contracts are associated with equal zero expected profits of insurers since in states $1, ..., s-1$, premiums are actuarially fair and thus insurers are indifferent between retaining and not retaining consumers.

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