ICIR Working Paper Series No. 04/11

Edited by Helmut Gründl and Manfred Wandt

Life Care Annuities - Trick or Treat for Insurance Companies?*

Tian Zhou-Richter[1] and Helmut Gründl[2]

[1] *Munich Reinsurance Company*
[2] *Goethe-Universität, Frankfurt am Main*

June 6, 2011

Abstract

A life care annuity is a bundled insurance product comprised of a life annuity and long-term care insurance. Some recent studies find the two risks-longevity risk and long-term care risk-to be opposing and thus life care annuities advantageous in regard to pooling the two risks. Based on empirical data, this study discovers-in contrast to previous work-a positive correlation between the two risks and the presence of adverse selection in the life care annuity market. We also address the pricing risk and solvency risk insurance companies face when providing life care annuities.

Keywords: Long-term care insurance, Annuities, Adverse Selection, Risk Management

*We are grateful to Olivia S. Mitchell, J.-François Outreville, Frederik Weber, Anja Zimmer, and the participants of the 2010 German Insurance Science Association Annual Meeting and the 2010 World Risk and Insurance Economics Congress for their comments and suggestions.

1 Introduction

Several empirical studies observe that both the private annuity market and the long-term care (LTC) insurance market are plagued by adverse selection and its accompanying market inefficiencies—annuitants live longer than the general population and thus increase the insurance price; LTC insurance providers employ strict underwriting strategies that exclude a major portion of the population from purchasing insurance (Friedman and Warshawsky, 1990; Mitchell et al., 1999; Murtaugh et al., 2001). Consequently, both academics and practitioners are interested in finding ways to mitigate these adverse selection problems. One prominent proposal is to bundle annuities and LTC insurance into a single product. According to Murtaugh et al. (2001), the selection effects in the two insurance markets work in opposite directions and thus the bundled product, called a "life care annuity" (LCA), should reduce the cost of both types of coverage through pooling the two opposing risks—longevity and LTC risk. Specifically, this natural hedge could ease adverse selection in the annuity market, lessen the need for strict underwriting of LTC coverage, enlarge the pool of insureds, lower the insurance premium for both types of coverage, and result in individuals being better off compared to the situation under current underwriting practice. The conclusion that the bundled product provides a natural hedge between longevity and LTC risk is adopted in several recent contributions to the field, the authors seeing it as either as a key advantage of LCA products (Warshawsky, 2007; Brazell et al., 2008) or as an essential assumption for theoretical models (Webb, 2009).

However, the question of whether LTC risk is negatively correlated with longevity risk in general still needs to be examined in detail. On the one hand, impaired people with high LTC risk live shorter lives; on the other hand, those who are currently healthy have a long life expectancy and, eventually, also a high probability of becoming care-needing. In addition, the

LCA market, like the annuity market, could suffer from adverse selection. Our paper fills these gaps by empirically examining the correlation of longevity risk with LTC risk and the presence of adverse selection in the LCA market. We especially focus on the question of what kind of risks and opportunities insurance companies face when providing LCAs.

Our paper is based on data derived from the Asset and Health Dynamics (AHEAD) cohort of the Health and Retirement Study (HRS), an individual-level survey conducted in the United States. The AHEAD cohort is representative of the U.S. population born in 1923 or earlier. We define AHEAD respondents who died between 1995 and 2008 as our sample group. The detailed information in the HRS study enables us to observe the decedents' demographic characteristics, insurance ownership, nursing home entry, lifespan, and health history.

Our results show, in contrast to previous literature, that longevity risk is positively correlated with LTC risk for the total sample population, conditional on age and gender. Moreover, we find that respondents who owned both annuities and LTC insurance policies had the highest risk in both risk dimensions, i.e., they lived longer *and* were more likely to enter a nursing home than either the general population, the "solo" annuitants, or the "solo" LTC insurance purchasers. We thus conclude that under current LTC insurance underwriting practice, people who are willing to buy and who are approved for LCAs will cause a much higher cost than does the general population. This is the first risk of providing LCA, which we call the "pricing" risk. The consequence for LCA providers is that when calculating prices for such products, they cannot simply rely on their past experience with stand-alone products but must also take into account that the bundled product will be subject to much more severe adverse selection.

Providing LCA could also change the solvency situation of insurance companies because the loss distributions of LCA will have a different variability compared to loss distributions of traditional annuity or LTC insurance products. We call this risk the "solvency" risk. To measure the solvency risk that accompanies LCA products, we build a multi-year solvency model for three insurance companies and compare their solvency situations when two of them offer stand-alone products and one offers LCA contracts. We parameterize our model with data drawn from HRS and find that providing LCA improves the solvency level of "solo" LTC insurance providers, but worsens that of "solo" annuity providers.

To the best of our knowledge, this is the first empirical work to analyze the risks and opportunities of providing LCAs at the enterprise level. Since the LCA is a very new product, arriving on the market only about a decade ago, there are no data available to assess its commercial success. This study solves this problem by combining annuity and LTC insurance ownership to proxy LCA ownership. Taking advantage of the good quality of the HRS panel data, this study provides the first, and a very valuable, insight into the risks and opportunities of the new product line.

The remainder of the paper is organized as follows. Section 2 discusses prior research on life care annuities. Section 3 provides a market overview of existing bundled products of this kind. In Section 4, we describe the data employed in this paper and analyze insurers' pricing risk of providing LCA. In Section 5, we examine the impact of LCAs on insurer solvency in an internal risk model framework. Section 6 concludes and discusses our results.

2 Literature Review

The first empirical investigation into the advantages of bundling a life annuity with LTC insurance is that of Murtaugh et al. (2001). The bundled product in their study takes the form of a fixed immediate life annuity with increased payments in case of disability. The authors draw on data from the U.S. National Mortality Followback Survey, which contains the histories of people who died in 1986 in the United States. However, the survey data do not record the deceaseds’ ownership of either an annuity or LTC insurance. Therefore, the authors define the hypothetical pool of insurance purchasers according to the deceaseds’ health history. Specifically, they define the purchasers of both traditional stand-alone LTC insurance and annuities as those people who would be eligible to purchase LTC insurance at a certain age under the current underwriting practice and who had above-average longevity. Accordingly, 77% of the population aged 65 meet the criteria for being prospective purchasers of both stand-alone LTC insurance and annuities. In addition, the authors assume that purchasers of the bundled product encompass the total population, excluding only those persons with a present disability at a certain age. This setting is named “minimal underwriting” situation. Thus, in their study, 98% of the population aged 65 are viewed as prospective purchasers of the bundled product.

By comparing these two hypothetical pools of insurance purchasers, the authors conclude that the bundled product could potentially enlarge the market by relaxing underwriting standards and increasing the number of people eligible to purchase LTC insurance coverage. More importantly, the authors find that the average insurance premium for combined annuity and disability benefits is lower for the bundled-product purchaser pool than for the stand-alone insurance purchaser pool. They conclude that the bundled product reduces the premiums for combined annuity and disability coverage because it utilizes the negative correlation between longevity and disability risk.

We believe it is a little hasty to conclude that there is a negative correlation between longevity and disability risk in general solely because the average premium for the two types of coverage is lower for the bundled-product purchaser pool than for the stand-alone insurance purchaser pool. We think the average premium is reduced because frail individuals, who are excluded from the stand-alone insurance purchaser pool, are now included in the bundled-product purchaser pool. As the authors show in their study, on the one hand, frail individuals would receive higher LTC benefits but, on the other hand, much lower annuity benefits than healthy individuals. Therefore, including these frail individuals in the purchaser pool lowers the total benefits. These calculations thus show for one segment of the population—the frail—that high disability risk is associated with low longevity risk. For another segment—individuals who live longer than average and have a higher probability of needing care (because the LTC probability increases with advanced age)—the correlation between the two risks would be positive. Therefore, the question of how the two risks are correlated for the total population still needs to be answered.

In addition, Murtaugh et al. (2001) obtain their major results based on the premise that there is no adverse selection. At the end of their paper, the authors do entertain the possibility of adverse selection and analyze whether the bundled product would actually attract the extended purchaser pool, which is what drives premium reduction. After finding that the premium for the bundled product is higher than the value of the benefits for most people in the extended purchaser pool, indicating that most people in the extended purchaser pool would prefer not to purchase the bundled product, the authors refer to the indirect value of insurance protection as a motive for insurance purchase and preserve their earlier assumption that there is no adverse selection in the market for the bundled product. We think, however, that it is reasonable to expect that individuals who are aware of their high longevity and disability risk prospects are more likely to purchase the bundled product under the relaxed underwriting. This expectation is supported by studies of current annuity markets, in which it is shown that in the absence of requiring a medical examination, insureds have higher risks than the general population (Friedman and Warshawsky, 1990; Mitchell et al., 1999).

The assumption of a negative correlation between the insureds' longevity risk and LTC risk is the foundation of Webb's (2009) theoretical work. Based on empirical evidence from Finkelstein and Poterba (2004) that more risk-averse individuals live longer and demand more annuities, and based on evidence from Finkelstein and McGarry (2006) that more cautious individuals have a lower probability of entering a nursing home and have more LTC insurance, Webb sets up a competitive insurance market model and differentiates individuals by their risk aversion. He assumes that individuals with higher risk aversion have a higher probability of survival but a lower probability of needing LTC. Based on this and also assuming the presence of administration costs, Webb shows that equilibrium could exist in a market for bundled contracts and the allocations with bundled products Pareto dominate the outcomes with stand-alone annuities and LTC insurance contracts. Webb (2009) is the first theoretical work examining the market equilibrium for LCA products under asymmetric information. Although the findings are interesting and novel, we advise caution in generally assuming a negative relationship between longevity and LTC risk as our empirical study reveals an opposite result.[1]

As a proposal for improving the public-private partnership in the United States in terms of financing LTC, Warshawsky (2007) extends the work of Murtaugh et al. (2001) and suggests that an innovative bundling a single-premium immediate life annuity with LTC insurance will offer new ways of financing LTC. Warshawsky calls this bundled product a “life care annuity” —thus originating the term used in this paper.

Starting in 2010 in the United States, the bundled product has been granted a tax advantage. In light of this, Brazell et al. (2008) describe the tax treatment of the LCA before and after 2010 either as an after-tax product or as a qualified retirement plan.

[1] The negative correlation between longevity and LTC risk in Webb (2009) is grounded on the role of individuals’ risk aversion in the relationship between risk and insurance in the annuity and LTC insurance market, as identified in previous studies. Nevertheless, there still could be other types of private information that are also related to risk occurrence and insurance coverage, such as the individuals’ prediction of their own risk, as found in Finkelstein and McGarry (2006), and this could change the general correlation between longevity and LTC risk for the insureds.

3 Market Overview of Life Care Annuities

According to Webb (2009), products combining annuity and LTC insurance currently account for about 10% of the voluntary annuity markets in the United States and the United Kingdom. In Germany, this kind of bundled product has been available for about a decade, with a couple of new providers entering the market in 2009.[2] The commercial success of these products is yet unknown.

In the United States, the Pension Protection Act (PPA) of 2006 gave a boost to products combining annuity and LTC insurance in that, effective 1 January 2010, qualified LTC benefits under an annuity contract are tax free. Moreover, LTC insurance premiums paid from the annuity account value are not included in the policyholder's gross income for tax purposes.

In the United States, a LCA is sometimes termed a "living care annuity," a "total living coverage annuity," an "annuity care," etc. The major providers in the U.S. market are United Omaha, Genworth, OneAmerica, and Guaranty Income Life.[3]

In a typical U.S. LCA product, the policyholder pays a single premium for a deferred annuity with a LTC rider. Usually, the annuity value grows from the single premium amount by a minimum interest rate guaranteed by the insurance company. Premiums for LTC coverage are withdrawn from the annuity interest earnings each month. When a LTC claim occurs, daily or monthly LTC benefits are paid to cover the policyholder's qualified LTC expenses, which are specified in the insurance contract. The maximum daily (or monthly) LTC benefits are equal to the accumulated annuity value divided by the number of days (or months) of a certain time

[2] Generali introduced one kind of LCA product in 1998. Bavarian Chamber for Insurance (Versicherungskammer Bayern) and Oeco Capital began providing LCA products in 2009.
[3] This list of providers was derived from information available on the Internet and does not claim to be complete.

period, e.g., two years. The maximum lifetime LTC benefits can be equal to two times or three times the accumulated annuity value.

If LTC is not needed within 8 – 10 policy years, the policyholder is usually allowed to annuitize the accumulated annuity amount or withdraw that amount as cash without paying any surrender penalty. If the policyholder opts for annuitization or has withdrawn the total accumulated annuity amount, the LTC benefits terminate. Therefore, the LCA products available in the U.S. market do not cover the lifetime LTC and longevity risk simultaneously as suggested in the theoretical works.

LCAs in other countries, such as Germany, have a slightly different design than the typical U.S. LCA described above. In Germany, policyholders can purchase a deferred annuity with a LTC rider against periodic premiums. If the policyholder is in need of care at the time the annuity payments begin, he or she is entitled to receive a higher annuity—up to three times the normal annuity as contracted. In these contracts, the policyholder has a one-time-only opportunity (at the time annuity payments start, which can be between ages 60 and 85, as specifically designated in the contract) to apply for this enhanced annuity. However, if policyholders become dependent after this point in time, the policy will pay only the contracted-for annuity. In Germany, products of this kind are provided by Provinzial and Oeco Capital, among others.

Another type of contract found in Germany is based on a deferred annuity and provides policyholders the option to purchase LTC insurance during a brief period of time shortly before annuity payments start. The advantage of this option for policyholders is that there is no underwriting process involved so even dependent policyholders can receive LTC coverage. The disadvantage of the option is that policyholders will not know in advance of exercising the option how much the insurance premiums for LTC coverage will be because the premiums are usually set according to the insurer's loss experience in the past up to the present date. In Germany, this sort of contract is available from the Bavarian Chamber for Insurance (Versicherungskammer Bayern) and Generali, among others.

Almost all the existing LCA products pay cash benefits for a LTC claim instead of indemnity benefits. Cash benefits give policyholders more flexibility when choosing LTC services and also help insurers avoid risks arising from LTC costs. As far as we know, there is still no "plain vanilla" LCA product, as originally proposed by Murtaugh et al. (2001), that provides both longevity and LTC coverage throughout the policyholder's post-retirement life.

4 Pricing Risk of Life Care Annuities

4.1 Survey and Data Description

Since a LCA is a very new product, there are no insurance data available for our analyses. We thus use the AHEAD cohort data from the HRS survey in the United States. We assume that people who purchased both an annuity and LTC insurance would also purchase a LCA. Therefore, we combine the respondents' annuity and LTC ownership, which are observable in HRS data, to proxy their LCA ownership.

Our respondents were born before 1924, meaning that they were at least 72 years old in 1995. The year 1995 is defined as the year of insurance purchase because the 1995 HRS survey is the first wave of the HRS that provides a reliable measure for ownership of LTC insurance. We exclude about 6% of the original respondents who were living in a nursing home in 1995 because LTC insurance cannot be purchased by care-needing people under current underwriting practice.

The question asked in the 1995 HRS questionnaire about LTC insurance ownership is: "Aside from the government programs, do you now have any insurance which specifically pays any part of LTC, such as, personal or medical care in the home or in a nursing home?" In our sample, 8.5% of respondents had this kind of LTC insurance coverage in 1995.

We can also observe annuity ownership from the 1995 survey. In the United States, retirees usually receive annuities from one or more of four sources: Social Security, occupational pensions, private pensions, and private annuities (Mitchell et al., 1999; Bodlak, 2008). Since we are interested in adverse selection in the annuity market, these four types need to be sorted on the basis of whether they are the result of an individual's voluntary decision or have been acquired in another manner. Social Security definitely falls into the latter category as it is a mandatory social insurance program financed by employment taxes that are paid in equal part by employer and employee. An occupational pension can be one of two types—a defined benefit (DB) or a defined contribution (DC) plan. DB plans pay a monthly benefit on retirement; only a few DC plans offer an annuity as a distribution option (Investment Company Institute, 2000; Bodlak, 2008). Whether employees receive an annuity from their occupational pension is thus usually not a personal decision, but depends on the type of pension plan the employer offers. We thus cannot consider annuity payments from occupational pensions as voluntary annuities. Individuals who are self-employed or work for a company that does not participate in any occupational pension program can provide for their old age by contributing to private pensions—individual retirement accounts (IRAs). In addition, employees can roll over amounts from their occupational pension plans to their IRAs when they change jobs. IRAs allow account owners to use the account balance to purchase annuity contracts (Internal Revenue Service, 2010). Therefore, we define those individuals who converted their IRAs into annuities before 1995—the hypothetical insurance purchase year in this study—as the group of voluntary annuitants. The last type of annuity—private annuities—are purchased by individuals from insurance companies and are entirely voluntary. We thus also put those respondents who purchased private annuities and were receiving private annuities in 1995 into the group of voluntary annuitants. According to this coding, 5.1% of our sample respondents had voluntary annuities in 1995.

Information as to the respondents' need for LTC and their month of death is taken from HRS Exit Data in 1998, 2000, 2002, 2004, 2006, and 2008. The HRS Exit Data include people who died between two subsequent survey waves and were obtained by interviewing proxy respondents, e.g., family members of the deceaseds.[4] We can observe from the Exit Data the deceaseds' lifespan, their nursing home entry, and the length of their nursing home stay over a 13-year period—from 1996 to 2008. The Appendix provides more detail on the construction of some of the variables.

Our final sample contains 3,924 respondents, more than half of whom (2,066 respondents) lived in a nursing home before death. For 1,870 of the people who stayed in a nursing home, we can also observe how long they stayed in a nursing home. However, there are 196 respondents who we know stayed in a nursing home, but do not know how long they were there. Therefore, the analyses in Section 5.2 that utilize the respondents' length of nursing home stay to quantify insurer LTC payments exclude these 196 respondents. This exclusion causes bias in that disabled respondents are underrepresented in the proxied sample of insureds, an issue that will be discussed later in the paper.

We use individuals' nursing home stay to proxy their need for care because nursing home stays are the original and also the most expensive LTC service covered by LTC insurance. The nursing home stay, therefore, constitutes the major component of insurer liability. Even though individuals' general need for care can be measured in other ways, for example, by

[4] The Exit Data in 1996 are not used because the 1996 HRS Exit Data include respondents who were interviewed in 1992 and/or 1994 and died between 1992 and 1996. Since the 1992 and 1994 HRS questionnaires do not provide reliable measures for respondents' ownership of LTC insurance, we cannot include these respondents in our sample.

their inability to perform activities of daily living (ADLs) or by cognitive impairment, the HRS data provide this type of information for less than two-thirds of our sample population, which would considerably reduce the precision in estimating the models.

4.2 Correlation Between Longevity Risk and Long-Term Care Risk

An individual's longevity risk could be measured by comparing the individual's further lifespan after a certain point in time with the average further lifespan of a person of the same age and gender in the general population. However, since our sample consists of people who died within a specified time period (13 years), their average further lifespans are lower than those of the overall population. The difference is especially large for the younger cohorts in our sample. To take account of this systematic bias in life expectancies, we use our sample data to proxy the population. Therefore, we define an individual's longevity risk as the difference between his or her lifespan after 1995 and the age-gender-comparable average lifespan after 1995 observed in our sample. Formally, the individual longevity risk is defined as:

$$LR_i^{m/f,x} = L_i^{m/f,x} - \overline{L^{m/f,x}},$$

where $LR_i^{m/f,x}$ indicates the longevity risk of individual *i* who is male/female and *x* years old in 1995, $L_i^{m/f,x}$ represents the individual *i*'s further lifespan after 1995, and $\overline{L^{m/f,x}}$ represents the average further lifespan after 1995 of all respondents in the sample with the same gender (male/female) and of the same age *x*. For example, the males in our sample aged 80 in 1995 had an average further lifespan of 5.8 years. Therefore, a male aged 80 in 1995 who lived for 7 more years has a realized longevity risk of 1.2 years.

Similarly, we define an individual's LTC risk as the difference between the individual's likelihood of entering a nursing home and the likelihood of his or her age-gender-comparable group doing so. Formally:

$$CR_i^{m/f,x} = NH_i^{m/f,x} - \overline{NH^{m/f,x}},$$

with $CR_i^{m/f,x}$ denoting the LTC risk of the individual *i* who is male/female and aged *x* in 1995, $NH_i^{m/f,x}$ the individual *i*'s likelihood of entering a nursing home after 1995, and $\overline{NH^{m/f,x}}$ the average likelihood of entering a nursing home for respondents who have the same gender and the same age in 1995 as the individual. Individual *i*'s likelihood of entering a nursing home after 1995 $NH_i^{m/f,x}$ is a binary variable and defined as:

$$NH_i^{m/f,x} = \begin{cases} 1, & \text{if the individual entered a nursing home after 1995,} \\ 0, & \text{otherwise.} \end{cases}$$

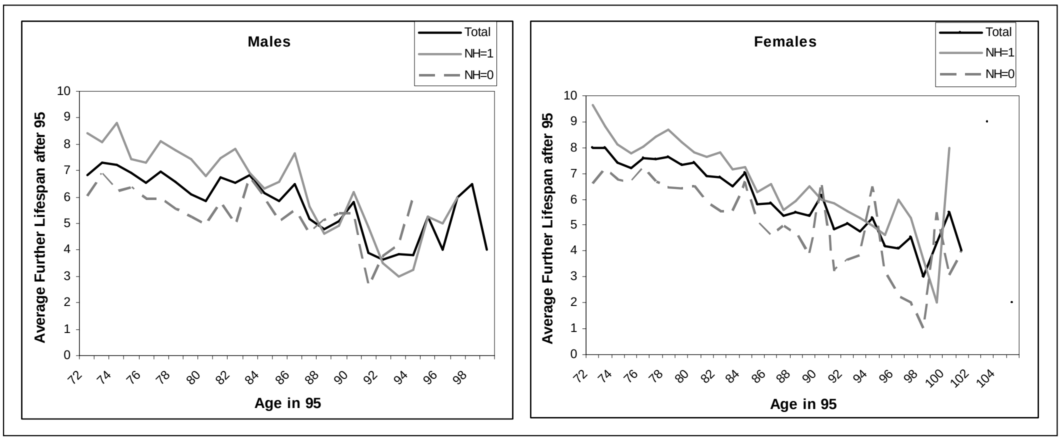
The individual's LTC risk $CR_i^{m/f,x}$ is thus calculated as the deviation of the individual's binary likelihood of entering a nursing home from the average likelihood of the age-gender-comparable group entering a nursing home. This measure is less straightforward; however, its numerical calibration does allow a comparison between the LTC risks of individuals and their age-gender-comparable cohorts. For instance, 30% of the males aged 80 in our sample entered a nursing home after 1995, and the ratio is 64% for males aged 90. Therefore, an 80-year-old man who entered a nursing home exceeds the age-gender-comparable average by 70% and a 90-year-old man who entered a nursing home exceeds the age-gender-comparable average by only 36%. In other words, the higher the difference from the cohort average, the higher the individual's LTC risk.

Our definition of LTC risk $CR_i^{m/f,x}$ is especially interesting when comparing LTC risk of specific groups of respondents. As we show next (in Figure 2), we calculate the average LTC risk for different longevity groups. If the average LTC risk is positive for one longevity group, the respondents in this group, on average, have a higher likelihood of entering a nursing home than their age-gender-comparable cohorts.

Based on our codings, an individual *i* has a higher longevity or LTC risk than his or her age-gender-comparable average if $LR_i^{m/f,x}$ or $CR_i^{m/f,x}$ is positive.

Figure 1 compares average further lifespans after 1995 grouped by individuals' gender, age, and entry into a nursing home. The diagram on the left-hand side shows the comparison for males and the diagram on the right-hand side for females. In both diagrams, the x-axis measures the respondents' age in 1995, and the y-axis presents the average further lifespans after 1995 for one group.

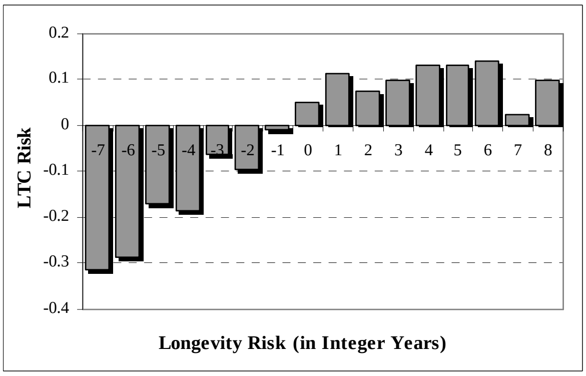
Figure 1: Comparison of average further lifespans, grouped by individuals' gender, age, and their entry into a nursing home



In the left diagram, the black solid line shows the average lifespans for all males of different ages. The gray solid line presents the average lifespans of the males who entered a nursing home after 1995 ($NH_i^{m,x} = 1$); the gray dotted line presents the average lifespans of the males who did not enter a nursing home after 1995 ($NH_i^{m,x} = 0$). In general, the gray solid line lies above the black solid line, indicating that males who entered a nursing home lived longer than males of the same age, on average. By contrast, the gray dotted line is almost always under the black solid line, showing that the males who did not enter a nursing home lived shorter lives than males of the same age, on average. The same pattern pertains for the females. The diagrams provide first evidence that, controlling for age and gender, respondents who entered a nursing home lived longer than respondents who did not.

Figure 2 illustrates how the previously defined longevity risk and LTC risk are correlated. In this figure, individuals are divided into 16 groups according to longevity risk $LR_i^{m/f,x}$. The negative values [-7, -1] indicate that the individuals in these groups lived from 7 years to 1 year less than people of the same age and gender. Similarly, the positive values [1, 8] mean that the individuals in these groups outlived their age-gender-comparable cohorts by 1 to 8 years. The y-axis shows the individuals' LTC risk $CR_i^{m/f,x}$.

Figure 2: LTC risk for different longevity groups (3,924 respondents)

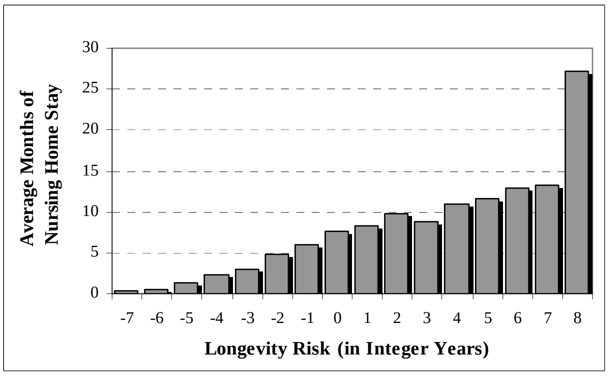


In Figure 2, the LTC risk is negative (positive) for all groups with negative (positive) longevity risk, indicating that people with below-average (above-average) lifespan are also less (more) likely to enter a nursing home than are age-gender-comparable people with an average lifespan. The average LTC risk of longevity group "7" deviates noticeably from the overall trend, most likely because the number of members in this longevity group is very small (13 out of 3,924 respondents) and this group has the highest standard deviation out of all the longevity groups.

The Pearson's correlation between the longevity risk $LR_i^{m/f,x}$ and the LTC risk $CR_i^{m/f,x}$ is 0.24 at a significance level of 0.0%. This correlation indicates that, conditional on age and gender, which are two of the primary criteria used in setting annuity and LTC insurance prices, the respondents' likelihood of entering a nursing home increases by 24% if their longevity risk is one year higher. Based on this result, we conclude that people with an above-average lifespan are indeed more likely to enter a nursing home than are people with a below-average lifespan.

As mentioned in Section 4.1, for most respondents, we know how long they stayed in a nursing home after 1995. Figure 3 displays the average length of nursing home stay (measured in months) for each longevity group.

Figure 3: Average months of nursing home stay for different longevity groups (3,728 respondents)



From the ascending trend of the bars, we conclude that the longer a person lives compared to the age-gender-comparable cohort average, the longer the person will stay in a nursing home. A simple regression of the length of nursing home stay on longevity risk results in a positive coefficient of 1.06 for the longevity risk, with a high significance level (p = 0.000). This correlation shows that, conditional on age and gender, respondents will stay 1.06 months longer in nursing homes if their longevity risk is one year higher.

4.3 Adverse Selection in the Life Care Annuity Market

In this section, we investigate whether adverse selection will occur if LCAs are provided. To do so, we regard those individuals who purchased both annuities and LTC insurance as proxied purchasers of LCA. This assumption implicates that current underwriting practice for LTC insurance also applies for LCA.

Adverse selection is deemed to occur if high-risk agents are more likely to purchase insurance than low-risk agents (Rothschild and Stiglitz, 1976; Chiappori, 2000). The analysis of adverse selection further requires the comparison in a homogeneous risk group, at least homogenous according to insurers' risk classification criteria.

Therefore, adverse selection will be judged to exist in the LCA market if the LCA purchasers have both higher longevity risk and higher LTC risk than do nonpurchasers. For this purpose, we split the investigation into two risk dimensions: first, we analyze whether LCA purchasers have higher longevity risk, controlled for risk classification criteria in annuity policies; second, we analyze whether LCA purchasers have higher LTC risk, controlled for risk classification criteria in LTC insurance policies.

Since no medical examination is required for the purchase of an annuity, and the insurance companies measure longevity risk only by the applicants' age and gender, we can examine the effect of adverse selection in the longevity risk dimension by regressing the individuals' lifespan after 1995 on their LCA ownership, conditional on respondents' gender and their age in 1995.

Since a medical examination is required for the purchase of LTC insurance, adverse selection in the LTC risk dimension can be examined by regressing the individuals' nursing home entry on their LCA ownership, conditional on all the criteria used by insurers in classifying applicants' LTC risk. Insurers' risk classification criteria usually go beyond mere age and gender, and the insurance application forms include questions as to the applicant's current health status and health history, e.g., whether he or she is care-needing or disabled, has cognitive impairments, suffers from a chronic illness, or has received medical treatment. As similar information is collected in the HRS survey, we can, in principle, replicate insurers' risk classification criteria.

One crucial type of insurance application information observable in the HRS data is the individual's need for care. As described before, we excluded from the original respondents those individuals who were living in a nursing home in 1995 so as to ensure respondents' eligibility for LTC coverage. As to other insurance application information, we observe in our sample that 37% of respondents had been patients in a hospital overnight and had talked to medical doctors an average of 11 times during the two years prior to 1995. Additionally, Table 1 shows summary statistics on the presence of certain diseases, revealing that more than half the respondents had high blood pressure and arthritis or rheumatism before 1995, and more than one-third had had a heart attack or other heart problems.

Table 1: Summary statistics on the presence of certain diseases among respondents prior to 1995

Variable	Obs	Mean	S.E.	Min	Max
High blood pressure	3922	0.54	0.50	0	1
Diabetes or high blood sugar	3922	0.16	0.37	0	1
Cancer or a malignant tumor	3922	0.17	0.37	0	1
Chronic lung disease	3923	0.13	0.34	0	1
Heart attack or other heart problems	3923	0.37	0.48	0	1
Stroke	3922	0.13	0.34	0	1
Emotional, nervous or psychiatric problems	3922	0.13	0.34	0	1
Arthritis or rheumatism	3924	0.56	0.50	0	1

Note : All variables are binary with 1 indicating the presence of the disease.

Many U.S. insurance companies employ the LTC status transition model developed by Jim Robinson to predict care utilization and set insurance prices (Robinson, 1996; Finkelstein and McGarry, 2006). In the Robinson LTC status transition model, an individual's future probability of needing LTC is derived based on age, gender, and current health condition. The health condition is further divided into seven states based on the number of limitations to instrumental activities of daily living (IADLs), the number of limitations to activities of daily living (ADLs), and cognitive impairment. Since this type of information is available in the HRS 1995 data, in principle, we can replicate insurers' actuarial predictions of respondents' future LTC risk according to the Robinson model. Table 2 presents summary statistics on respondents' limitations to ADLs, IADLs, and cognitive impairment in 1995. Figure 4 illustrates the distribution of the respondents' health condition across the seven health states according to Robinson's definitions.

Table 2: Summary statistics on respondents' limitations to ADLs, IADLs, and their cognitive impairment in 1995

Variable	Obs	Mean	S.E.	Min	Max
ADLs					
Walking	3924	0.14	0.35	0	1
Dressing	3924	0.18	0.38	0	1
Bathing	3924	0.17	0.37	0	1
Eating	3924	0.07	0.26	0	1
Getting in or out of bed	3924	0.12	0.32	0	1
Using the toilet	3924	0.11	0.31	0	1
IADLs					
Using a map to get around in a strange place	3922	0.44	0.50	0	1
Preparing hot meals	3924	0.23	0.42	0	1
Shopping for groceries	3923	0.27	0.45	0	1
Making phone calls	3924	0.12	0.32	0	1
Taking medications	3924	0.13	0.33	0	1
Cognitive impairment	3924	0.04	0.20	0	1

Note : All variables are binary with 1 indicating the presence of the limitation or impairment.

Figure 4: Percentages of respondents in different health states in 1995 according to the Robinson LTC status transition model (3,924 respondents)

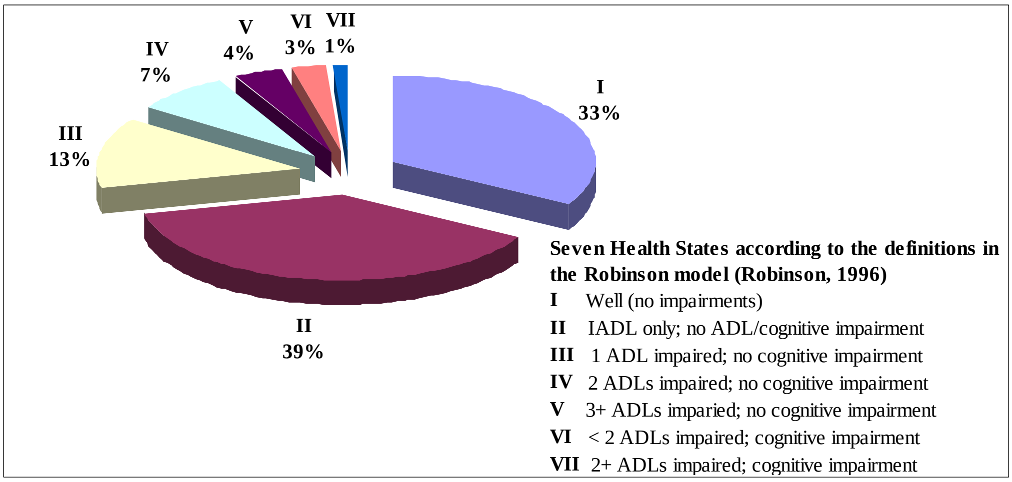


Table 3 presents the results of adverse selection in proxied LCA ownership on both the longevity and LTC risk dimensions. Model (1) estimates a linear regression of individuals' further lifespan on LCA ownership, conditional on age and gender. Model (2) estimates a probit regression of individuals' nursing home entry after 1995 on LCA insurance coverage, conditional on age, gender, health state as defined in the Robinson model, and additional insurance application form information (hospital stays, frequency of visiting medical doctors, and presence of illnesses listed in Table 1). The estimated regression parameters and *p*-values are shown for each variable in the models. The coefficients of LCA coverage in both regression models are significant and positive, indicating that the proxied purchasers of LCA are more likely to live longer and also more likely to enter a nursing home than are the nonpurchasers.[5]

[5] In additional tests for Model (1) and (2) in Table 3, we added as control variables certain other information that insurance companies do not collect, including individuals' education level, number of children, and marital status. Our results showed that a higher education level is significantly positively correlated with a longer lifespan and a higher probability of entering a nursing home. Moreover, having more children and being married (or living with someone) highly significantly reduces the probability of entering a nursing home. However, these additional control variables did not notably weaken the magnitude and significance of the coefficient of the proxied LCA ownership in either model.

Table 3: Influence of proxied LCA ownership in 1995 on individuals' further lifespan and nursing home entry after 1995

		Linear regression of further lifespan after 95 (1)		Probit regression of nursing home entry after 95 (2)	
		β	*p*-values	*β*	*p*-values
Test variable	Proxied LCA ownership in 95	0.951 *	0.062	0.527 ***	0.010
Control variable	Age in 1995	-0.134 ***	0.000	0.027 ***	0.000
	Gender (male =1)	-0.566 ***	0.000	-0.138 ***	0.002
	Health state according to Robinson's definition			0.043 ***	0.009
	Been a patient in a hospital overnight in last 2 years? (yes=1)			0.050	0.280
	Times talked to a medical doctor in last 2 years			-0.001	0.361
	High blood pressure			-0.003	0.951
	Diabetes or high blood sugar			0.059	0.309
	Cancer or a malignant tumor			-0.177 ***	0.002
	Chronic lung disease			-0.070	0.262
	Heart attack or other heart problems			-0.121 ***	0.007
	Stroke			-0.003	0.965
	Emotional, nervous or psychiatric problems			0.147 **	0.022
	Arthritis or rheumatism			-0.011	0.802
	Constant	17.624 ***	0.000	-2.118 ***	0.000
N		3848		3700	
R^2		0.051			
Pseudo R^2				0.024	

* p<0.1, ** p<0.05, *** p<0.01

To illustrate the discovered adverse selection, in Figure 5, different policyholder groups are plotted in a two-risk-dimensional diagram. The x-axis denotes the average longevity risk of one group, and the y-axis exhibits the average LTC risk of one group. Since the longevity risk and LTC risk are measured as individuals' differences from age-gender-comparable group averages, the dot representing the total sample is the origin of the coordinates. The "solo" annuitants and the "solo" LTC insurance purchasers both have above-average longevity and above-average LTC risk. According to Murtaugh et al.'s (2001) calculations, purchasers of LCA should have slightly higher longevity risk and lower LTC risk than the general population, as the "M-S-W" point demonstrates. However, we find that individuals who purchased both an annuity and LTC insurance are much higher risks in both risk dimensions, which is strong evidence of adverse selection in the LCA market. More specifically, the LCA purchasers, on average, live 0.86 years longer and have a 19% higher probability of entering a nursing home than their age-gender-comparable cohorts in the total sample.

Figure 5: Map of longevity risk and LTC risk for different groups of insureds

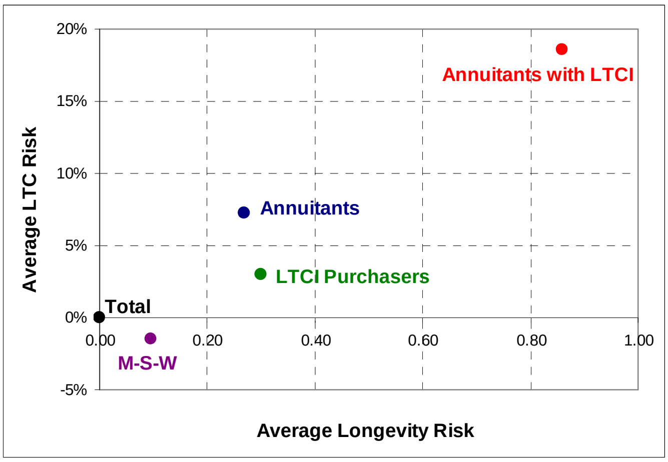


Figure 5 clearly demonstrates that there is a severe risk of inadequately pricing LCA products: if insurers set the prices of LCA products according to their past experience with stand-alone products, they will greatly underestimate the average loss both for longevity and LTC coverage. This pricing error, however, can be averted by examining the extent of adverse selection in the market of proxied LCAs, as done in this paper. Our results suggest for longevity coverage a risk premium of 0.86-year longer life expectancy and for the LTC coverage a risk premium of 19% higher probability of entering a nursing home than the general population. Since our results are based on respondents who were born before 1924 and died between 1995 and 2008, the risk premiums for other cohorts should be adjusted appropriately.

It is worth noting that the positive correlation between risk occurrence and insurance coverage could also arise from moral hazard. However, the problem of moral hazard would be marginal for annuities and LTC insurance because it does not usually happen that insureds would try to live longer after purchasing annuities or purposefully increase their chances of becoming dependent after buying LTC insurance. Therefore, we believe that at least a major part of our results is caused by adverse selection.

5 Solvency Risk of Life Care Annuities

5.1 Insurers' Multi-Period Solvency Model

In addition to pricing risk due to adverse selection, i.e., the misspecification risk of identifying expected loss, an insurance company's financial stability is also influenced by other characteristics of the loss distribution, e.g., its variance, skewness, and kurtosis. In this section, we assume that insurers correctly predict expected losses so that there is no pricing risk. Based on a simulation study, we examine how the solvency situation changes if insurers provide different insurance contracts that have different loss distributions.

We consider three insurance companies: one sells only LCAs, one sells only "solo" annuities, and the third sells only "solo" LTC insurance policies. We assume the insurers do not purchase reinsurance. For each insurance company, we set up a multi-period solvency model. The equity capital EC_t in period t is:

$$EC_t = EC_{t-1} + E_t - Tx_t - D_t ,$$

where EC_{t-1} stands for the equity capital in the last period t-1, E_t the insurer's earnings in period t, Tx_t the tax payment, and D_t the distribution of dividends to shareholders in period t.

The tax payment Tx_t depends on the company's taxable earnings in period t. In the United States, currently the federal corporate income tax is imposed at graduated rates (Internal Revenue Service, 2006), which we adopt in our model.

If the insurance company has positive taxable earnings, a fraction of them is distributed to shareholders. The dividend payout ratios of the S&P 500 averaged 32% in the period from 1995 to 2005.[6] We therefore assume the dividends D_t are:

$$D_t = \max\left\{32\% \cdot E_t, 0\right\}.$$

The taxable earnings E_t are given by:

$$E_t = (EC_{t-1} + P_t + PR_{t-1}) \cdot (e^{r_t} - 1) + P_t - L_t - \Delta PR_t - C_t,$$

with P_t denoting (net) premium income, PR_{t-1} the policy reserves of the last period, r_t the rate of interest, L_t the (net) underwriting loss, ΔPR_t the change in policy reserves, and C_t the administration costs.

In our model, premiums are marked up by 10% of the expected underwriting loss to reflect a conventional level of expense, safety loading, and profit loading for life insurance companies.[7] We further assume that insurance coverage is purchased by paying a single premium at the beginning of period 1.

Policy reserves PR_t are needed in period t to finance—taking account of the interest earned—the future insurance benefits. The changes in policy reserves are given by:

$$\Delta PR_t = PR_t - PR_{t-1}.$$

If the change is positive, the insurance company builds up policy reserves in this period; if the change is negative, the insurance company dissolves policy reserves to pay insurance benefits.

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[6] The historical monthly dividend payout ratios up to November 2005 are available on the website of Barra Inc. (http://mim.barra.com/Research/Fundamentals.aspx).
[7] Mitchell et al. (1999) compare the real premiums of life annuities and mortality rates of annuitants in the U.S. market and find that the expected present discounted value of annuity payouts accounts for 90 – 94% of every dollar annuity premium on average.

The rate of interest r_t is assumed to be 5% p.a., which is the historical yield on U.S. Treasury nominal securities at 5-year maturity in the period 1996 – 2008. The 5-year maturity yield is used because, as we explain in Section 5.2, the first period in our solvency model includes 5 years; the second and third periods are 4 years long. We therefore assume that the insurance companies invest only in risk-free U.S. government bonds. The same interest rate is applied to calculate policy reserves for each period *t*.

Administration costs C_t consist of underwriting and loss adjustment expenses. Underwriting expenses include commissions to agents, as well as expenditures for pricing/underwriting, marketing, and issuing policies. The loss adjustment expenses are costs associated with processing claims. Based on historical average cost ratios of the German life insurance industry for 1996 – 2008, we set the underwriting expenses, which occur only in the first period, as 5.2% of the total premium income and the loss adjustment expenses for each period as 1.1% of the total premium income (GDV, 2009).[8]

We measure an insurer's financial stability by its probability of ruin and its expected policyholder deficit (EPD). Insurer ruin occurs if the insurer's equity capital becomes negative at the end of one period. An insolvent insurance company is not allowed to continue operations in the following periods. We thus define the multi-period probability of ruin Ψ_t as:

$$\Psi_t = pr_t(\,EC_\tau < 0\,)\ for\ 0 \le \tau \le t\,.$$

However, there is some question as to the appropriateness of using the probability of ruin as the decisive measure for insolvency risk because it ignores insolvency severity. By combining

[8] The historical cost ratios of the German life insurance industry are taken from statistics collected by the German Insurance Association (GDV). The loss adjustment expense ratio of 1.1% of total premium income relies on a historical average ratio of 3.3% of annual gross premiums written in GDV (2009). Since we assume single premiums are charged in our 3-period solvency models, we equally divide the ratio 3.3% into 3 periods. The cost ratios in our models are calibrated according to German data because we had difficulty finding adequate data for the U.S. life insurance industry.

the probability and magnitude of ruin, the EPD measures the expected cost of insolvency. We define the multi-period EPD as:

$$EPD_t = E[max(-EC_t, 0)] = pr_t(EC_\tau < 0) \cdot E[-EC_t \mid EC_t < 0] \text{ for } 0 \le \tau \le t .$$

The EPD is the expected value of the difference between the amount insurers are obligated to pay policyholders and the amount they actually pay, and, therefore, the expected amount of loss for policyholders.

These two parameters are often used to measure an insurer's risk profile and derive its optimal capital level (Butsic, 1994; Barth, 2000). In the standard formula of Solvency II—the forthcoming EU insurance regulation framework—the solvency capital requirement (SCR) is defined as that amount of capital that will guarantee the insurer's probability of ruin to be no higher than 0.5% for one year (European Parliament and Council of the European Union, 2009). In the United States, the EPD is adopted as a basic risk parameter not only in the regulatory risk-based capital (RBC) formula developed by the National Association of Insurance Commissioners, but also in the capital adequacy models used by A.M. Best and Standard & Poor's (Barth, 2000).

5.2 Calibration of Insurers' Underwriting Loss Distributions

To estimate the loss distributions of the insurance companies, we narrow our sample to those HRS respondents for whom we know the length of nursing home stay. Our proxied sample of insureds now contains 3,728 respondents.

The type of LCA we employ in our model is an LTC insurance policy bundled with a single-premium immediate life annuity that will pay $1,000 every month if the insured is alive and healthy. If the insured enters a nursing home, the LCA policy will pay an additional $2,000 every month on top of the annuity payment. We chose these benefit amounts to ensure that an elderly person in the United States owning the LCA contract and receiving Social Security benefits will be able to pay for his or her basic living expenses and the average cost of a nursing home stay in the period 1995 – 2008.[9]

We assume that in the absence of LCA products, individuals would purchase stand-alone products with the same insurance benefits. Therefore, we further consider an insurance company that provides stand-alone annuity policies paying $1,000 every month for life, and an insurance company that provides stand-alone LTC insurance policies paying $2,000 every month in the case of a nursing home stay.

From our proxied sample of insureds, we can calculate the underwriting loss of an insurance company that sells only LCAs, or only annuites, or only LTC insurance policies. The underwriting loss from longevity coverage depends on insureds' further lifespan; the underwriting loss from LTC coverage is determined by the length of insureds' nursing home stay.

Table 4 provides summary statistics on the further lifespan and length of a nursing home stay after 1995 for the total sample, the proxied LCA purchasers, the annuitants, and the LTC insurance purchasers. Table 4 also provides evidence that LCA purchasers, without any control, lived the longest and spent the most months in nursing homes compared to the total sample, the annuitants, and the LTC insurance purchasers.

Since we want to compare the solvency situation of the LCA-only provider, the annuity-only provider, and the LTC-insurance-only provider, we assume the three insurers have the same equity capital and the same premium income. Thus, it is only the distribution of total

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[9] In 2002, for instance, the cost of nursing home care averaged $4,290 per month for a semi-private room (Brown and Finkelstein, 2007). In the same year, retirees received an average old-age benefit of $1127 per month from Social Security (Board of Trustees, 2002). Combing this income with an annuity benefit of $1,000 per month and an LTC benefit of $2,000, the retirees could cover the above-mentioned average nursing home cost.

underwriting loss that affects the insurers' solvency situation.[10] Based on the assumption of same premium income, we first determine the number of insureds for the LCA provider N_{LCA}, and then calculate the comparable number of insureds for the annuity provider N_A and for the LTC insurance provider N_{LTC}.

Table 4: Summary statistics on the further lifespan and length of nursing home stay after 1995 for different groups of insureds

Insured risk	Groups of insureds	Obs.	Mean	S.E.	Min	Max
Further lifespan (in years)	Total	3728	6.62	3.45	1	13
	LCA purchasers	40	7.53	3.51	1	13
	Annuitants	193	7.02	3.43	1	13
	LTC insurance purchasers	311	7.12	3.48	1	13
Length of nursing home stay (in months)	Total	3728	6.66	14.58	0	134
	LCA purchasers	40	9.40	15.37	0	48
	Annuitants	193	6.82	12.76	0	57
	LTC insurance purchasers	311	6.90	13.90	0	83

For further analyses, we need to discover the distributions of the insurers' total underwriting loss for a collective of LCA/annuity/LTC insurance purchasers with $N_{LCA}/N_A/N_{LTC}$ insureds. Based on information derived from the HRS data, we can accurately measure individuals' further lifespan in months. Multiplying the individuals' survived months in one certain year with the assumed monthly annuity payment, we can measure the individual per-capita loss for longevity insurance for each year between 1996 and 2008. Similarly, we can count the length of individuals' nursing home stay also in months. Multiplying the number of months individuals stayed in a nursing home in a certain year with the assumed monthly LTC payment, we obtain the individual per-capita loss for LTC insurance for each year between 1996 and 2008. Starting from the individual per-capita loss, we employ a resampling

[10] The premiums, as described above, are marked up by 10% of the expected underwriting loss. The assumption of the same premium income implicates the same expected total underwriting loss for the three insurers. The possible difference in the three insurers' solvency situation is then determined by the variance and higher moments (skewness and kurtosis) of their total loss distributions because we measure an insurer's solvency situation through its probability of ruin as well as its EPD.

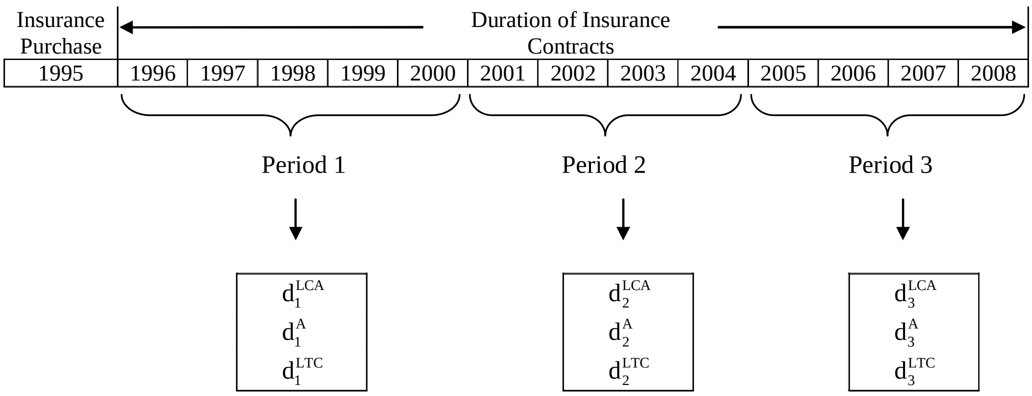
approach similar to bootstrap to approximate the true total loss distributions for the insurers' collectives.

Like bootstrap, the resampling approach assumes that the individuals' losses are independent and identically distributed. Taking the case of the LCA provider to illustrate the approach, we first draw N_{LCA} random samples with replacement from the empirical per-capita loss distribution to construct one collective of the LCA provider. We then calculate the total loss of this collective. By repeating this process *m* times (*m* = 10,000 in our simulations), we obtain *m* possible values of the LCA provider's total loss. Finally, we fit parametric models to the *m* values of the total loss and use the fitted total loss distribution to approximate insurer liabilities in the solvency model. The procedure is described in more detail below.

The basic idea behind this resampling method is that we view the empirical per-capita loss distribution as the true population distribution. By drawing random samples from the empirical distribution with replacement, we create a collective that has a distribution similar to that of the true population. If we repeat the process of sampling a collective more times, the distribution of the total loss of the sampled collective approximates the distribution of the true total loss.

Due to the limited number of LCA purchasers (*N* = 40) in our sample, we can identify only a very few LCA purchasers who stayed in a nursing home in each year. Therefore, we divide our 13-year observation period into 3 business periods, as shown in Figure 6.

Figure 6: Procedure for identifying per-capita loss distributions of each business period for different insured groups



As illustrated in Figure 6, 1996 – 2000 is the first business period, 2001 – 2004 is the second business period, and 2005 – 2008 is the third business period. This grouping ensures that there are a similar number of care-needing cases among LCA purchasers in each period. For each period, we calculate the individual loss of each LCA purchaser by summing up the individual annual losses (the derivation of which was previously explained) in this period.

Based on the individual losses in each period, we obtain the empirical per-capita loss distribution of insureds for each period. As an example, we show in Figure 7 the empirical per-capita loss distribution of LCA purchasers d_t^{LCA} for period t (t = 1, 2, 3). Analogously, we can estimate the per-capita annuity loss distribution d_t^A and the per-capita LTC insurance loss distribution d_t^{LTC} for period t.

In the next step, the total loss distribution of a single insurance company with a certain collective is estimated. Figure 8 is a visualization of how we estimate the total loss distribution of each period, again using the LCA provider as an example. For the period t, we draw 1,000 random samples $L_t^{LCA}(i)$ stochastically from the empirical per-capita loss distribution d_t^{LCA} with $i \in [1, 1000]$ and calculate the sum as the total loss $L_t^{LCA}(Total)$. After repeating this process 10,000 times, we obtain 10,000 stochastic values of total claims and then estimate the distribution of the total loss D_t^{LCA}.

Figure 7: Empirical per-capita loss distribution (in $) for 3 periods, taking LCA purchasers as an example (d_1^{LCA}, d_2^{LCA}, and d_3^{LCA})

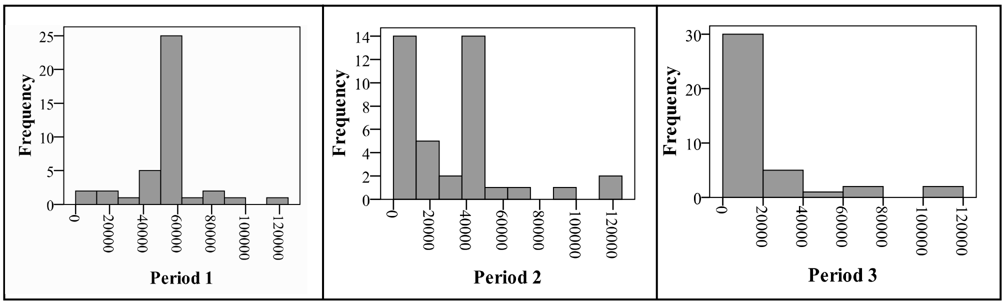
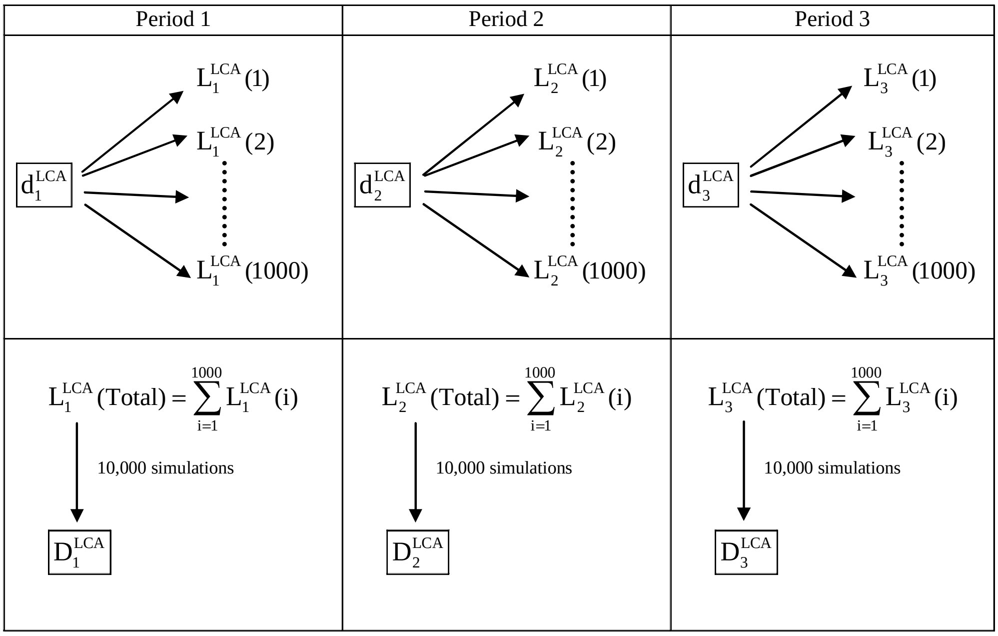


Figure 8: Process of estimating the distribution of total loss for each period, using the LCA provider as an example (D_1^{LCA}, D_2^{LCA}, and D_3^{LCA})



Note: This graph uses the LCA provider as an example. To estimate the total loss distribution of the annuity provider and the LTC insurance provider, we respectively draw N_A (=1,280) and N_{LTC} (=7,561) random samples from the empirical per-capita loss distribution d_t^A and d_t^{LTC}.

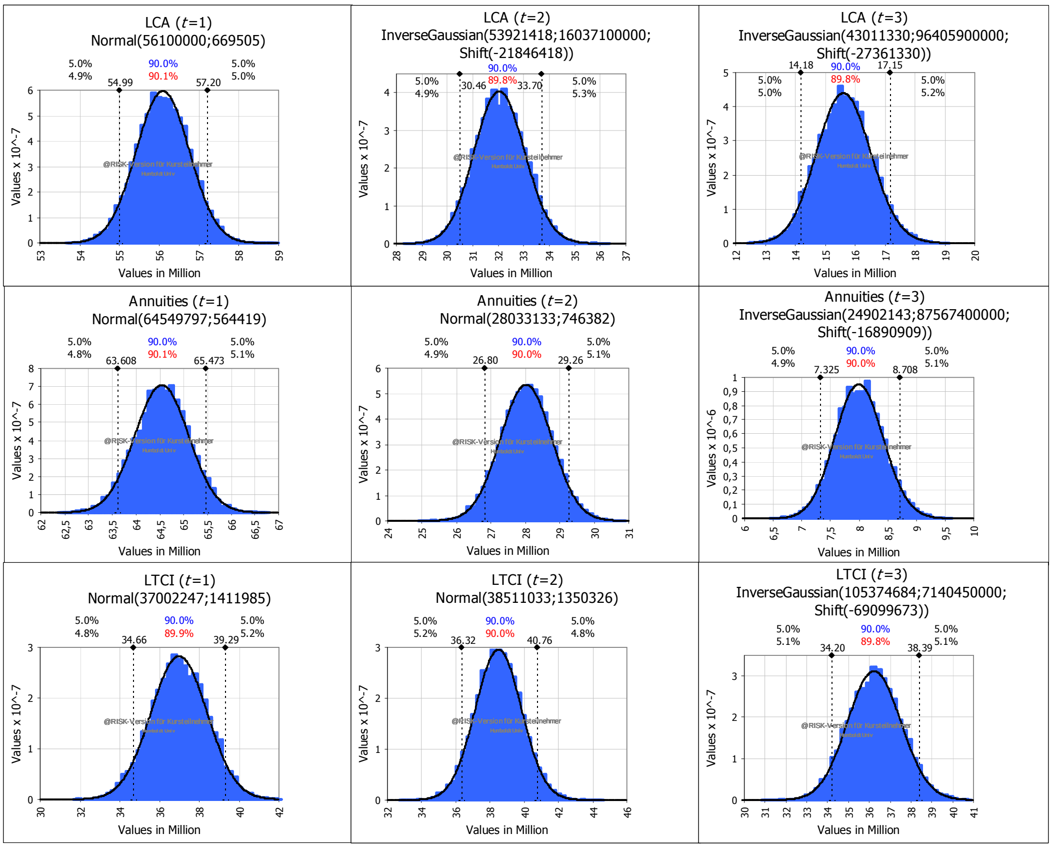
To make the three insurance companies comparable, we set the initial equity capital EC_0 and the total single-premium income P the same for each company. We assume each insurance company has $500,000 equity capital at the beginning of the first period. In addition, we assume that the LCA provider sells 1,000 LCA contracts at the beginning of the first period. Taking the loading factor of 10% and the annual compounded interest rate of 5% into account, the LCA provider receives total premium income of $79,543,929. Based on this amount of premium income and the expected per-capita losses, which can be estimated from the empirical per-capita loss distributions d_t^A and d_t^{LTC}, we find that the annuity provider needs to sell 1,280 insurance contracts, and the LTC insurance provider 7,561, to receive the same total premium income. The assumption we apply here is that the loading factor is proportional to the expected losses. This approach ignores the possibility that consumers will demand a substantial reduction in insurance premiums in the face of default risk, as is found to be the case in experimental studies (see, e.g., Zimmer et al., 2009). If we did take into consideration consumer reaction to default risk, however, it would not change the ranking of the insurers' solvency levels, but only enlarge their differences because a company with higher default risk would collect fewer premiums, resulting in reduced earnings for the same expected amount of losses, and thus would have an even higher probability of becoming insolvent.

We then perform the same process as described in Figure 8 for the annuity provider and the LTC insurance provider to estimate their total underwriting loss distributions, with the only difference being that the number of samples drawn from the empirical per-capita loss distribution $d_t^A(i)$ and $d_t^{LTC}(i)$ are increased to 1,280 and 7,561, respectively.

Figure 9 provides an overview of the fitted total underwriting loss distributions D_t^{LCA}, D_t^A, and D_t^{LTC}, which are estimated by sampling from the empirical per-capita loss distributions d_t^{LCA}, d_t^A and d_t^{LTC} for the period t (t = 1, 2, 3). We identify the best fitted distribution by choosing the distribution function providing the smallest χ^2 goodness-of-fit statistics. These total underwriting loss distributions will be applied in our solvency model to simulate the total loss and to analyze the insurers' financial stability.

Note that total underwriting loss distributions will converge to normal distributions as the number of insureds approaches infinity, as suggested by the central limit theorem. However, the more asymmetric the per-capita loss distribution, the more the total loss distribution will deviate from normality for a finite number of single claims. Since some of the per-capita loss distributions are strongly asymmetric (e.g., d_2^{LCA} and d_3^{LCA}; see Figure 7), some of the total loss distributions also deviate from normal distributions (e.g., D_2^{LCA} and D_3^{LCA}).

Figure 9: Overview of the fitted total underwriting loss distributions estimated from sampling from empirical per-capita loss distributions (D_t^{LCA} , D_t^{A} , and D_t^{LTC})



5.3 Simulation Results for the Insurers' Solvency

We run 10,000 simulations to determine the financial stability of the three insurance companies over three time periods, all of which begin in 1996, but end in 2000, 2004, and 2008, respectively. Table 5 reports the probability of ruin Ψ_t and EPD_t (t = 1, 2, 3) after each time period for each company. We also show how the companies would be rated by Moody's for each of the ruin probabilities in each of the time periods. The ruin probabilities of different rating classes refer to the empirical cumulative issuer-weighted default rates for a cohort formed on January 1, 1996 over the time period 1996–2008 (the same time period in which the insurers in our solvency model operate) in Emery and Ou (2009).

Table 5: Probability of ruin, Moody's rating, and EPD for three insurers over three time periods

	Period 1 (1996-2000)	**Period 2 (1996-2004)**	**Period 3 (1996-2008)**
	Ψ_1	Ψ_2	Ψ_3
LCA provider	0.000% (Moody's: Aaa)	0.032% (Moody's: A)	1.348% (Moody's: A)
Annuity provider	0.000% (Moody's: Aaa)	0.001% (Moody's: A)	0.039% (Moody's: A)
LTC insurance provider	0.000% (Moody's: Aaa)	0.701% (Moody's: Ba)	5.894% (Moody's: Baa)
	EPD_1	EPD_2	EPD_3
LCA provider	0	100	6,951
Annuity provider	0	0	113
LTC insurance provider	0	3,564	43,413

In the first period (1996 – 2000), none of the companies have any insolvency risk and would receive the best Moody's rating—Aaa. In the two longer time spans, the annuity provider has the lowest probabilities of ruin, followed by the LCA provider. Both insurers would be downgraded to A in 2004 and 2008 because of their overproportionally increased probabilities of ruin over time. The LTC insurance provider has the highest insolvency risk for the two longer time spans and thus receives the worst Moody's ratings. The fact that the Moody's ratings of all three insurers become substantially lower over time indicates that these insurers are less financially stable than their corporate peers over the long run.

The lower part of Table 5 presents the EPD, which is the expected cost of insolvency. In the shortest time span, all three insurance companies have no cost of insolvency. For the two longer time spans, the annuity provider has the lowest EPD, followed by the LCA provider. Again, the LTC insurance provider has the highest cost of insolvency in the two longer time spans. When comparing EPD with insolvency probability, it can be observed that, generally, higher insolvency risk is accompanied by higher expected costs of insolvency.

Consequently, given the same equity capital and the same total premium income, in the long run, selling LCA contracts is more risky and more costly than providing annuities, but safer and cheaper than providing LTC insurance contracts.

5.4 Discussion

When estimating the per-capita loss distributions from survey data in Section 5.2, we exclude from the proxied sample of insureds 196 respondents who we know stayed in a nursing home but do not know how long they stayed. This exclusion creates bias in the sample in that disabled respondents are underrepresented, meaning that if we had no missing data as to length of nursing home stay and thus could include all respondents in the sample, the total LTC benefits would be higher. As a consequence, the expected per-capita loss of LCA purchasers and that of LTC insurance purchasers should actually be higher than we estimated.

In addition, the results of this study are based on the very important assumption that current LTC insurance underwriting practice is employed in pricing and selling LCA products. Since the LTC insurance underwriting criteria are designed to exclude frail applicants and select healthy ones, the underwriting process could be one reason why LTC insurance purchasers live longer than average. If LCA providers waive the underwriting process, they would not face higher underwriting risk but instead benefit from reduced underwriting expenses.

6 Conclusion

A LCA is a bundled insurance product comprised of a life annuity and a LTC insurance policy. This innovative product is based on the idea that pooling longevity risk and disability risk will reduce adverse selection in both insurance markets and eventually lower insurance prices. Our paper questions the pooling effect and examines what risks and opportunities insurance companies face when providing LCAs.

We first examined the insurer's pricing risk of providing LCAs. Based on HRS data, we find that strong adverse selection would occur in the LCA market: people who bought both the longevity coverage and LTC insurance coverage had higher risk in both risk dimensions than both the general population and people who bought only "solo" insurance contracts. This result indicates that there will be a high risk of mispricing if insurance companies set premiums according to their past experience in selling annuities or LTC insurance separately.

In the second part of our analysis, we circumvent the pricing risk by assuming insurers set premiums appropriately and concentrate on the risk of insolvency posed by selling LCAs. We set up a multi-period solvency model and calibrate insurer loss distributions with empirical data. Our results show that, in the long run, providing LCAs will lead to a higher insolvency risk and higher insolvency cost than providing annuity contracts. However, compared to LTC insurance, selling LCA contracts is safer and less costly. These results suggest that an annuity provider planning to engage in the LCA business should raise additional equity capital or undertake additional risk management to maintain the same financial stability. On the contrary, an LTC insurance provider could reduce the equity capital needed to maintain a certain solvency level by switching to selling LCAs. Although there are at present very few insurance companies that provide only LTC insurance contracts, our results could provide some guidance to health insurance companies whose portfolios include LTC insurance and other health-related insurance contracts that have positively correlated risks with LTC risks.

Appendix: The HRS Exit Data and Variable Definitions

Nursing home entry: We measure nursing home entry for 1995─2008 by the answers to two questions in the HRS Exit questionnaires:

CS11: "Was R (respondent) living in a nursing home or other health care facility at the time (he/she) died?"

E5: "In addition to that nursing home stay (if R died in a nursing home), excluding any hospice stays, had (he/she) been a patient overnight in a nursing home, convalescent home, or other long-term health care facility (since the previous wave/in the last two years)?"

We code the variable for nursing home entry 1 if the respondent answers yes to either question.

Length of nursing home stay: We measure the length of respondents' nursing home stay during 1995─2008 via two alternatives. The first is based on the following question in HRS Exit questionnaires:

CS25: (If the respondent was living in a nursing home or other LTC facility at the time he/she died), "in what month and year did he/she move to the nursing home/health care facility where he/she was a resident just before his/her death?"

Combining the answers to this question with the month and year the respondent died, allows us to calculate the number of months the respondent stayed in a nursing home. We further limit the date of nursing home entry to be no earlier than January 1996 and the time of death to be no later than December 2008.

As an alternative, the proxy respondents could answer another question in HRS Exit questionnaires concerning respondents' total length of nursing home stay:

E7: "Altogether, how many nights was he/she a patient in a nursing home (since the previous wave/in the last two years)?"

We divide the number of nights in a nursing home by 30 and use the higher integer of the quotient as the length of nursing home stay measured in months.

Based on these two alternative methods and taking the maximum of both when both questions were answered, we identify the length of the nursing home stay between 1996 and 2008 for 1,870 respondents.

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