

Essays on Insurance Economics

DISSERTATION

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Summary

This dissertation consists of three essays that offer a holistic view of the challenges existing in the market for private long-term care insurance and a deeper analysis of the behavioral and actuarial aspects of that product. It explores the existing research gaps and anomalies found in this market and provides appropriate answers using both economic and actuarial frameworks. In particular, this dissertation focuses more on demand for private long-term care insurance.

The first essay entitled “Research on long-term care insurance: Status quo and directions for future research” provides a comprehensive literature review of long-term care insurance using a mathematical tool to identify the most significant paths in the citation network. Three major research areas (financing, demand, and insurability) are identified and then evaluated systematically based on the standard frameworks, and then future directions are discussed. The existing immense difficulties of long-term care insurance are analyzed from the demand and supply side of that product to explain the marginal contributions of insurance mechanisms to long-term care financing overall.

In the second essay, “Willingness to take financial risks and insurance holdings: A European survey” a behavioral challenge that exists on the demand side of the insurance market, in particular, the market for life insurance and long-term care insurance, is examined. Using a cross-national survey dataset from 14 countries, the relationship between individual’s willingness to take financial risks and ownership of life and long-term care insurance is analyzed when the specific determinants of the demand for each insurance product are controlled. These findings support the conclusion that there exists a positive link between the willingness to take financial risks and the ownership of both long-term care insurance and life insurance where that link is not supported by the classical expected utility framework.

The third essay, entitled “The interplay between longevity and morbidity on optimal choice of long-term care insurance” analyzes how longevity improvements and their interactions with alternative morbidity scenarios influence the retiree’s optimal choice of purchasing long-term care insurance. The essay concludes that only in the morbidity expansion scenario does the optimal level of purchasing long-term care insurance decrease since the actuarially fair premium increases. In addition, testing for existing survival ambiguities of retirees by using constructed morbidity scenarios, it is found that when survival ambiguities exist, both morbidity compression and expansion lead to a lower level of long-term care insurance purchases.

Zusammenfassung

Diese Dissertation besteht aus drei Aufsätzen, die eine ganzheitliche Sicht auf die Herausforderungen privater Pflegeversicherungen und eine vertiefte Analyse der verhaltensbezogenen und versicherungsmathematischen Aspekte bieten. Sie untersucht die bestehenden Forschungslücken und Anomalien im privaten Pflegeversicherungsmarkt und liefert neue Erkenntnisse, indem sie sowohl ökonomische als auch versicherungsmathematische Ansätze nutzt.

Der erste Aufsatz mit dem Titel "Research on long-term care insurance: Status quo and directions for future research" bietet mit Hilfe eines mathematischen Tools zur Ermittlung der wichtigsten Pfade im Zitationsnetzwerk einen umfassenden Literaturüberblick über die Pflegeversicherung. Drei grosse Forschungsbereiche (Finanzierung, Nachfrage und Versicherbarkeit) werden identifiziert, systematisch bewertet und anschliessend zukünftige Forschungsrichtungen diskutiert. Die Herausforderungen in der Pflegeversicherung werden aus Sicht der Nachfrage- und Angebotsseite analysiert, um die Beiträge von Versicherungsmechanismen zur Finanzierung der Langzeitpflege insgesamt zu erklären.

Im zweiten Aufsatz, "Willingness to take financial risks and insurance holdings: A European survey" wird ein Verhaltensproblem auf der Nachfrageseite des Versicherungsmarktes untersucht. Unter Verwendung eines Datensatzes aus 14 Ländern wird die Beziehung zwischen der individuellen finanziellen Risikobereitschaft und dem Besitz von Lebens- und Pflegeversicherungen analysiert. Die Ergebnisse stützen die Schlussfolgerung, dass ein positiver Zusammenhang zwischen der Bereitschaft finanzielle Risiken einzugehen und dem Besitz von Pflege- und Lebensversicherungen besteht, obschon diese Beobachtung dem klassischen Erwartungsnutzen widerspricht.

Der dritte Aufsatz mit dem Titel "The interplay between longevity and morbidity on optimal choice of long-term care insurance" analysiert, wie Langlebigkeit und ihre Wechselwirkung mit alternativen Morbiditätsszenarien die optimale Wahl des Rentners beim Abschluss einer Pflegeversicherung beeinflussen. Der Aufsatz kommt zum Schluss, dass nur bei Morbiditätsausweitung die optimale Nachfrage nach Pflegeversicherungen sinkt, da die versicherungsmathematisch faire Prämie steigt. Darüber hinaus wird anhand von konstruierten Morbiditätsszenarien getestet, ob Ambiguität im Hinblick auf die Lebenserwartung bei Rentnern bestehen, und es wird festgestellt, dass sowohl die Morbiditätskompression als auch die -expansion zu weniger Abschlüssen von Pflegeversicherungen führen, wenn Überlebensambiguitäten bestehen.

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Omid Ghavibazoo

Introduction

The elderly population in the world is growing rapidly, and people are living longer than ever in many developed countries. This phenomenon has led long-term care, the care that its main recipients are over 65, to have more important global relevance. The increasing cost of long-term care, together with its prevalence among many of the elderly, calls for alternative public and private financing resources to reduce the households' financial burden. This dissertation offers a comprehensive literature review of long-term care insurance to identify the existing research gaps and address some of those gaps using both economic and actuarial methods.

Due to the importance of long-term care, hundreds of studies have addressed its different aspects and offered alternative financing solutions from both public and private sources. The first essay of this dissertation, entitled "Research on long-term care insurance: Status quo and directions for future research" presents the most comprehensive literature review of long-term care insurance using main path analysis, a mathematical tool that identifies the most significant paths in the citation network of 591 articles from the Web of Science. Using this technique, three major research areas (financing, demand, and insurability) are identified. Each of these research areas is then systematically evaluated using standard frameworks. The effort further identifies the huge difficulties in insuring long-term care both on the demand side (e.g., low value of consumption while in care, existence of substitutes) and supply side (e.g., lack of predictability and asymmetric information) that explains the marginal contribution of insurance mechanisms to long-term care financing. Alternative solutions, such as combined products that bundle the risks, the public-private partnership, and other methods beyond the idea of risk pooling, are then discussed to help improve the sustainability of long-term care financing. In addition, this first essay summarizes the useful potential future research to undertake on long-term care insurance overall.

Despite the clear importance of long-term care insurance as a mechanism to protect the elderly and their families against huge long-term care costs, the demand for this product has remained low in many developed countries. Theoretical studies suggest that when facing such a risk, rational agents who are more risk-averse purchase more insurance. In the previous literature, many economic, social and cultural, structural and demographic factors have been found to impact the demand for long-term care insurance. Such determinants are also discussed and categorized in the first essay.

Still, the previous empirical findings have found inconclusive links between individuals' risk attitudes and the demand for insurance, particularly long-term care insurance and life insurance. Therefore, in Essay II, "Willingness to take financial risks and insurance holdings: A European survey" the association between individuals' willingness to take financial risks and ownership of long-term care insurance and life insurance is investigated using a large cross-sectional dataset of elders in 14 countries from Survey of Health, Ageing and Retirement in Europe. In this essay, a significantly positive link is found between financial risk-taking and insurance holding, by using the self-reported willingness to take financial risks. Robust evidence of the main findings is provided using self-reported risky asset ownership as an alternative measure of financial risk-taking. Controlling for a wide range of individual- and household-level determinants of the demand for long-term care insurance and life insurance, these findings are less robust for long-term care insurance than life insurance. The main contribution of this essay is that analyzing the association between risk attitudes and individuals' insurance purchase decisions using classical utility theory should be cautiously done since higher-order risk attitudes can play a role in this relationship. This finding calls for future research that investigates the relationship using alternative economic theories beyond utility theory (e.g., higher-order risk attitudes or prospect theory). In addition, practitioners can benefit from such results by redesigning their marketing strategies to improve individuals' understanding of such products in terms of financial riskiness.

As emphasized earlier, life expectancies have improved in many countries, and this change has further impacted the financial planning of elders. Multiple studies have investigated the role of mortality improvement on pensions, annuities and individuals' financial decisions. However, an increase in life expectancy and its interaction with changes in morbidity trends has been neglected in the literature on long-term care insurance. Essay III entitled "The interplay between longevity and morbidity on optimal choice of long-term care insurance" fills that gap by examining how mortality improvements and their interplay with morbidity trends impact retirees' optimal choice to purchase long-term care insurance. By utilizing health state transitions in the U.S. from the Health and Retirement Study and mortality rates from the Human Mortality Database, mortality improvements of a 65-year-old retiree are incorporated along with constructing four scenarios of morbidity compression/expansion found in the previous studies. To test the interaction between mortality improvements and morbidity scenarios on the optimal choice of retirees' purchase of long-term care insurance, a discrete life-cycle framework is used that incorporates bequest motives and consumption floors. It is

found that only in the morbidity expansion scenario does the optimal choice of purchasing long-term care insurance decrease due to the fact that an actuarially fair premium is the highest in this scenario. Such an analysis is based on the strong assumption that retirees do have an accurate estimate of their survival probabilities. To further relax this assumption, a benchmark is assigned to retirees' health state transitions and then used in optimizing lifetime utility. Alternative actuarially fair premiums calculated by the insurance provider from multiple morbidity scenarios are utilized in this benchmark case. It is found that if survival ambiguities exist, in both morbidity expansion and compression scenarios, the optimal choice of purchasing long-term care insurance decreases. This is an important result that may contribute to the low demand for long-term care insurance even though the theoretical models do suggest higher demand (i.e., the existing long-term care puzzle).

Ultimately, this dissertation provides data-driven answers to some of the existing important research questions in the long-term care insurance literature. It identifies major research areas, existing anomalies, and directions for future research on long-term care insurance (Essay I). On the demand side, this dissertation offers a better understanding of behavioral anomalies when purchasing long-term care insurance and life insurance using alternative risk attitude measures (Essay II), and also contributes to the literature on longevity and morbidity trends by testing the plausible role of longevity improvements and their interaction with morbidity scenarios on optimal purchase of long-term care insurance (Essay III). Indeed, these findings can shed important light on the future directions of research on long-term care insurance to improve the financing of long-term care expenses of the elderly and to ensure they receive the best possible care.

Essay I

Research on long-term care insurance: Status quo and directions for future research

Abstract

We provide a structured literature review of long-term care (LTC) insurance using main path analysis, a mathematical tool to identify the most significant paths in a citation network. We identify three major research areas (financing, demand, and insurability) and systematically evaluate them based on standard frameworks. We further review established and innovative (insurance) solutions for LTC financing. Our results illustrate the immense difficulties in insuring LTC both on the demand (e.g., low value of consumption while in care, existence of substitutes) and supply side (e.g., lack of predictability and asymmetric information) explaining the marginal contribution of insurance mechanisms to LTC financing. Combined products that bundle the risks, and public-private partnerships that integrate LTC into the pension systems, might help to overcome the insurability limitations. In addition, alternative financing methods that go beyond the idea of risk pooling (LTC bond, LTC put option, equity release) could help to improve the sustainability of LTC financing.

Keywords

Long-term care, Long-term care insurance, Main path analysis, Citation network, Demand, Financing, Insurability

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1 Motivation and aim of the paper

The organization and financing of LTC is arguably one of the most important societal tasks of the 21st century. Although significant uncertainties in terms of potential need, intensity and duration of LTC provide a powerful rationale for sharing this risk across individuals (Colombo et al., 2011), the market for long-term care insurance (LTCI) is very limited.¹ From the academic side, the low demand for LTCI remained largely unexplored until the late 1990s. However, the academic literature on LTC and insurance is now growing exponentially with more than 1,200 articles in Web of Science alone (see Appendix A). While a considerable amount of research on LTC has been published in medical or gerontological journals, a growing number of studies can be documented in the fields of business and economics, calling for a structured and timely review of this emerging academic field.

We provide a structured review of LTC in the context of insurance (see Figure 1) using an identification technique – main path analysis – that to our knowledge has not yet been used in the insurance field. Based on the review results, we evaluate the literature using three established frameworks (Chen, 2001; Outreville, 2013; Berliner, 1982) and compare our results with the findings from other insurance markets. Our review includes a summary of alternative insurance and financing models that we use to identify innovative insurance and financing solutions. Finally, we offer an overview of potential research topics from the perspectives of academics and practitioners to encourage future work on this important topic. The focus of the analysis is on the business and economics literature in the risk and insurance field.²

To summarize our main results, there is a combination of ex-ante (insurance) and ex-post (public sector, family) funding mechanisms with some variations in all advanced economies. When it comes to private insurance, high premium loadings and limited coverage are needed on the supply side because of uncertainty with respect to probability, intensity and duration of

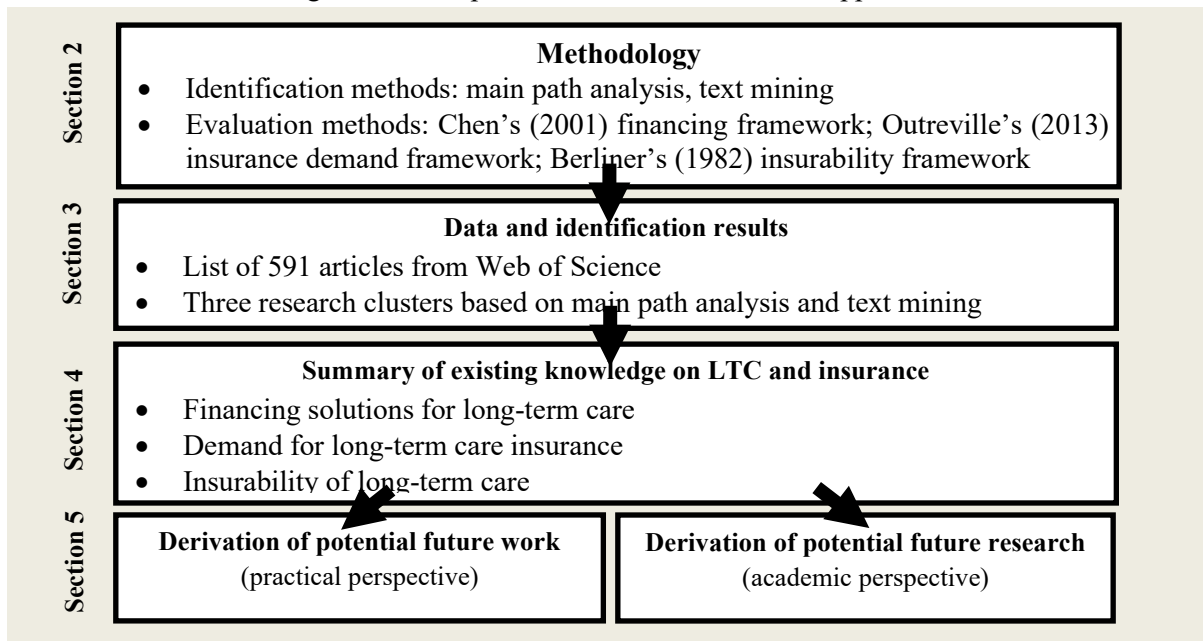
¹ The statistics on LTC financing in OECD countries presented in Colombo et al. (2011) emphasize the low relevance of insurance. Private insurance as a source of LTC funding ranges from 0% (Netherlands, Czech Republic) to a maximum of 9.8% (Belgium). Social security, which might also use some insurance mechanisms is, however, important in some countries (90% in the Netherlands, 70% in the Czech Republic).

² There are a few previous literature surveys on LTC with a slightly narrower focus. The most comprehensive study is by Norton (2000), in which the taxonomy of LTC, supply, demand and demographic trends based on previous theoretical and empirical research is discussed. Cremer et al. (2012) and Klimaviciute and Pestieau (2018) review more recent publications, seeking a sustainable public LTC scheme that combines both market and family solutions. Pestieau and Ponthiere (2012) study the vicious circle in the LTC market (i.e., the market for LTCI is thin because people may find most of the current LTCI products too expensive and at the same time, insurance companies provide LTCI with higher prices due to thinness of its market) from both the demand and supply sides. Brown and Finkelstein (2011) discuss the LTC expenditures, the relevant nature of private market for LTCI along with Medicaid in the U.S.

LTC and pronounced information asymmetries. On the demand side, only well-educated middle-income people with LTC experience and a pessimistic outlook tend to be interested in buying LTCI, which is a rather small group. Limited knowledge, low value of consumption while in care, and the availability of public and private substitutes all reduce the demand for LTCI.³ Combined products that bundle risks and public-private partnerships that integrate LTC into the pension systems, might help to overcome the insurability limitations. In addition, alternative financing methods that go beyond the idea of risk pooling (LTC bond, LTC put option, equity release) could improve the sustainability of LTC financing.

The remainder of this paper is structured as follows. We begin with a description of our methodology (Section 2) and present our data and identification results (Section 3). Then, we cluster the literature according to the three research topics (Section 4). Finally, we discuss areas of future work from practitioners' and researchers' perspectives (Section 5).

Figure 1. Conceptual framework and research approach



2 Methodology

We use main path analysis and text mining to identify the main research topics in the field of LTCI. Main path analysis is a methodological improvement on classical citation network analysis. Citation network analysis, introduced by Garfield et al. (1964), is a non-weighted

³ We discuss 20 factors whose impact on LTCI demand has been empirically studied. Of these, 12 are clear in their prediction and in line with observations from other insurance markets. For the other eight factors, however, the literature is either inconclusive or contradictory.

directional graph representing the idea that knowledge flows from older to newer articles. Main path analysis, first suggested by Hummon and Dereian (1989), simplifies the citation network using predefined weighting indexes and has become state of the art for literature screening in a variety of fields.⁴

A citation network consists of nodes (articles) and links (arrows) between the nodes representing the citations between the articles directed towards the cited article. We produce our citation network and main path as follows. First, the data is exported from Web of Science to the HistCite (Garfield 2009) software to produce a citation network. Then, the resulting file is imported to the Pajek software introduced by Batagelj and Mrvar (1998) for path analysis. Figure B1 illustrates our citation network extracted from Web of Science. To extract the main path from such a citation network, a weighting index is needed for the links between the nodes. Hummon and Dereian (1989) and Batagelj (2003) present various weighting indexes along with a discussion of their pros and cons.⁵ We follow Batagelj (2003) and use Search Path Count (SPC) as a weighting index of the links. This index counts the number of times a link is traversed through certain starting nodes (source nodes) to ending nodes (sinking nodes).

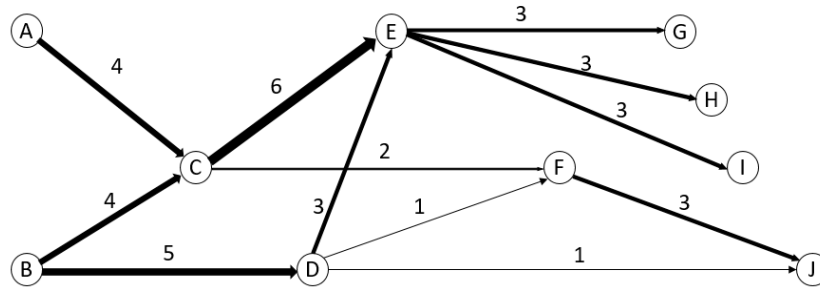
Figure 2 illustrates a simple example of citation network based on the SPC index. Here we follow Ma and Liu (2016), Liu et al. (2016), and Lu and Liu (2016) and choose the global⁶ key-route main path analysis as our methodology for identifying the most important publications in the citation network. Global key-route main path finds the most significant link globally and searches forward and backward (until meeting a sinking or source node) to build the path. In the following example, nodes A and B are source nodes and G, H, I and J are sinking nodes. The global key-route main paths (the path with the highest traversal count globally) are identified as A-C-E-G, A-C-E-H, A-C-E-I, B-C-E-G, B-C-E-H and B-C-E-I. The thickness of the arrow is an indicator for the importance of the research indicating the traversal weight.

⁴ See, e.g., Liu et al. (2016) for an application to data envelopment analysis or Huang et al. (2017) for an application to 3D printing.

⁵ Four measuring traversal counts discussed in the literature are Search Path Link Count (SPLC), Search Path Node Pair (SPNP), Node Pair Projection Count (NPPC), and Search Path Count (SPC). Although there are small variations in these indexes, Batagelj (2003) recommends SPC over other traversal counts.

⁶ We choose global rather than local search to connect the links in a way that delivers the largest traversal counts (see Liu and Lu, 2012, for further explanation of this idea and a discussion of different approaches).

Figure 2. A simple citation network with SPC index



For more details on the main path analysis, we refer to De Nooy et al. (2011). Building upon the identified networks, we analyze the underlying research topics with text mining. We use the R package ‘tm’ (Feinerer and Hornik 2012) to identify the most frequently used words in titles, keywords, and abstracts.

We then rely on three widely used frameworks to systematically evaluate the main results in the identified research fields (see Table 1). We begin by using Chen’s (2001) financing framework to categorize standard LTC financing approaches and to identify innovative financing solutions that do not fit into the standard categories. Then, we follow Outreville (2013) and categorize insurance demand in four categories.⁷ Finally, we address the insurability of LTC risk based on the Berliner (1982) insurability framework.⁸

Table 1. Evaluation frameworks

<i>Chen (2001) financing framework</i>	<i>Outreville (2013) demand framework</i>	<i>Berliner (1982) insurability criteria</i>
Public sector: General governmental (excl. social security)	Economic factors • Price⁹ • Income • Wealth • Bequest motives	Actuarial criteria • Randomness of loss occurrence • Maximum possible loss • Average loss per event • Loss exposure • Information asymmetry
Public sector: Social security • Inter-generational model • Intra-generational model	Social and cultural factors • Education and knowledge • Preferences, experience and beliefs	Market criteria • Insurance premium • Cover limits
Private sector: Private LTC • Stand-alone LTC policy • Combined policy	Structural factors • Substitute for insurance • Tax incentives	Social criteria • Public policy • Legal restrictions
Private sector: Out of pocket	Personal and demographic factors • Age and gender • Marital status and number of children	

⁷ See, e.g., Eling et al. (2014) for an application to microinsurance demand.

⁸ Biener and Eling (2012) and Biener et al. (2015) show applications to micro and cyber insurance.

⁹ Both Outreville (2013) and Berliner (1982) do not differentiate between subsidized price at point of utilization or tax price, although they should. We refer to studies on the effects of changes in price on the demand for LTCI and also do not further differentiate different price concepts.

3 Data and identification results

To ensure scientific quality, we limit our review to articles included in the Thomson Reuters Web of Science.¹⁰ The Web of Science covers 18,000 journals in all academic disciplines. We conducted our search on March 8, 2018 using ‘long term care’ AND ‘insurance’ as keywords; publications from 1984 to February 2018 were retrieved by the search engine for further analysis, leading to 1,280 articles with ‘long term care’ and ‘insurance’ in their title, abstract or keywords. Due to overlap with medical, gerontology and other journals irrelevant to our topic, we did not exclude these journals ex-ante, because some articles relevant to economics are included in those journals (e.g., Cramer and Jensen, 2006). Hence, to be more comprehensive in our selection, we examined each paper individually and included all studies on LTC and LTCI from a business, finance and economics point of view, resulting in 591 articles used for further analyses.¹¹

The main path based on the 591 articles is shown in Figure 3 and can be separated into three categories: insurability, demand, country-specific studies.¹² Early studies, beginning with Wiener et al. (1987), focus on restrictions, conditions and insurability of LTC. The group of studies beginning with Pauly (1990) deal with demand and market inefficiencies for LTCI, with a peak of research activity after 2000, especially with the contributions from Finkelstein and McGarry (2006) and Brown and Finkelstein (2007, 2008). Among the most recent works on the main path are country-specific studies and regional comparisons of LTC mechanisms (e.g., Doty et al. 2015; Nadash and Cuellar, 2017). Text mining within the 591 articles (Table 2) lets us also identify five clusters: ‘demand’, ‘financing’, ‘country-specific studies’, ‘demography’ and ‘insurability’. In Section 4, we focus on demand and insurability, included in both the main path and text mining. As our overarching framework, we take financing as third research focus; demographic questions are not the focus of our research. Appendix B contains a review of country-specific studies and a complete documentation of the results.

¹⁰ For identifying main research areas in LTC (applying main path analysis and text mining) we use Web of Science database. However, in the later discussion we also include relevant studies and working papers from other sources.

¹¹ A complete list of all articles and papers included in the review is available upon request.

¹² For clarity, the family name of the first author along with first letter of family name of other authors following the year of the publication is mentioned for each node on the graph.

Figure 3. Main path based on 591 articles

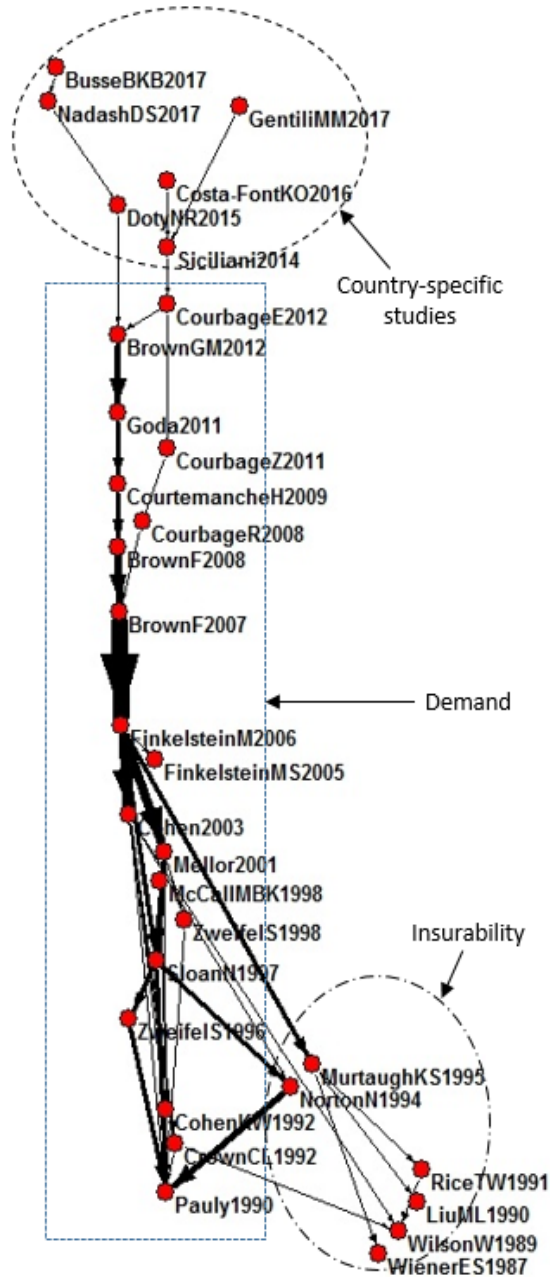


Table 2. Text mining results

<i>Research area / cluster</i>	<i>Keywords (Frequency)</i>
1. Demand	• Market (214) • Demand (159) • Purchase (94)
2. Financing	• Financing (194) • Income (153) • Financial (125)
3. Country-specific studies	• Japan (171) • Germany (112) • Korea (70) • China (59) • United States (41)
4. Demography	• Population (212) • Age (202) • Children (56) • Demographic (53)
5. Insurability	• Benefits (167) • Coverage (164) • Premium (68) • Moral hazard (35) • Underwriting (35) • Adverse selection (34)

4 Evaluation of results

4.1 Financing of long-term care

Table 3 illustrates sources of financing LTC with their pros and cons as discussed in academic papers. We also present the relative importance of the different sources in terms of funding, emphasizing the marginal role of insurance today. Our model of classifying LTC financing

schemes follows Chen (2001)¹³ who proposed three-legged funding model for the U.S., consisting of social insurance, private insurance and personal savings. Mandatory social insurance with basic coverage serves as a safety net. Other voluntary coverages can supplement the base coverage with funding from private sources. Chen (2001) suggests using trade-off principles to compensate for the inefficiencies in both private and public LTC funding. To improve the attractiveness of the private LTC products, he proposes combined (or hybrid) policies. Some of them are addressed comprehensively in the literature, such as life insurance or annuities with LTC riders (e.g., Kyle, 2013). Combined products attempt to increase the use of LTCI, especially by addressing adverse selection. In the public sector, Chen (2001) suggests collecting funds by employment-based contributions so that the majority of the population contributes to the financing and thus ensures the sustainability of the safety net.

Both ex-ante and ex-post funding mechanisms, with some variations, exist in all advanced economies. A system that relies exclusively on private insurance is not likely to work because fluctuating income and unemployment will endanger its financial sustainability (Rothgang and Engelke, 2009). However, by comparing comprehensive LTC financing schemes of social insurance like in Japan or Germany, Campbell et al. (2010) argue that reining in moral hazard effects (as done by private insurers) is also necessary for sustainability. There have also been diverging trends such as an increase of public coverage of LTC expenditures in France, Japan, Spain and Korea, but a decrease in relative terms in Germany, Sweden and the Netherlands.¹⁴ Overall, it is empirically unclear what the optimal mix of financing should look like. It is also likely that there is not one optimal model; the best model might depend on economic, social, cultural and demographic factors. One simple example is that a pay-as-you-go financing scheme will work well in countries with growing populations and economies, but not so well in countries whose economies are stagnating or even declining.

¹³ There are many ways to categorize LTC financing. Wittenberg et al. (2003) propose five categories: private savings, private insurance, private insurance with public-sector support, public-sector tax-based support, and social insurance. Costa-Font et al. (2015) distinguish ex-ante (insurance) from ex-post financing (public sector, family). We rely on Chen's (2001) categorization, because it allows us to make a statement on the empirical relevance using Colombo et al. (2011).

¹⁴ Colombo et al. (2011, p. 79).

Table 3. Financing LTC expenditures

Source of funding			Pros (+) and cons (-) discussed in the literature	Empirical relevance ¹⁵
Public sector	General governmental (excl. social security)	Tax-based sources (e.g., U.S. Medicaid)	+: Provides a safety net for those who are in need.¹⁶ Income and wealth are taken into account (solidarity between rich and poor).¹⁷ Inclusion of entire population.¹⁸ Immediate benefits possible (from day one). -: Labor income taxes may discourage work and decrease savings and consumption (negative purchasing power effects).¹⁹ Vulnerable to government budget constraints;²⁰ reduced incentive to take care of the costs.	52.3%
	Social security	• Inter-generational model (pay as you go)	+: Mandatory enrolment avoids adverse selection problems. Provides coverage for risks that are uninsurable in private insurance. Can adjust to changing circumstances. Democratic legitimacy of restrictions on coverage, e.g., extending or tightening the eligibility based on medical advancements. ²¹	32.0%
		• Intra-generational model (capital funded)	-: Intergenerational models ensure solidarity between generations, but depend on demographics. ²² If limited to employees, non-employed have no coverage. ²³ For intra-generational models immediate benefits are not possible, but models do not depend on demographics and diversification of risk.	
Private sector	Private insurance	Stand-alone LTC policy	+: Covers individuals not eligible for public LTC; offers coverage expansion on top of public system; heritage protection; insurers have an incentive to manage costs. -: Information asymmetry.²⁴ Costly medical tests and exclusion of high risks (e.g., older or chronically ill people).²⁵ Not affordable for many people, because of high premium loadings.²⁶ Lapse risk when income/liquidity varies.²⁷	0.9%
		Combined policy	+: Combining LTC with annuities might mitigate adverse selection and lower administrative costs.²⁸ Annuities mitigate the risk of illiquidity during disability.²⁹ Use of available equity (e.g., reverse mortgage). Expanding coverage to population which is excluded from stand-alone LTCI. -: Relatively complex products.	
	Out of pocket		+: Prevents moral hazard and increases individual responsibility.	13.5%

¹⁵ Average percentage of funding based on Colombo et al. (2011) comparing LTC financing in 23 countries. The remaining 1.3% to complete 100% are other sources mentioned in Colombo et al. (2011). The funding from private insurance ranges from 0% (e.g., the Netherlands) to 9.8% (Belgium) with an average of 0.9%.

¹⁶ Feder et al. (2000).

¹⁷ Ikegami and Campbell (2002).

¹⁸ Glendinning et al. (2004).

¹⁹ Kitao (2015).

²⁰ Yang et al. (2016). It can be considered as both an advantage and disadvantage because a regular political discussion is necessary.

²¹ Barr (2010). While democratic legitimacy of restrictions on coverage is mentioned as an advantage of social insurance, Rothgang (2010) mentions lack of adjustment (or late adjustment) of LTCI benefits as weakness which may result in increasing co-payments and encouraging delegitimization of the insurance system.

²² Rothgang (2010).

²³ Yang et al. (2016).

²⁴ Frank et al. (2013).

²⁵ Comas-Herrera et al. (2012).

²⁶ Brown and Finkelstein (2007).

²⁷ Rothgang and Engelke (2009); Konetzka and Luo (2011).

²⁸ Murtaugh et al. (2001).

²⁹ Weston (2012).

The private insurance market is small but growing. The number of insured in the U.S. rose from 1.7 million in 1992 to 7.2 million in 2014 (NAIC, 2016, p. 9). In Germany, the number of private insurance policies for LTC increased by 65% -- to 3.5 million -- from 2012 to 2017 (Brüss, 2018; Nadash and Cuellar, 2017). The low demand for stand-alone LTC policies has also motivated insurance companies to design combined products that bundle LTC with other risks. Getzen (1988) is one of the early researchers discussing longlife insurance to combine annuities, health insurance and LTC. Bundling different risks has not only the advantage of cost-effectiveness compared to separate purchases,³⁰ but also addresses the insurability problems caused by asymmetric information. For example, by purchasing combined LTCI products that cover both the LTC risks and longevity risk, the problem of adverse selection can be mediated, and strict medical exclusions might be reduced.³¹

Panel A of Table 4 illustrates alternative LTCI policies. The products can be distinguished by 1) purchase time (at younger ages, during retirement, or at the time of LTC need), 2) timing of premium payment (at younger ages, during retirement, at the time of LTC need, or after death using whole life insurance or other assets, such as real estate, as collateral) and 3) coverage (complete or only partly; in cash or in kind).³² One of the latest innovation discussed in the literature is the variable life care annuity with guaranteed lifetime withdrawal benefits,³³ providing protection against shortfalls of income through guaranteed income streams and including an LTC rider.

Panel B of Table 4 depicts some alternative financing methods that go beyond the idea of risk pooling provided by insurance. The equity release uses the value of a house to finance LTC expenditures, but no risk pooling is done. The LTC bond is a pure savings product that is inheritable in case of non-use for LTC services and the consortium³⁴ issues the right to future LTC services in exchange for payments today.

³⁰ Murtaugh et al. (2001).

³¹ Murtaugh et al. (2001); Brown and Warshawsky (2013).

³² There are some alternative products for traditional LTCI such as short-term care insurance (STCI or convalescent insurance) and critical-illness insurance (critical-care) which provide partial LTC coverage in terms of period (STCI is generally less than one year coverage) or limited risks (critical-care covers only specified serious illnesses such as cancer or stroke).

³³ Hsieh et al. (2017).

³⁴ See Shilling (1991) for the formation, structure and operation of the consortium. In his study, he defines a consortium as a group of proprietary facilities that provides LTC.

Table 4. Alternative insurance and financing models

Category		Definition
Panel A: Insurance models		
Annuity	Life care annuity	Combination of a deferred ³⁵ or immediate ³⁶ annuity with LTC disability coverage at retirement; pays retirement income along with increased benefit; the amount of annuity may be set according to the level of frailty. ³⁷ The annuity can be paid when the insured is in need of LTC.
	Enhanced annuity	Targets people who are entering or are already in a nursing home. Based on higher mortality assumptions and payment of single premium, the coverage offers an enhancement in the amount of annuity. ³⁸
	Enhanced pension	Specific model of life care annuity offered at the time of retirement. It provides an increased annuity payment if LTC is needed; the premiums are collected by reduced annuity payments while the retired person is still healthy. ³⁹
	Variable life care annuity with guaranteed lifetime withdrawal benefits (LCA-GLWB)	Combination of LzTCI and a variable annuity with guaranteed lifetime withdrawal benefits. The guaranteed income component protects the insured against downside risk, and the LTC component protects him against LTC expenses. ⁴⁰
Life insurance	Accelerated life insurance ⁴¹	Whole life insurance with monthly benefits paid to cover LTC expenses up to death. ⁴²
	Life insurance with LTC rider	Pays the actual cost of LTC services up to a limit or a fixed indemnity charge. It is offered to people near their retirement age. It can be structured either as a reduced benefit amount from the cash value of the life insurance part of the policy or as an additional benefit requiring a single premium. Universal life policies may be a good option for this benefit. ⁴³
	Lifestage LTC product	Term life insurance up to specific retirement age and change of cover to LTCI afterward with the same premium and coverage amount. ⁴⁴
Disability insurance	Combined disability coverage	A disability insurance policy that protects the insured against the shortfall in income caused by disability. The coverage may give the option to convert the disability insurance policy to LTC policy after retirement without the need for medical underwriting. ⁴⁵
Combination of annuities and health insurance	Longlife insurance	Covers costs of chronic illness (i.e., any cost related to nursing care in any facility or any medically necessary home health care) during retirement based on specific daily benefits for each of the coverages. In addition, it provides monthly payments after age 76 regardless of the health status of the insured. The premium is collected based on

³⁵ Webb (2009).

³⁶ Murtaugh et al. (2001); Spillman et al. (2003).

³⁷ Pitacco (1999).

³⁸ Ibid.

³⁹ Ibid.

⁴⁰ Hsieh et al. (2017).

⁴¹ Freiman (2007); Mayhew et al. (2010); Pitacco (1999); LTC cover as a rider benefit; that is the same concept as equity release (with life insurance as underlying equity).

⁴² Pitacco (1999); Spillman et al. (2003).

⁴³ Weston (2012).

⁴⁴ Own Your Future Minnesota (2015).

⁴⁵ Freiman (2007).

<i>Category</i>		<i>Definition</i>
		initial lump sum paid at the beginning of retirement along with monthly premiums up to the end of longlife contract. ⁴⁶
Health insurance	Whole life health insurance ⁴⁷	Combination of permanent health insurance with LTC coverage, covering 'own or similar occupation' disability before retirement and LTC annuity paid based on frailty.
Panel B: Financing models		
LTC bonds	Personal care savings bonds ⁴⁸	Regular bond which is liquidated in the event of LTC or death, but a small proportion of its value will be used for funding periodic cash prizes.
LTC put option	Consortium	Consortium of LTC providers issues securities to the public. They are put options the proceeds of which are to be used for financing LTC services.
Equity release	Reverse mortgage ⁴⁹	Homeowner receives LTC coverage by taking a loan (a lump sum or annuity payment) and has lifelong access to his home; the payments for the loan will be collected after the death of the insured or selling the equity. ⁵⁰
	Home reversion plan ⁵¹	Selling (partly or in total) the equity in exchange for a lump sum based on private arrangements. The homeowner has the right to stay in his property as long as he lives or moves out.

4.2 Demand for long-term care insurance

Table 5 categorizes the research findings on LTCI demand using the Outreville (2013) demand framework into four major groups – economic, social and cultural, structural and demographic factors – for a total of 20 factors.⁵² Twelve of the 20 factors are clear in their prediction and consistent with observations from other insurance markets (see Outreville, 2013; Eling et al. 2014). More income,⁵³ education, knowledge, experience,⁵⁴ beliefs about worse future

⁴⁶ Getzen (1988).

⁴⁷ Pitacco (1999); Mayhew et al. (2010).

⁴⁸ Mayhew and Smith (2014) argue that the cash prizes offered by PCSBs are similar to lottery tickets which are more attractive for low-income people.

⁴⁹ Ahlstrom et al. (2004).

⁵⁰ The idea is mentioned in earlier studies by Sawyer (1996) and Rasmussen et al. (1997). Mayhew et al. (2017) introduce similar products for UK market called 'equity-for-insurance' and 'equity bank' products. The former product collects insurance premiums in exchange for the whole or a percentage of the equity value after the death of the homeowner. The latter provides the homeowner or his dependents with income or annuity, during his remaining lifetime, and the debt will be paid after the death of the homeowner.

⁵¹ See Alai et al. (2014) and Hanewald et al. (2016).

⁵² Some LTCI demand studies consider actual purchase decisions (e.g., Mellor, 2001 and Sperber et al., 2017), while others test demand and willingness to pay (e.g., Brau and Bruni, 2008). Both approaches have their limitations and are included in our review. While studies with actual purchase decisions might be biased towards risks that are not excluded by insurance companies, studies that test the intention to purchase do not know whether it really reflects real-world behavior. We also note that a few other demographic aspects were studied in the literature such as race, ethnicity and their effect on the ownership of LTCI (Headen Jr, 1992, Sloan and Norton, 1997, Cramer and Jensen, 2006 and McGarry et al. 2013).

⁵³ Courbage and Roudaut (2008) illustrate a non-linear bell-shaped effect of income on demand, emphasizing that only a fraction of the population is interested in LTCI; poor people cannot afford it while extremely wealthy people can pay the potential costs out-of-pocket.

⁵⁴ Only Kumar et al. (1995) report negative effect of experience on demand for LTCI. They state that most of LTCI policies available at the time of survey did not provide significant home health coverage.

conditions, whether economically or socially, trust in insurance and providers and being a woman⁵⁵ all increase demand for LTCI.⁵⁶ An increase in price, substitutes for LTC (via public insurance), intra-family moral hazard and state-dependent utility negatively impact the demand for LTCI. Finally, risk aversion has an insignificant effect on demand.⁵⁷

Table 5. Main factors affecting LTCI demand

<i>Category</i>	<i>Sub-category</i>	<i>Results with respect to LTCI demand</i>
Economic Factors	Price	-: Cohen et al. (1992), Cramer & Jensen (2006), Schaber & Stum (2007), ⁵⁸ Brown et al. (2012), Wang et al. (2018).
	Income	+: Kumar et al. (1995), McCall et al. (1998), Mellor (2001), Cramer & Jensen (2006), Schaber & Stum (2007), Brau & Bruni (2008), Wang et al. (2018); Courbage & Roudaut (2008): non-linear bell-shaped.
	Wealth ⁵⁹	+: McCall et al. (1998), Mellor (2000), Mellor (2001), Chatterjee & Fan (2017). 0: Kumar et al. (1995). -: Costa-Font & Rovira-Forns (2008): owning house or flat; Davidoff (2008), Davidoff (2010): home equity.
	Bequest motives	+: Pauly (1990) ⁶⁰ , Cramer & Jensen (2006), Courbage & Roudaut (2008, 2011), Brown et al. (2012), Chatterjee & Fan (2017). 0: Sloan & Norton (1997), Lin & Prince (2016), Sperber et al. (2017). -: Zweifel & Strüwe (1996,1998), Eisen & Sloan (1996), Courbage & Zweifel (2011), Zweifel & Courbage (2016), Lockwood (2018).
Social and Cultural Factors	Education	+: Kumar et al. (1995), Sloan & Norton (1997), McCall et al. (1998), Mellor (2000), Mellor (2001), Cramer & Jensen (2006), Chatterjee & Fan (2017), Wang et al. (2018). 0: Costa-Font & Rovira-Forns (2008).
	Knowledge	+: Cohen et al. (1992): lack of information; Schaber & Stum (2007), Zhou-Richter et al. (2010): adult children awareness; Gottlieb & Mitchell (2015): ⁶¹ use of many information sources; Lin & Prince (2016): awareness of Partnership Program and financial literacy; McGarry et al. (2016): numerical literacy.
	Experience	+: McCall et al. (1998), Coe et al. (2015): having family member or friend in need of LTC; Courbage & Roudaut (2008, 2011): experience of disability; Finkelstein et al. (2012), Tennyson & Yang (2014): previous caregiving experience. 0: Cramer & Jensen (2006): experience of individual's own parents. -: Kumar et al. (1995): previous caregiving experience.

⁵⁵ Costa-Font and Rovira-Forns (2008) explain their insignificant results by the fact that a part of the gender effect is captured by the effect of the individual's own disability risk perceptions.

⁵⁶ Our focus in this study is the demand for LTCI in general. However, articles such as Meier (1999) focus on the postponement of purchasing LTCI by young generation and its reasons.

⁵⁷ Costa-Font and Rovira-Forns (2008) attribute this insignificant effect to the fact that risk-averse people may prefer to protect themselves through other means such as protective savings and self-insurance.

⁵⁸ They study the effects of group LTCI enrollment decision (and affordability of LTCI instead of price).

⁵⁹ Various categories of wealth are considered here such as net worth, asset, and net asset.

⁶⁰ Pauly (1990) argues that individuals protect the bequest by buying insurances, such as LTCI and life insurance, and he believes the demand for LTCI would be higher among those who purchase (term) life insurance. However, Meier (1998) does not find any systematic correlation between demand for life insurance and the demand for LTCI.

⁶¹ Gottlieb and Mitchell (2015) define 'narrow framing' as people's tendency to make decisions in isolation.

Category	Sub-category	Results with respect to LTCI demand
	Beliefs	+: Kumar et al. (1995): increased expectation of LTC cost; Sloan & Norton (1997): probability of being at nursing home; McCall et al. (1998): belief of having no caregiver and independence from government in LTC expenditures; Brown et al. (2012), Chatterjee & Fan (2017): need for care in future; Sperber et al. (2017): belief of autonomy; Finkelstein & McGarry (2006): belief about the likelihood of entering nursing home; Pincus et al. (2017): promoting emotional frame; Schaber & Stum (2007): belief of higher risk.
	State-dependent utility	-: Brown et al. (2012), Brown & Finkelstein (2009).
	Intra-family	0: Mellor (2001).
	moral hazard	-: Pauly (1990), Zweifel & Strüwe (1996, 1998), Zweifel (1996), Sloan & Norton (1997). ⁶²
	Current health status	+: McCall et al. (1998), Cramer & Jensen (2006); Courbage & Roudaut (2008, 2011): having high-risk factors of dependency. ⁶³ 0: Mellor (2001). -: Schaber & Stum (2007), Costa-Font & Rovira-Forns (2008).
	Risk aversion	0: Finkelstein & McGarry (2006), Costa-Font & Rovira-Forns (2008).
	Trust in insurers	+: Finkelstein & McGarry (2006): strong taste for insurance; Brown et al. (2012): ⁶⁴ trust in insurers; Chatterjee & Fan (2017): preference for risk management through other types of insurances.
Structural Factors	Substitutes for LTCI: family resources	+: Courbage & Roudaut (2008). 0: Mellor (2001). -: Brown et al. (2012), Costa-Font & Courbage (2015): financial support by family.
	Substitutes for LTCI: public insurance	0: Brown et al. (2012); Costa-Font & Courbage (2015): expectation of public payment for insurance. -: Sloan & Norton (1997), ⁶⁵ Brown et al. (2007), Brown & Finkelstein (2008), Zweifel & Courbage (2016).
	Tax Incentives	+: Cramer & Jensen (2006). 0: Courtemanche & He (2009), Goda (2011), Nixon (2014); Lin & Prince (2013): Partnership in Medicaid.
Demo-graphic Factors	Age	+: Schaber & Stum (2007); Costa-Font & Rovira-Forns (2008): higher for middle age. 0: Chatterjee & Fan (2017). -: Kumar et al. (1995), Wang et al. (2018).
	Gender (women)	+: Kumar et al. (1995), Chatterjee & Fan (2017). 0: Costa-Font & Rovira-Forns (2008).
	Marital status (married)	+: Kumar et al. (1995), Courbage & Roudaut (2008 & 2011), Brown & Finkelstein (2009). 0: Sloan & Norton (1997); Cramer & Jensen (2006): results vary depending on different range of assets. ⁶⁶
	Children	+: Courbage & Roudaut (2008, 2011). 0: Sloan & Norton (1997); Costa-Font & Rovira-Forns (2008): household size. -: Cramer & Jensen (2006); Schaber & Stum (2007): family size.

Note: + (-;0) denotes a positive (negative, insignificant) relationship between the change in a factor and LTCI demand.

The other eight factors are inconclusive and sometimes even contradictory in their predictions. While higher wealth generally leads to more demand for LTCI, some studies report that home

⁶² They find self-evaluated probability of being in a nursing home in five years is significant. However, for a time frame of 10-15 years it is not.

⁶³ These factors are defined as smoking, drinking alcohol and critical level of body mass index.

⁶⁴ They find that lack of trust in insurers negatively affects the demand for LTCI.

⁶⁵ For people over age 70, the correlation is negative but for the 51-64 age cohort it is not.

⁶⁶ Married people with assets in the middle range have positive correlation, otherwise negative.

equity reduces the demand for LTCI.⁶⁷ This result is also linked to the inconclusive results for bequest motives. Lockwood (2018) argues that inconsistencies of retirees' saving and insurance choices match with models in which bequests are considered luxury goods compared to standard life-cycle models where people care only about their own consumption. He argues that bequest motives, by reducing the opportunity cost of precautionary efforts, decrease the value of insurance and might therefore explain a lower demand for late-life risks. Moreover, financial family support has a negative effect on the demand for LTCI.

Unobserved bad health status leading to more demand for LTCI is one of the fundamental information asymmetries in this market. A positive effect of health status documented in some studies might be due to potential empirical bias that LTCI policyholders are already filtered by exclusions from the insurers underwriting process.⁶⁸ Courbage and Roudaut (2008) have addressed substitutes such as informal care from family. In their study of the French population, they cite altruism as a reason for positive effect of informal care and the demand for LTCI. However, Mellor (2001) shows that caregiver availability does not discourage parents from buying LTCI.⁶⁹ Within the category of structural factors, it is also not clear whether tax incentives have a positive or insignificant impact on LTCI demand.⁷⁰

Costa-Font and Rovira-Forns (2008) report that middle-aged people have more demand for LTCI than other age cohorts. Chatterjee and Fan (2017) find an insignificant effect of age on LTCI demand. They argue that while many studies find demand to increase with age, the insignificant effect may be due to offsetting effect of health and perceived risk along with increase in premiums based on age. Moreover, Kumar et al. (1995) and Wang et al. (2018) find that the demand for LTCI decreases with age, perhaps because of the reduced expected value

⁶⁷ The same is observed for other measures related to home equity, such as having a larger home equity to wealth ratio (see Davidoff, 2008).

⁶⁸ McCall et al. (1998).

⁶⁹ Other types of private insurance such as (the surrender value from) classical life insurance without LTC rider or critical illness insurance (for diseases that might result in LTC) might be interpreted as a third category of substitutes next to public insurance and the family.

⁷⁰ Cramer and Jensen (2006) note that the demand for coverage is price-inelastic; a \$1,000 decrease in the annual premium would cause only an increase of 0.01 (on a scale of 0 to 1) in the probability of an individual purchasing LTCI. It thus seems that premium subsidies or intense price competition may not stimulate the demand for insurance. Overall, it is not fully understood under which conditions premium subsidies or tax incentives are an effective and efficient tool for promoting LTCI demand.

of coverage.⁷¹ A more detailed study of potential non-linear and interaction effects might be needed to better explain the ambiguous results of age on LTCI demand.^{72/73}

The effects of marital status and number of children are also mixed. While Courbage and Roudaut (2008, 2011) explain the positive relationship between being married and having children and LTCI demand by altruistic behavior, Cramer and Jensen (2006) argue the opposite: that the negative effect of having children on LTCI demand may be attributable to expectations on the part of parents for their children to provide informal care as a substitute for formal care. Courbage and Zweifel (2011) theoretically prove the existence of a two-sided (bilateral) intergenerational moral hazard in which purchase of LTCI by parents decreases the child's incentive to provide informal care, and in the meantime, parents purchase less LTC coverage, expecting their child's efforts to keep them out of a nursing home. In a survey conducted in China, Xu and Zweifel (2014) find a similar two-sided intergenerational moral hazard on respondents' statements. However, they do not confirm the evidence of the effects of exogenous changes, such as more parental wealth and higher expected inheritance for the child, on intergenerational moral hazard.⁷⁴ Overall it seems that many of the inconclusive and contradictory results are explained by interactions among economic, social and demographic factors. More research might thus be needed to untangle those interaction effects in order to derive cleaner predictions for those factors.

4.3 Insurability of long-term care

Applying Berliner's (1982) insurability criteria to LTC risk, we now systematically analyze the problematic features of LTC risk and identify the major impediments to the development of the LTCI market (see Table 6).⁷⁵ We identify and discuss four problem areas.

⁷¹ Kumar et al. (1995) states that as the probability of the LTC need increases, the utility value of purchasing fair (or constant load) insurance to meet that needs falls, and self-insurance becomes more attractive. An additional explanation is the age variation in prices.

⁷² Wang et al. (2018) also mention that higher demand in younger cohorts in China may be due to the strict one-child policy that was in effect at the time of their birth. They may feel a greater need for LTC coverage than their elders.

⁷³ Ambiguous results with respect to age are also documented in other insurance markets. These results, however, may reflect the U-shaped relationship as identified in Cohen and Einav (2007) and Halek and Eisenhauer (2001). Similar tests seem warranted in the LTCI market.

⁷⁴ While Courbage and Zweifel (2011) theoretically predict that more parental wealth and higher level of expected inheritance induce intergenerational moral hazard whose net effect would lead to purchase of less LTCI coverage, Xu and Zweifel (2014) argue the lack of such predictions in China may be interpreted as traditional Chinese view of the importance of filial piety, which means children do more to support their ailing parents, no matter how much LTC coverage the parents have.

⁷⁵ The insurability model is defined from an insurance carrier point of view and analyzes the risks at the aggregate portfolio level (not individually). It maps out the major factors that should be taken into account by

Randomness of loss occurrence: There are two criteria for analyzing randomness: independence and predictability. The need for formal LTC depends on many factors such as lifespan (with and without disability) and presence of family support (Kessler, 2008), which do not seem critical to independence. Barr (2010) argues that the LTC probability may not be independent, but rather interdependent. Because of technological progress and increasing life expectancy, there might be an upward trend in LTC probability due to multi-morbidity and dementia in later life. For instance, medical advancements have improved addressing cardiovascular disease, which will increase the life expectancy of elders who are now more prone to dementia. This effect is, however, not trivial, because connecting future life expectancy and historical morbidity data neglects the finding that the morbidity of the future population might also be different.⁷⁶ While there are difficulties in describing morbidity and variations in the population morbidity,⁷⁷ some empirical studies conclude that there has been morbidity compression in recent years,⁷⁸ while others do not.⁷⁹ Moreover, conditions such as random fluctuations, lack of complete knowledge of relevant probabilities, long time dimensions and the dynamic nature of the environment affecting LTCI make LTC predictions difficult.⁸⁰ It is not only that multi-state models are more difficult to estimate and calibrate than single-state models (both conceptually and empirically), but there is a limited understanding of how the future of LTC might look.⁸¹

practitioners (for product design) or policymakers (for institutional framework) to improve insurability. Although leading to some overlap in the demand factors, we believe that the consideration of both the Outreville (2013) insurance demand framework and the Berliner (1982) insurability criteria provides a value added, because it highlights the fundamental points from two different perspectives.

⁷⁶ An example is that future dementia might be overestimated just by connecting the number of elderly people in the future with today's dementia occurrences and neglecting changes in dementia occurrences.

⁷⁷ Crimmins and Beltrán-Sánchez (2011).

⁷⁸ Stallard (2016).

⁷⁹ Crimmins and Beltrán-Sánchez (2011).

⁸⁰ Brewster and Gutterman (2014).

⁸¹ In a personal conversation, Christian Mumenthaler, CEO of Swiss Re, called LTC 'science-fiction' insurance, because insurance companies have no idea what LTC will look like in ten or 20 years. While insurance companies can limit the amount or coverage period, it is unclear whether this amount and time is sufficient.

Table 6. Assessment of insurability for LTC risk

<i>Insurability criteria</i>	<i>Main findings</i>	<i>Assessment</i>
<i>Actuarial</i>	(1) Randomness of loss occurrence	• Losses are independent (but may be interdependent). • Long time dimension of the risk along with the dynamic nature of the environment affecting LTCI makes predictability difficult. • Actuarial basis for calculating LTCI premiums is not yet well developed in many countries. • Intertemporal risks such as inflation affecting cost of care cannot be diversified between age cohorts. <i>problematic</i>
	(2) Maximum possible loss	• Possible portfolio loss may increase because of demographic factors and medical enhancements.⁸² • Insurance companies protect themselves by limits on either payout⁸³ or duration of coverage.⁸⁴ <i>not problematic</i>
	(3) Average loss per event	• The average loss for LTC may increase due to long-term nature of the risk and increase in medical costs or decrease due to morbidity compression.⁸⁵ • Insurance companies prefer providing indemnity-based benefit rather than service benefits to better calculate the average losses.⁸⁶ <i>not problematic</i>
	(4) Loss exposure	• Loss exposure may increase by aging baby-boomers. • It depends on the structure of population age cohorts. <i>not problematic</i>
	(5) Information asymmetry	• Existence of both adverse selection and moral hazard. • Possible existence of intra-family moral hazard. • Insurers exclude the higher risk individuals by use of medical scanning at the inception of cover. <i>problematic</i>
<i>Market</i>	(6) Insurance premium	• High loading needed because of uncertainty with respect to future losses and information asymmetry. • Low demand (only educated middle-income class people with experience and pessimistic outlook are interested). • Demand is rather inelastic with respect to price indicating that subsidies may not be very effective. <i>problematic</i>
	(7) Cover limits	• Intertemporal risk⁸⁷ encourages insurers to put limitation for their coverage. • Exclusion of people with pre-existing health conditions. <i>problematic</i>
<i>Society</i>	(8) Public policy	• The coverage is consistent with societal values. <i>not problematic</i>
	(9) Legal restrictions	• Coverage is allowed in all jurisdictions. <i>not problematic</i>

⁸² Kyle (2013).

⁸³ Barr (2010).

⁸⁴ Comas-Herrera et al. (2012).

⁸⁵ Payne et al. (2007) study the impact of aging on health care expenditures and find that the duration and severity of morbidity increase with age. However, Schut and van den Berg (2010) address the healthy aging process that leads to longevity gains for the population. He states that the occurrence of this process is mixed. In addition, Stallard (2016) discusses comprehensively the compression of morbidity and mortality period based on empirical data.

⁸⁶ Cutler (1996) illustrates this issue by describing indemnity payments that are fixed in amount (daily benefit) and time, comparing to the real expenses of LTC services, which may exceed the daily benefits.

⁸⁷ Ibid. The risks associated with long-term insurance policies arising from decreasing accuracy of predictions.

While many studies use Markov models for pricing LTCI,⁸⁸ the research has focused on the future evolution of mortality and disability transition intensities.⁸⁹ The complex effects of the processes of aging⁹⁰ (i.e., disability and cognitive impairment), death probabilities for both autonomous and disabled people, pathological information and longevity gains in the late 20th century⁹¹ and time spent in dependency⁹² illustrate the need for comprehensive models for pricing LTC risks. More research is thus needed to improve the modeling and empirical basis for LTCI as well as the drivers of LTC probability, duration and intensity.⁹³

Information asymmetry: Early studies by Cutler (1996) or Chen (2001) cite both adverse selection and moral hazard as main insurability limitations. In the meantime, there is clear empirical evidence for adverse selection. For example, Oster et al. (2010) find strong evidence of adverse selection in LTCI analyzing individuals' genetic information.⁹⁴ Zick et al. (2005) report that adverse selection exists for people who were diagnosed with Alzheimer's disease.⁹⁵ When it comes to moral hazard, Li and Jensen (2011) and Konetzka et al. (2014) discuss the effect of having LTCI on the likelihood of using nursing home care. The moral hazard issue in LTC can also occur as an intra-family moral hazard in which changes in caregivers' behaviors may affect LTCI demand and losses.⁹⁶ Various kinds of LTCI benefits, such as fixed versus proportional, may affect the kind and the intensity of intra-family moral hazard.⁹⁷ Insurance companies deal with adverse selection by medical screening and exclusions, especially for

⁸⁸ See Levikson and Mizrahi (1994), Pitacco (1995), and Haberman and Pitacco (1998) for early works.

⁸⁹ See Levantesi and Menzietti (2012) and Fong et al. (2015).

⁹⁰ Pritchard (2006).

⁹¹ Biessy (2017).

⁹² Fuino and Wagner (2018).

⁹³ The actuarial basis for calculating LTCI premiums is not well developed in many countries (the probability estimates of LTC are more accessible in the U.S. than in European and Asian countries), but is getting better (see, e.g., Fuino and Wagner, 2018 for Switzerland). Furthermore, the cost of care that is covered by LTCI is exposed to intertemporal risk. Cutler (1996) argues that inflation affects all members of the insurance pool by gradual increase of the costs of services. Hence, it would be more difficult for an insurance company to pool such an interdependent risk. See Karlsson (2002).

⁹⁴ They use data from individuals at risk for Huntington disease (HD) and find that those who carry the HD genetic mutation are up to five times more likely to buy LTC than are individuals from the population without that mutation.

⁹⁵ Seventeen percent of applicants who tested positive changed their LTCI coverage in the year following the test. This rate was 2% for people who tested negative, and 4% for those who did not receive the disclosure of their APOE (Apolipoprotein E). Studies of lapse behavior in LTCI also discuss dynamic adverse selection, in which the insured may decide to cancel his policy when his health improves. See Finkelstein et al. (2005) mentioning this inefficiency in the private LTCI market. Konetzka and Luo (2011) mention factors such as the characteristics of the individuals who cancel their LTC policies. They state that health status plays a small role in the decision to allow a policy to lapse. They also find small evidence of ex-post adverse selection based on health status, and conclude that LTCI lapse is usually based on financial problems rather than changes in health risk. Basu (2016) also confirms the low economic conditions of the individuals as the factor affecting the lapse decision, and they find evidence of ex-post advantageous selection.

⁹⁶ See Pauly (1990); Zweifel and Strüwe (1996); Zweifel (1996); Zweifel and Strüwe (1998).

⁹⁷ See Klimaviciute (2017).

those with pre-existing health conditions.⁹⁸ Combined policies might help to resolve some of the information problems.

Insurance premium: Kessler (2008) mentions three problems that insurers face in pricing LTCI. The first is the substantial uncertainty in LTC cost projections, resulting in substantial uncertainty on future loss payments. The second risk is adverse selection, which requires insurers to set high loadings on the premiums. The third risk is moral hazard. Obviously, the insurability problems here are the natural consequence of the latter two aspects discussed above. Brown and Finkelstein (2007) consider the high premium loadings to be a signal of supply-side market failure. As discussed above (Cramer and Jensen, 2006), subsidies or tax incentives reducing the effective price of LTCI are very likely not a general solution to the problem.

Cover limit: Insurance companies need limits on daily benefits and coverage period to protect against uncertainties⁹⁹ and inefficiencies such as adverse selection and moral hazard.¹⁰⁰ These cover limits also interact with factors such as public LTC. In addition, the tendency to provide an indemnity benefit rather than a service benefit may discourage individuals from purchasing private LTCI, because they are unsure whether coverage is sufficient.

To conclude, both supply-side and demand-side factors are used to explain the small market for private LTCI and thus reduced insurability. Among the supply-side explanations are high loadings on the actuarial fair price and rationed coverage (Brown and Finkelstein, 2007) that result from significant actuarial uncertainties and asymmetric information. It seems, however, that supply-side constraints alone are not significant enough to be blamed for the small market size.¹⁰¹ Limited consumer knowledge or rationality, state-dependent utility (i.e., a low value of consumption while in care), and the existence of potential substitutes for formal insurance are important demand-side explanations that reduce the insurability. Potential substitutes can be any informal financial or in-kind insurance provided by families, illiquid housing equity that

⁹⁸ See Hendren (2013) for existence of more private information for those who are rejected by an insurer.

⁹⁹ Barr (2010).

¹⁰⁰ Colombo et al. (2011).

¹⁰¹ Brown and Finkelstein (2007, 2008). Focusing on the demand side, Ameriks et al. (2016) study the under-insurance in late-life risks by designing an idealized insurance product that does not have the defects of the LTCI policies available in the market. They then quantify the demand for their new product based on survey data and compare it with the demand for a normal LTCI product; their model predicts 59% of the sample will want to purchase their policy, while only 22% of the sample already has LTCI. This gap sheds light on unmet demand in the market.

may be liquidated to pay for care, or public insurance provided, for instance through Medicaid in the U.S. Information asymmetries have also been the center of attention in many studies.¹⁰²

5 Summary and directions for future research

Table 7 summarizes our results and proposes avenues for further research. The list of research directions presented in the Table is based on a structured review of recent papers and the papers on the main path which is provided in Table C1 in Appendix C. As one might expect for an applied research topic such as LTCI, the recommendations are intended both for academic researchers and for practitioners. While the majority of research topics are addressed to researchers who must produce conceptual work and conduct empirical tests, most of the outcomes of such studies have implications for a practitioner audience.¹⁰³

Table 7. Summary of results and potential future research

<i>Financing</i>	<i>Demand</i>	<i>Insurability</i>
Panel A: Summary of results		
• Mix of ex-ante (insurance) and ex-post (public sector, family) used in all advanced economies. • Contribution of private LTCI is marginal. • Combined insurance policies and alternative financing models might help to increase demand and improve sustainability.	• 20 factors have empirically been studied with respect to their impact on LTCI demand. • 12 factors are relatively clear in their prediction and in general in line with observations from other insurance markets.¹⁰⁴ • The other eight factors are inconclusive or contradictory.¹⁰⁵	• High premium loadings and rationed quantities needed because of uncertainty with respect to probability, intensity and duration of LTC and information asymmetries. • Reduced interest also on the demand side (low value of consumption while in care, existence of public and private substitutes).
Panel B: Potential future research		
• Optimal mix of public and private funding. • Interaction with other parts of welfare (e.g. pension schemes). • Wealth trajectories in retirement / life-cycle models. • Non-linear LTCI policies. • Swap with cash flows depending on the survival of disabled people.	• Impact of culture on formal and informal care. • Non-linear and interaction effects, e.g., with respect to income or age. • Role of taxes / premium subsidies. • Two-sided altruism. • Emotional framing vs. rational framing.	• Morbidity data (more data with better quality, more countries). • Better models for calculating risks and prices. • Alternative Risk Transfers (ART) to cover LTC risk. • Lapse of LTCI. • Risk preferences in the context of asymmetric information.

¹⁰² See Finkelstein and McGarry (2006), Webb (2009) and Sloan and Norton (1997).

¹⁰³ For example, the development of better datasets is mainly a to-do for practitioners, but if they exist, they are an important input for research. At the same time, the development of better models for calculating risk and prices is a primary task for researchers, but if the models exist, they might be well applied in the industry. It is thus difficult, if not impossible, to identify which recommendation specifically addresses researchers or practitioners.

¹⁰⁴ More income, education, knowledge, experience, future beliefs related to future worse condition, trust in insurance and providers and being female increase the demand for LTCI. An increase in price, substitutes for LTC, intra-family moral hazard and state-dependent utility reduce the demand for LTCI. Risk aversion has an insignificant effect on demand.

¹⁰⁵ Wealth, bequest motives, health status, substitutes such as informal care from family, tax incentives, age, marital status, and number of children are inconclusive or ambiguous.

New methods and products are needed for financing the rise of LTC expenditures.¹⁰⁶ Some studies propose combined policies and other innovative ideas to compensate for inefficiencies such as adverse selection in the private LTCI market. Recent examples are reverse mortgages, variable life care annuities with guaranteed lifetime withdrawal benefits and personal care saving bonds. While social insurance and tax-based financing may provide universal coverage to all the population, in the long run the significant increases in public expenditures might question the sustainability of these types of funding.¹⁰⁷ Moreover, other effects of public financing of LTCI, such as crowding-out effects on private savings and informal care should be treated cautiously.¹⁰⁸ Recent studies have taken both information asymmetry and sustainability problems into account, and propose to embed LTCI costs in the Notional Defined Contribution (NDC) pension schemes as optimal method of financing of LTC expenditures.¹⁰⁹ Implementation of such proposals may need further study on requirements and major obstacles to the transition from other methods of financing to new ones.¹¹⁰ Blundell et al. (2016) compare retirement wealth trajectories in the U.S. and England. Their study addresses the importance of constructing a life-cycle model that explains different asset trajectories during retirement in various countries. While they mention the necessary ingredients of such model as bequest motives, risk of health expenses and consideration of housing as a distinct asset, the literature on this field is still immature. Further research is needed, for example, to describe the determinants of housing wealth release during retirement.

Four categories of factors (economic, social and cultural, structural, demographic) influence the demand for private LTCI; social and cultural factors are the most-frequently mentioned in the literature. The recent study by Gentili et al. (2017) gives new insights into cultural

¹⁰⁶ De la Maisonneuve and Martins (2015) categorize the determinants of LTC expenditures in demographic and non-demographic drivers. In the demographic part the transformations of the population towards older ages increases the number of old people. However, whether this leads to higher number of people needing LTC depends on the development of disability rates among older generations (de Meijer et al., 2012). Disability trends seem to vary across countries; while some countries experience a decline in disability prevalence rates in elderly people (e.g., Denmark, Finland, and Italy) others experience stability (such as Australia and Canada) and even growth (Belgium, Japan, and Sweden); see Colombo et al. (2011). The dynamics of disability prevalence rates in different periods and countries is one of the major obstacles for predicting the effect of demography on future LTC expenditures and needs to be better understood. Non-demographic drivers such as the price of LTC (driven for example by productivity and labor costs), increase in demand for formal LTC (decline in availability of informal care-givers) and income effects (rise in real incomes leading to demand for higher quality services) are other factors determining LTC expenditures.

¹⁰⁷ Colombo and Mercier (2012); Angelis et al. (2017).

¹⁰⁸ See Xu and Zweifel (2014) on the analysis of public expenditures in China and Courbage and Zweifel (2015) on the effect of means-tested public provision on crowding-out effects of private savings and informal care.

¹⁰⁹ See Pla-Porcel et al. (2016); Ventura-Marco and Vidal-Meliá (2016); Vidal-Meliá et al. (2018); Pla-Porcel, et al. (2017).

¹¹⁰ See Meier (1996) for the analysis of moving from private funding system to a social aid regime and from the latter to the compulsory insurance regime and their effects on LTCI and savings.

differences and their role in the demand for private LTCI along with public expenditures. They study the cultural differences in different regions of Switzerland and their effect on optimal coverage and public plans provided by the government. This study might be extended to other countries to examine the role of culture on demand for formal and informal care, as well as its effect on the optimal method of financing LTCI.

Some studies mention non-linear effects of the demand side. Courbage and Roudaut (2008), using data from France, find a bell-shaped relationship between income and the demand for private LTC; in other words, demand is low for low- and high-income individuals but higher for middle-income individuals. This non-linear pattern could be studied in a cross-country setup. Next to country effects, interaction effects (e.g., with respect to age) might be considered in such a setup, for example to analyze a potential U-shape between age and LTCI demand (Cohen and Einav, 2007; Halek and Eisenhauer, 2001).

Brown and Finkelstein (2008) explore the interaction of public and private insurance in the U.S. They estimate the implicit tax for a median-wealth man to be 60% and for a median-wealth woman to be 75%. Implicit tax is the amount of premium that should be paid to private LTCI for similar coverage that would have been covered by Medicaid (meaning that the private policy replaces 60% of benefits otherwise covered by Medicaid; so the implicit tax is 60%). It would be worthwhile to compare different tax-based systems of funding LTCI on this criterion and compare the results. This will improve our understanding of the relation between implicit tax and the demand for private LTCI and the interaction between public and private activities in general. Moreover, the dynamics of changes in implicit tax due to recent reforms have the potential for future research. Given that it is in general not clear whether tax incentives have a positive or insignificant impact on LTCI demand and given that a lot of money might be used to finance tax incentives, more empirical studies should be done to analyze the real demand effect of tax incentives and their efficiency.

Altruistic behavior between parents and children also deserves further attention. Cremer et al. (2016b) propose social LTCI utilizing subsidies, payroll and inheritance taxes. Their model might be extended to cases in which parents leave no bequest or bequeath only in the healthy state. They also propose to study non-linear LTCI policies where LTC benefits are linked to the level of informal care provided by children. Cremer et al. (2017) study the role of private and public insurance in an uncertain family assistance setting. They analyze optimal conditions

and properties of public LTCI in this environment. Their model can be extended in a way that adds heterogeneity by considering individuals with different wealth and probability of altruism.

The traditional models for framing the LTCI need to be improved. Pincus et al. (2017) show that emotional narrative frameworks can improve willingness to pay for LTCI compared to statistical evidence (i.e., level of probability). Further experimental research is needed to illustrate the cognitive and emotional drivers underlying the emotional frameworks and the influence of various emotions generated by communications. Also, the recent discussion on narrow framing and LTCI demand (Gottlieb and Mitchell, 2015) might provide an alternative avenue to understand the decision-making process of individuals when buying LTCI. Experimental research might also provide clean tests in a controlled environment, for example, to more accurately analyze the effects of adverse selection and moral hazard, both of which are relevant for LTCI, but cannot be separated in most empirical research.

Longevity and morbidity risks have significant effects on LTC expenditures and insurability. However, the results of previous studies concerning these risks are inconclusive. As discussed above, some studies conclude that there has been morbidity compression in recent years¹¹¹ while others do not.¹¹² Other researchers focus on longevity¹¹³ and disability¹¹⁴ trends and their effects on LTC expenditures. These studies show that longevity, morbidity and disability not only change based on gender and age differences but also among age cohorts. It would be interesting to derive precise results on the effect of morbidity trends on LTC expenditures in countries other than the U.S. Moreover, further studies should be done on the dynamics of mortality and morbidity changes and the future predictions based on population growth.

Li et al. (2017) propose a new multiple state functional disability model that uses systematic trend and uncertainty of mortality and disability for transition rates. Their new model is suitable for pricing LTCI products based on uncertainties of transition rates. More studies are needed on the comprehensiveness of their model in morbidity compressions or expansions and its effect on LTCI pricing and risk management. Pauses or slowdowns in morbidity improvements and their effects should be emphasized. There is also a lack of alternative risk transfers (ART) in the market for LTCI. While there are longevity securities, such as longevity bonds¹¹⁵ and

¹¹¹ Stallard (2016).

¹¹² Crimmins and Beltrán-Sánchez (2011).

¹¹³ Lakdawalla and Philipson (2002); Spillman and Lubitz (2000).

¹¹⁴ See de Meijer et al. (2012) for trends in mild and severe disability; Stearns, Norton, and Yang (2007); Freedman et al. (2013) on late-life activity limitations.

¹¹⁵ Bartkowiak (2012); Blake et al. (2006).

longevity swaps¹¹⁶ for hedging the longevity exposure in annuity products, the financial market suffers from ART mechanisms for risks exposed to LTC.

The literature lacks comprehensive studies of possible ex-post adverse or advantageous selection in the lapse of LTCI. Friedberg et al. (2017) mention unintended lapse as the major source of dynamic advantageous selection. Bauer et al. (2017) find the advantageous selection in both the decision to purchase and the decision to extend complementary LTCI coverage in Germany. Finkelstein et al. (2005) claim that the reason for immediate lapse could be a wrong purchase. Other studies have found a U-shaped lapse rate curve based on the duration of policy purchase.¹¹⁷ More studies of lapses, the lapse rate curve, income shocks on lapse decision and the ex-post effects of the lapse on LTCI portfolios are needed for better understanding, optimal design and improved risk management of LTCI policies. Also, the general information asymmetries inherent to the LTCI market need attention. Finkelstein and McGarry (2006) argue that heterogeneity of private information exists not only on risk types but also on risk preferences. They encourage further study of the effects of heterogeneity in risk preferences on the costs of asymmetric information about risk types.

The literature on LTCI thus still lacks empirical and theoretical research on numerous emerging areas. While more than a decade has passed since the introduction of combined LTCI products, more empirical research is needed to analyze their (in)efficiencies, in terms of demand and supply. This might not only help practitioners to improve current LTCI products, but also provide better insights for modeling the new ones. Moreover, there remain a few theoretical observations that might need better empirical verification. Among them are crowding-out effects of various public provisions (as addressed e.g., by Courbage and Zweifel, 2015), non-linear LTCI policies and separation of LTCI expenditures by quantity and inflation.

This paper focuses on alternative financing and risk management models, including insurance. Such a study should, however, not overlook other means of improving the sustainability of the LTC system, which might come from areas outside of financing. When it comes to the organization of LTC, the introduction of new technologies to LTC can affect the cost development in this sector. Information, communication and technology can enhance communication among the actors such as citizens, informal and professional caregivers who provide LTC services.¹¹⁸ The U.S. Center for Technology and Aging (2009) mentions seven

¹¹⁶ Chen (2016).

¹¹⁷ Society of Actuaries (2011).

¹¹⁸ ENEPRI (2012).

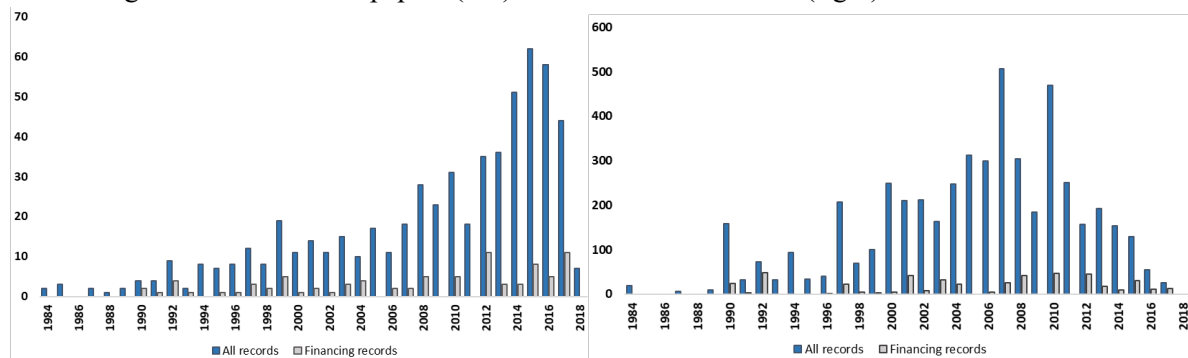
focal areas of technology to help older adults remain independent and to make LTC more cost efficient: 1) medication optimization, 2) remote patient monitoring, 3) assistive technologies, 4) remote training and supervision, 5) disease management, 6) cognitive fitness and assessment technologies and 7) social networking. New technologies, such as remote monitoring and virtual care, might significantly lower LTC expenditures, for example, by reducing the amount of labor needed in care provider facilities.¹¹⁹ This may contribute to a lowering of the premiums of existing products as well as facilitate the design of new ones.

¹¹⁹ According to Argentum (2016), more than 1.2 million employees will be needed by 2025 to provide the required care for the growing aging population.

Appendix A. Increasing relevance of long-term care insurance

Figure A1 documents the exponential growth in the academic interest in the topic of LTCI by showing the number of papers (left) and the number of citations (right) from Web of Science. We depict the extracted records of total LTCI literature along with the one related to financing of LTCI in different colors for comprehensiveness of our results. The early peaks in the number of citations are 135 citations for the Pauly (1990) article and 67 and 64 citations to Sloan and Norton (1997) and Ikegami (1997). The three most often-cited papers are by Van Houtven and Norton (2004), Finkelstein and McGarry (2006) and Ikegami and Campbell (2000) with 192, 187 and 152 citations, respectively.

Figure A1. Number of papers (left) and number of citations (right) in Web of Science



We found 1,280 articles based on search criteria of ‘long term care’ and ‘insurance’ from Web of Science and manually filtered out those unrelated to the insurance aspect of LTC. This left us with 591 articles for our citation network. Table A1 illustrates the authors and journals with most publications in our database of 591 articles.

Table A1. Authors and journals with most publications in the dataset

No.	Author	Records	Journal	Records
1	Costa-Font, J.	20	Gerontologist	51
2	Courbage, C.	13	Health Affairs	21
3	Pestieau, P.	13	Health Policy	21
4	Finkelstein, A.	8	Geneva Papers on Risk and Insurance	20
5	Ikegami, N.	8	Journal of Risk and Insurance	15
6	Nadash, P.	8	Health Economics	14
7	Wiener, J.M.	7	Inquiry: the Journal of Health Care Organization Provision and Financing	13
8	Brown, J.R.	7	Journal of Health Economics	12
9	Cohen, M.A.	7	Social Policy Administration	11
10	Cremer, H.	7	Gesundheitswesen	9

Appendix B. Main path analysis

Figure B1 illustrates the raw citation network of 591 records exported from Web of Science.¹²⁰ Liu and Lu (2012) identify the following advantages of main path analysis. First, it simplifies the citation network with hundreds of nodes into a smaller number of nodes and links. This gives us a satellite view of the network. Second, it demonstrates the historical evolution of a topic via main contributions in the literature. Third, it shows which papers have attracted the most attention in the historical development of a topic. Although the citation count illustrates the direct effect of the articles on a certain topic, the main path analysis also considers the indirect effects.¹²¹ Review papers are not included in the path because of the bias they may introduce to the analysis.¹²² Hence, after removing the review papers on the path, we list the top 40 routes based on global main path analysis, as depicted in Figure 3.

The results show that the most important path is from Brown and Finkelstein (2007) to Finkelstein and McGarry (2006). Their relative GCS are 85 and 187, LCS are 64 and 41 and their GCS ranks are 10 and 2.¹²³ While there are papers with higher GCS and LCS in our database, the global key-route main path has chosen the above path as the most important in the evolution of knowledge. There are 31 papers on the main path, 21 of which are empirical, five are theoretical and five are policy papers.¹²⁴ Table B2 illustrates the main path studies along with a summary of their findings.

¹²⁰ While most of these articles are empirical, approximately 106 are purely theoretical.

¹²¹ The indirect effect is captured not only by the citation count, but also by traversal weights between the nodes in the citation network.

¹²² See Ho, Liu, and Chang (2017).

¹²³ Local Citation Score (LCS) counts the number of the times the paper is cited within the local network (extracted from HistCite Software). Global Citation Score (GCS) is the number of the times the paper is globally cited (i.e., citation count from all the articles available in Web of Science). We also provide the rank of the paper based on its GCS in our network.

¹²⁴ Table B1 also identifies the most important datasets used in the academic literature which are the U.S. National Nursing Home Survey (NNHS) mainly used in the 1990s by five main path studies, the U.S. Health and Retirement Study (HRS) used in six main path studies and the Survey of Health, Ageing and Retirement in Europe (SHARE) used by three main path studies.

Figure B1. Citation network of the 591 papers

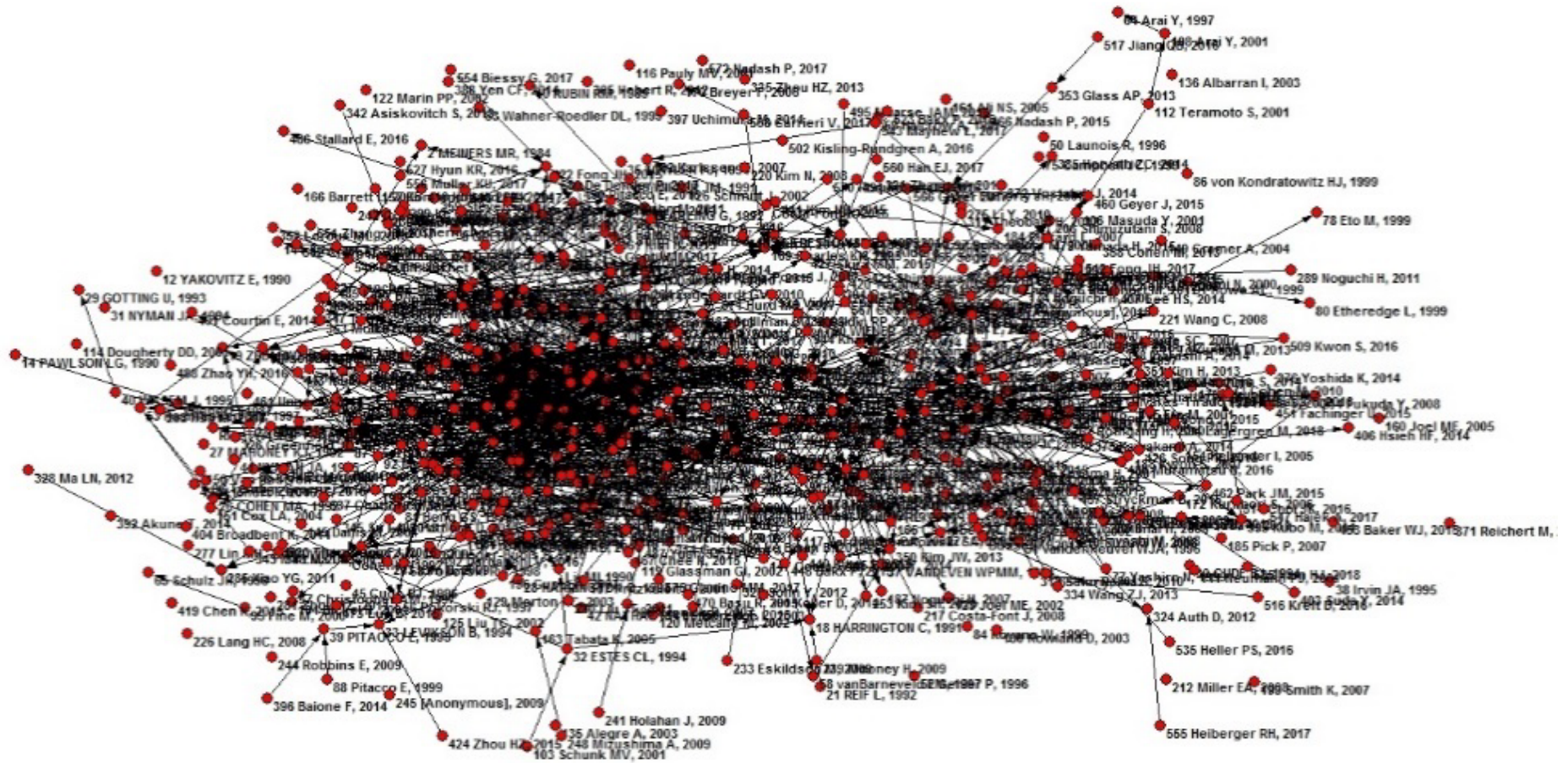


Table B1. Main path studies

<i>Article</i>			<i>Data</i>			<i>Citation Scores</i>		
<i>Author</i>	<i>Type</i>	<i>Main findings</i>	<i>Country</i>	<i>Source & Year</i>	<i>Main Variables</i>	<i>LCS</i>	<i>GCS</i>	<i>Rank</i>
<i>Insurability and Policy conditions</i>								
Wiener et al. (1987)	Empirical	• Evaluate affordability, coverage amounts and restrictions of available policies. • Find that LTCI policies are expensive and limited based on eligibility restrictions. • Recommend inflation adjustment of benefits for improvement of coverage	U.S.	31 private insurance policies -1986.	Price, eligibility to purchase, coverage provisions, payment levels.	2	6	164
Wilson & Weissert (1989)	Empirical	• Focus on combinations of policy restrictions and exclusions. • Estimate likelihood of policy compliance. • Find two restrictions, prior hospitalization and prior skilled care clauses, as the major limitations of coverage.	U.S.	National Nursing Home Survey (NNHS)-1985	Prior hospitalization, mental illness exclusions, skilled or prior skilled-care requirements, deductible waiting periods, length of nursing home stay.	6	9	128
Liu et al. (1990)	Empirical	• Compare insurability of LTCI with health insurance. • Study the important factors needed for designing and pricing private LTCI. • Find that LTC needed population as very dynamic with higher levels of disability. • Implications for financing.	U.S.	Supplement on Aging (SOA) of National Health Interview Survey (NHIS)-1984, National Long Term Care Survey (NLTCs)-1982-84, (NNHS)-1985.	Age, gender, ADL ¹²⁵ difficulty by specific chronic condition, income, number of ADL, fifty six health and functional variables, associated measures of acute and LTC service use both formal and informal, nursing home length of stay.	3	18	69

¹²⁵ Activities of daily living (ADLs) are the activities most of the people do in their daily life without assistance. The basic six ADLs are: bathing, eating, toileting, dressing, transferring and continence.

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<i>Article</i>			<i>Data</i>			<i>Citation Scores</i>		
<i>Author</i>	<i>Type</i>	<i>Main findings</i>	<i>Country</i>	<i>Source & Year</i>	<i>Main Variables</i>	<i>LCS</i>	<i>GCS</i>	<i>Rank</i>
Rice et al. (1991)	Empirical	• Focus on current LTCI contracts in U.S. • Examine their effects on out-of-pocket costs. • Confirm the restrictions mentioned in Wilson & Weissert (1989) and suggest two other restrictions, policy maximums and lack of inflation adjustment as major blocks.	U.S.	NNHS-1985, LTC policies from 11 leading companies in 1988.	Age, gender, marital status, nursing home length of stay, out of pocket costs paid by policies, policy restrictions.	2	4	209
Norton & Newhouse (1994)	Policy paper	• Analyze U.S. LTC system. • Discuss four issues related to public LTC financing which are eligibility, benefits, financing, and reimbursements. • Suggest public LTC rather than private one.	U.S.	-	-	12	25	46
Murtaugh et al. (1995)	Empirical	• Focus on underwriting criteria of LTCI. • Discuss medical underwriting necessary to purchase LTCI. • Discuss efficiency of underwriting limitations on identifying high-cost groups.	U.S.	National Mortality Followback Survey-1986, interview and NNHS-1985.	Death certificate of residents age 25 or older who died in 1986, nursing home use information, age, ADL limitation, major illnesses, lifestyle.	17	22	54
<i>Demand</i>								
Pauly (1990)	Theoretical	• Discusses rationality of limited tendency to buy private LTCI. • Argues existence of intra-family moral hazard. • Suggests intervention of government for LTCI market failure.	-	-	-	94	135	5

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<i>Article</i>			<i>Data</i>			<i>Citation Scores</i>		
<i>Author</i>	<i>Type</i>	<i>Main findings</i>	<i>Country</i>	<i>Source & Year</i>	<i>Main Variables</i>	<i>LCS</i>	<i>GCS</i>	<i>Rank</i>
Crown et al. (1992)	Empirical	• Study the affordability and potential market of private LTCI for various age cohorts. • Provide new estimates on significant potential market in the group of individuals age 65-69. • Discuss the role of public policy on the issue.	U.S.	Survey of Income and Program Participation (SIPP)-1984, Consumer Expenditure Survey (CES)-1984.	Age, asset, income, marital status, household expenditure data.	6	12	94
Cohen et al. (1992)	Empirical	• Study the differences between purchasers and non-purchasers of LTCI. • Mention various factors affecting the demand for private LTCI.	U.S.	LifePlans Inc., Survey of Purchasers and Nonpurchasers; U.S. Bureau of the Census, 1990.	Age, gender, marital status, household income, liquid income, liquid asset, education, opinion about LTC.	5	11	105
Zweifel & Strüwe (1996)	Theoretical	• Study the existence of intra-family moral hazard. • Discuss the role of bequest in affecting intergenerational relationships.	-	-	-	19	22	55
Sloan & Norton (1997)	Theoretical	• Discuss the role of adverse selection, bequests and crowding-out on demand for private LTCI in U.S. • Find no evidence of bequest motives.	U.S.	Asset and Health Dynamics of the Oldest Old (AHEAD)-1993, Health and Retirement Study (HRS)-1992-1994.	Variables related to expectations, adverse selection, bequest motive, Medicaid crowding-out, degree of risk aversion, income and wealth, expenditure risk, family structure, other demographic characteristics.	48	67	3
Zweifel & Strüwe (1998)	Theoretical	• Discuss the pros and cons of compulsory LTCI. • Argue that although by compulsory LTCI the adverse selection may	-	-	-	24	27	37

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<i>Article</i>			<i>Data</i>			<i>Citation Scores</i>		
<i>Author</i>	<i>Type</i>	<i>Main findings</i>	<i>Country</i>	<i>Source & Year</i>	<i>Main Variables</i>	<i>LCS</i>	<i>GCS</i>	<i>Rank</i>
		enhanced, the moral hazard between parents and children may increase.						
McCall et al. (1998)	Empirical	• Study the factors affecting the purchase of Partnership Program. • Find out the determinants of purchasing Partnership LTCI.	U.S.	Telephone survey of Partnership purchasers and random sample of population in each Partnership state-1995	Health status, opinions about LTC and LTCI, financial planning activities, demographic and social characteristics, income and assets.	20	23	50
Mellor (2001)	Empirical	• Studies on substitutability of children as formal care for LTCI. • Does not confirm the existence of intra-family moral hazard. • Find level of income, assets, and education as major factors affecting the demand for LTCI.	U.S.	AHEAD-1994, Panel Study of Income Dynamics (PSID)-1994	Relationship of caregivers, age, education, income, net worth, health status, gender, marital status, color, perspective toward receiving help, family size, having a daughter.	32	38	27
Cohen (2003)	Empirical	• Summarizes the current knowledge available for private LTCI. • Discusses growing market for private LTCI and its effect on public expenditures, policyholders, their families and providers.	U.S.	Health Insurance Association of America (HIAA)-1995-2000, Robert Wood Johnson Foundation (RWJ) & Department of Health and Human services (DHHS)-2000-2001.	Annual sale, policy characteristics, age, gender, marital status, benefit package, wealth profile, education and awareness, daily cost of care, length of time receiving service, health status, availability of family support.	7	17	75
Finkelstein et al. (2005)	Empirical	• Discuss the dynamic inefficiencies of the market for LTCI by addressing the lapse patterns on LTCI.	U.S.	HRS-1995 to 2000, administrative data from a specific	Age, gender, number of limitations to IADLs ¹²⁶ , number of limitations	11	22	56

¹²⁶ Instrumental activities of daily living (IADL) are more complicated tasks which are needed to live independently. They include doing laundry, cooking, shopping, using the telephone, cleaning, accessing transportation, taking medicines and managing personal finances.

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<i>Article</i>		<i>Data</i>				<i>Citation Scores</i>		
<i>Author</i>	<i>Type</i>	<i>Main findings</i>	<i>Country</i>	<i>Source & Year</i>	<i>Main Variables</i>	<i>LCS</i>	<i>GCS</i>	<i>Rank</i>
		• Suggest the immediate lapses maybe due to wrong purchase.		insurance company-1997 to 2001.	to ADLs, and the presence of cognitive impairment.			
Finkelstein & McGarry (2006)	Empirical	• Study various dimensions of existence of private information market for LTCI. • Emphasize two types of people with private information that purchase private LTCI, high-risk individuals and people with strong taste for insurance.	U.S.	AHEAD cohort of HRS-1995 to 2000	Age, gender, marital status, age of spouse, over 35 health indicators, limitations to ADL, limitations to IADL, cognitive impairment, average length of benefit period, wealth status, preventive activity, rating category, deductible, daily benefit, benefit period, escalation of benefit.	41	187	2
Brown & Finkelstein (2007)	Empirical	• Discuss the market failures for private LTCI. • Present the supply-side market failures of private LTCI. • Find out the supply-side factors are not the sole reason for LTCI market failures.	U.S.	Weiss Rating Inc., 132 known insurance companies-2002, HRS-2000, MetLife Market Survey-2002, Society of Actuaries (SOA)-2002, NLTCs and NNHS.	Market-wide premium and benefits, gender, marital status, age, termination probabilities.	64	85	10
Brown & Finkelstein (2008)	Empirical	• Analyze the effect of Medicaid on demand for LTCI. • Suggest reforms to reduce the implicit tax imposed by Medicaid to stimulate private LTCI.	U.S.	MetLife Market Survey- 2002.	Average national daily care cost of nursing home and assisted living facilities, hourly costs of both skilled and unskilled home health care, age, wealth.	51	88	9
Courbage & Roudaut (2008)	Empirical	• Study the LTCI purchase in France and the factors affecting the demand for LTCI. • The findings are altruistic behavior, risk behaviors and experience of	France	Survey of Health, Ageing and Retirement in Europe (SHARE)-2007.	LTCI ownership status, age, marital status, education, income, inheritance, health status, life insurance ownership, recent hospitalization, risk factors, having chronic conditions, having symptoms, mobility, ADL, IADL,	26	29	34

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<i>Article</i>			<i>Data</i>			<i>Citation Scores</i>		
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		disability as reason for low demand for private LTCI.			family members, receipt or providing help to relatives, physical activity.			
Courtemanche & He (2009)	Empirical	• Study the effect of tax incentives on the purchase of private LTCI. • Conclude even offering above the line tax deductions may have minor effects on expansion of market for private LTCI. • Estimate the price elasticity of demand for LTCI and discuss the effects of the taxes on government expenditures.	U.S.	HRS-1996, 1998, 2000, 2002, 2004.	LTCI ownership status, household income and wealth, mortgage payment, property tax, out-of-pocket medical expenses, demographics, and a detailed set of variables on health status.	12	15	82
Courbage & Zweifel (2011)	Theoretical	• Discuss the two-sided intergenerational moral hazard in the purchase of LTCI, the one in which purchase of LTCI by parents protects the bequests from cost of nursing homecare and the other one in which parents purchase less LTC coverage knowing that the children keep the parent out of nursing home.	-	-	-	10	11	109
Goda (2011)	Empirical	• Studies the effects of tax subsidy programs on the number of people purchase LTCI.	U.S.	HRS-2006 (including AHEAD sample, War Baby (WB) sample and Children of the Depression Age (CODA) sample).	Demographics, health status, family structure, housing, employment, disability, retirement plans, net worth, income, and insurance coverage.	10	12	101
Brown et al. (2012)	Empirical	• Survey to understand the effect of preferences and beliefs, likelihood of	U.S.	Survey field in RAND American Life Panel-2011	LTCI ownership, age, gender, education, ethnicity, preferences and beliefs, state-dependent utility,	15	22	58

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<i>Article</i>			<i>Data</i>			<i>Citation Scores</i>		
<i>Author</i>	<i>Type</i>	<i>Main findings</i>	<i>Country</i>	<i>Source & Year</i>	<i>Main Variables</i>	<i>LCS</i>	<i>GCS</i>	<i>Rank</i>
		becoming disabled, formal care substitutes and features of the private market on demand for private LTCI. • Explain the findings related to low demand for LTCI.			bequest motives, substitutes for insurance, substitutes for formal care; price and affordability, counter-party risk, trust in insurers.			
Courbage & Eeckhoudt (2012)	Theoretical	• Study the optimal level of LTCI insurance and informal care and relation of these in the case when the child is also decision maker for the purchase of LTCI and informal care provider for their parents.	-	-	-	3	5	202
<i>Country-specific studies</i>								
Siciliani (2014)	Policy paper	• Discusses the factors affecting expenditure growth of LTCI and relative projection in OECD countries. • Addresses the role of regulations imposed by government on quality of care the individuals receive. • Discusses public and private insurance in different countries.	OECD	-	-	2	4	237
Doty et al. (2015)	Policy paper	• Study the long-term services and supports in France and compared them with available policy in U.S. • Provide solutions to American private LTCI based on French example.	France	-	-	0	5	208
Cost-Font et al. (2016)	Empirical	• Focus on the LTC market changes during and after great recession in European countries. • Discuss the determinants of changing receipt of informal care during crisis	European Countries	SHARE, 2013	Receiving informal care, number of limitations to ADL, net worth, housing wealth, having one or more children live with the respondent, having one or more children live	0	2	311

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<i>Article</i>			<i>Data</i>			<i>Citation Scores</i>		
<i>Author</i>	<i>Type</i>	<i>Main findings</i>	<i>Country</i>	<i>Source & Year</i>	<i>Main Variables</i>	<i>LCS</i>	<i>GCS</i>	<i>Rank</i>
					within 1 km from the respondent, cohabitation with a partner, unemployment change, education, demographics, born in country of interview.			
Gentili et al. (2017)	Empirical	Study the cultural differences and its effect on the market for LTC and other elderly arrangements in Switzerland.	Switzerland	Statistics on socio-medical institutions (SOMED)-2007 to 2013, Home care survey (HCS)-2007 to 2013, Voting data from national referenda-2013, Public use sample (PUS) of Swiss census, SHARE-Wave 4, Release 5, Swiss Statistical Office (SFO).	Dependency level, age at entry, gender, place of residence, nursing home, share of people voting yes to amendment of Swiss Constitution, household characteristics, control variables at municipal and hospital level.	0	0	574
Nadash & Cuellar (2017)	Policy paper	- Study the private LTCI in Germany. - Apply the example from German private LTCI to U.S. and France for better performance.	Germany	-	-	1	1	383
Busse et al. (2017)	Policy paper	- Focus on the evolution of statutory health insurance and LTC in Germany. - Discuss the challenges exposed to the German system.	Germany	-	-	0	8	147

Note: Local Citation Score (LCS) counts the number of the times the paper is cited within the local network (extracted from HistCite Software). Global Citation Score (GCS) is the number of the times the paper is globally cited (i.e., citation count from all the articles available in Web of Science). We also provide the rank of the paper based on its GCS in our network

Appendix C. Review of future research

In this Appendix we present potential future research that we extracted from the articles on the main path (from 2000 onwards) and conclusion part of all the recent publications (106 publications from 2016 to 2018) in our dataset. We use this to derive directions for future research in Section 5 of the paper.

Table C1. Potential future directions based on main path and recent studies

<i>Authors (year)</i>	<i>Title</i>	<i>Potential future research</i>
<i>Main path articles beyond 2000</i>		
Finkelstein et al. (2005)	Dynamic inefficiencies in insurance markets: Evidence from long-term care insurance	The empirical relevance of effects of uninsured negative wealth or income shocks on lapsation. Further study for finding the reasons behind immediate lapse after purchase of policy.
Finkelstein & McGarry (2006)	Multiple dimensions of private information: Evidence from the long-term care insurance market	The necessary conditions related to effect of heterogeneity in risk preferences on the efficiency cost of asymmetric information about risk type.
Brown & Finkelstein (2008)	The interaction of public and private insurance: Medicaid and the long-term care insurance market	The way private market will be affected by new Medicaid reform given the existence of market failures such as asymmetric information, incomplete commitment in contracting and nondiversifiable risks.
Courbage & Roudaut (2008)	Empirical evidence on long-term care insurance purchase in France	Improve the results of the study by combining market data, such as characteristics of the products offered, and individual data, such as risk aversion behaviors.
Courtemanche & He (2009)	Tax incentives and the decision to purchase long-term care insurance	Estimate elasticity of demand for LTCI using more refined measure of individuals' federal marginal income tax rates. Study the efficiency of state-level incentives in promoting private LTCI market.
Siciliani (2014)	The economics of long-term care	Study the relation between formal home care and institutional care. Analyze the existence of Baumol's disease in LTC. The role of technology on LTC costs (cost-saving or cost-augmenting). Study the effect of competition on quality. Review systematically the availability, ownership structure and funding arrangements in various countries. Empirically determine important factors explaining observed public-private mix. Theoretical determination of optimal public-private mix. Study the solutions for moral hazard problem in the design of future LTCI policies.
Gentili et al. (2017)	The role of culture in long-term care arrangement decisions	Study the determinants of informal caregiving more comprehensively.
Busse et al. (2017)	Statutory health insurance in Germany: A health system shaped by 135	Further study of the problems related to discontinuous care and oversupply in Germany's health system.

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<i>Authors (year)</i>	<i>Title</i>	<i>Potential future research</i>
	years of solidarity, self-governance, and competition	Analyze the long-term challenges raised by population aging, growth in chronic disease, multimorbidity, migration, digitalization and existing urban-rural discrepancies.
<i>Recent articles 2016-2018</i>		
Stallard (2016)	Compression of morbidity and mortality: New perspectives	Treat the recent pauses in morbidity improvements (as a new phenomenon disconnected from past trends or as a correction that restores long-term trend).
Cremer et al. (2016)	Social long-term care insurance with two-sided altruism	Extend the context of two-sided altruism to the case in which parents don't leave any bequest or they only bequeath in the healthy state. Introduce private insurance with loading costs and possibility of non-linear LTCI policies.
Blundell et al. (2016)	Comparing retirement wealth trajectories on both sides of the pond	Explore bequest motives differences in cross-country setting. Estimate late-life health expense risk in England. Study the factors that affect households not to draw on their housing wealth (such as consumption value of housing, the financial and emotional transaction costs of releasing housing wealth, the risk–return mix provided by housing). Constructing life-cycle model that could explain the asset trajectories in the U.S. and England.
Brown et al. (2016)	Heterogeneity in state-dependent utility: Evidence from strategic surveys	Further research on whether state dependence in utility is multiplicative. Assess the reliability of the measures obtained in this study by asking the same sample similar questions could help determine whether the responses reflect true measures of state dependence.
Chatterjee (2016)	Reverse mortgage participation in the United States: Evidence from a national study	Improve the dataset of those who have reverse mortgage. Further study on awareness and demand for reverse mortgage products with better dataset including a large number of reverse mortgage participants.
Pla-Porcel et al. (2016)	Life care annuities (LCA) embedded in a Notional Defined Contribution (NDC) framework	Adapt the designed actuarial balance sheet for NDC systems to include the new model with LTC and evaluate the impacts of the introduction of a minimum pension on the system's financial equilibrium. The transition rules of moving from old financing system to the integrated NDC framework, the importance of including a minimum pension, permanent disability relationship with LTC, the necessary conditions for updating of the annuity divisors and the required statistical data for computation of real dependency cost. The design of yearly account statement including individual pension information about retirement and LTC rights, introducing automatic balance mechanism based on an actuarial balance sheet in order to take into account in the system the changing realities.
Kreft & Doblhammer (2016)	Expansion or compression of long-term care in Germany between 2001 and 2009? A small-area decomposition study based	Investigate the future trends in the new care level 0 and the diversity causes in the mortality and morbidity effects. Living conditions in counties and their overall change related to the trends in care need and mortality.

<i>Authors (year)</i>	<i>Title</i>	<i>Potential future research</i>
	on administrative health data	Further study to find the underlying mechanisms of health aging for better understanding and dealing with the problems of a growing more heterogeneous aging society.
Cremer et al. (2016a)	The design of long-term care insurance contracts	Extend their model by also including welfare of caregivers in the design of social insurance.
Fong (2017)	Old-age frailty patterns and implications for long-term care programmes	Study the reversibility of human aging in aging models. Use richer datasets on health conditions and mortality rates to explore the possibility of recovery from frailty and the impact of population health trends on frailty. Identify seasonality patterns by constructing longer time-series data.
Pla-Porcel et al. (2017)	Converting retirement benefit into a life care annuity with graded benefits	Further research on the effect of ruling out the recovery assumptions in their proposed model in a specific case that the annuitant is not healthy in the initial state. Separate the redistribution of resources when the unisex actuarial factor is included in computation of the initial benefit.
Pincus et al. (2017)	Framing the decision to buy long-term care insurance: Losses and gains in the context of statistical and narrative evidence	Expand future research by focusing more on the type and strength of emotions generated by communications rather than rational uncertainty frameworks.
Sperber et al. (2017)	How can adult children influence parents' long-term care insurance purchase decisions?	Study on defining specific communication channels and intervention activities.
Biessy (2017)	Continuous-time semi-markov inference of biometric laws associated with a long-term care insurance portfolio	Extend the one level LTC model proposed in the paper to consider several levels of LTC.
Cremer & Roeder (2017)	Long-term care policy with lazy rotten kids	Study the effect of crowding-out and altruism on a more disaggregate level and country-specific way.
Cremer et al. (2017)	Uncertain altruism and the provision of long term care	Extend the model by adding heterogeneity in such a way that individuals may have different wealth and probability of altruism.
Levantesi & Menzietti (2018)	Natural hedging in long-term care insurance	Study on developing non-parametric models in a multiple state framework to examine the effectiveness of natural hedging and also utilize different data set. Introduce alternative risk management tools rather than natural hedging. Study the possibility of constructing a swap written on the survival of disabled people and to evaluate their hedge effectiveness.
De la Pena et al. (2018)	Long-term care pension benefits coverage via conversion factor based on different mortality rates: More money as age goes on	Extend the data on the different degrees or levels of dependence to obtain the transition probabilities from one stage to another. Quantify the effect of this factor not only in the Spanish social security system but also in other countries such as France, Italy or Germany.

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Essay II

Willingness to take financial risks and insurance holdings: A European survey

Abstract

We investigate the relationship between self-reported willingness to take financial risks and ownership of life insurance and long-term care insurance (LTCI). For a representative sample of individuals aged 50+ from 14 countries and controlling for demographic and socioeconomic determinants of insurance demand, we find a positive link between willingness to take financial risks and ownership of both LTCI and life insurance. The link is stronger for whole life insurance compared to term life insurance and LTCI. Two robustness tests that (i) use risky asset ownership instead of willingness to take financial risks and (ii) focus on specific demographic and socioeconomic groups confirm the results for life insurance, while the results for LTCI are less clear. Our empirical results cannot be explained by the classical expected utility framework and thus support recent research indicating that alternative models (e.g., higher-order risk attitudes or prospect theory) are needed to explain insurance demand.

Keywords

Risk attitudes, Long-term care insurance, Life insurance, SHARE data

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1 Introduction

In this paper, we investigate the relationship between risk attitudes and insurance ownership. We focus on life insurance and LTCI because these two products provide coverage against the major risks many households face. Life insurance protects families against loss of income due to the early death of an income earner (e.g., Han and Hung, 2017). LTCI protects individuals against potentially high costs of long-term care (LTC) needs as they get older (e.g., Mitchell, 2018).

Theoretical studies (e.g., Mossin, 1968) suggest that when faced with the same risky situation, rational agents who are more risk-averse purchase more insurance. However, empirical studies testing this link for LTCI and life insurance report inconclusive and inconsistent results. For instance, Costa-Font and Rovira-Forns (2008) find no significant association between risk attitudes and demand for LTCI, while Stum (2008) reports that those who are more willing to take financial risks participate more in group LTCI. For life insurance, Luciano et al. (2016) and Giesbert et al. (2011) find negative effects of risk aversion on demand for insurance, and Liebenberg et al. (2012) find no significant association between risk aversion and life insurance ownership.

We test the link between risk attitudes and life insurance and LTCI holdings using data for 14 countries from the Survey of Health, Ageing and Retirement in Europe (SHARE). Our sample consists of 33,892 individuals from the 2013 SHARE wave. We use self-reported willingness to take financial risks as a measure of risk attitudes because previous research shows that this measure is a strong predictor of risky behavior in financial matters (Dohmen et al., 2011; Barasinska et al., 2012). In a robustness test, we use self-reported risky asset ownership as an alternative measure for risky behavior. One advantage of the SHARE dataset is that it allows us to include a wide range of individual- and household-level control variables.

We find that the link between willingness to take financial risks and insurance take-up is significant and positive, with a stronger association for whole life insurance compared to term life insurance and LTCI. A robustness test that uses self-reported risky asset ownership as an alternative measure confirms the results for whole life and term life insurance, whereas it does not confirm any association for LTCI. We also repeat the analysis for respondents with no risky assets and run the models in specific demographic and socioeconomic groups and again confirm the robustness for whole life insurance in all groups. In contrast, the results for term life insurance and LTCI are less clear. Another robustness test analyzing the association between

willingness to take financial risks and ownership of supplementary health insurance also confirms our main results that the link between willingness to take financial risks and insurance ownership is significant and positive.

Our study contributes to both the classical literature on insurance demand based on expected utility (e.g., Schlesinger, 2013; Woodard and Yi, 2020) and the growing literature on behavioral aspects of insurance purchase decisions (Corcos et al., 2020; Bonsang and Costa-Font, 2020; Richter et al., 2019). We provide new results on how individuals' risk attitudes are associated with ownership of life insurance and LTCI, using both individual financial risk preferences and risky asset ownership as proxies for risk aversion. While other studies typically analyze smaller samples from one country, our study is based on a large dataset across 13 European countries and Israel. We also analyze the possible interaction of the effects of willingness to take financial risks and age on insurance ownership in our robustness tests. We contribute to the current literature by showing how the magnitude and significance of the link between willingness to take financial risks and insurance ownership differ among demographic and socioeconomic groups.

Overall, our results, that individuals who are more willing to take financial risks purchase more insurance, cannot be explained via the classical expected utility theory.¹²⁷ Instead, our results might signal that many individuals do not fully understand the risk transfer mechanism underlying life insurance and LTCI products. This is concerning because the resulting underinsurance of these products can increase financial burdens on individuals and public insurance programs. Our results might also motivate future studies to test such a link using higher-order risk attitudes, or alternatively use other theoretical frameworks such as prospect theory because researchers have recently considered narrow framing and loss aversion as potential explanations for finding a negative/insignificant link between risk aversion and insurance demand (Gottlieb and Mitchell, 2020; Hwang, 2017). We thus interpret our results for a large sample across many countries as a benchmark for other future studies that may help to better understand the link between risk attitudes and insurance demand.

The insights of our study suggest that product providers could enhance their marketing strategies and product designs so that consumers better understand insurance products. Such improvements should increase individuals' awareness of their exposure to financial risks. In addition, insurance providers should clearly communicate the crucial role of insurance products

¹²⁷ We note that the extension of classical utility theory based on higher-order risk attitudes or other theoretical models such as prospect theory might help explaining our results; see, e.g., Noussair et al. (2014); Gottlieb and Mitchell (2020).

in reducing financial risks. This is essential in whole life insurance where we find robustly that individuals with no willingness to take any financial risks own less whole life insurance (even though we control for the demographic and socioeconomic characteristics of the respondents). However, for term life insurance and LTCI, there exist more heterogeneities across demographic and socioeconomic groups in terms of the link between willingness to take financial risks and insurance ownership, which might call for more diverse marketing strategies for different consumer segments.

The remainder of the paper is organized as follows. Section 2 describes the relevant conceptual background of risk attitudes and demand for insurance. Section 3 describes the SHARE data and our methodology. Section 4 provides the descriptive statistics, reports the main results and presents the robustness tests. Section 5 discusses our findings and Section 6 concludes the paper.

2 Conceptual background

Pratt (1964) and Arrow (1965) independently introduced the measure of absolute and relative risk aversion in economic models describing risky situations. Since then, risk-aversion has been considered as a key driver in many prominent economic applications among which are the demand for insurance, financial investments, principal-agent models, or life-cycle models considering employment, income, asset returns, health, and many other aspects of life (O'Donoghue and Somerville, 2018).

Mossin (1968) proved that, in a one-period expected utility setting, risk-averse individuals purchase full insurance when the premium is actuarially fair and purchase less than full coverage in the case of proportional premium loading.¹²⁸ Schlesinger (1981) and Szpiro (1985) further analyzed the link between risk aversion and optimal choice of insurance theoretically by implicitly assuming that individual risk aversion influences the subjective discounting factors of policyholders, who evaluate insurance options based on premium payments and expected rate of returns (Outreville, 2014). Schlesinger (1981) proved that for insurance contracts with a deductible, a higher degree of risk aversion leads to more insurance

¹²⁸ The analysis of changes in risk aversion and its effect on optimal insurance demand is often attributed to Mossin (1968), while Smith (1968) also has similar analysis. In Appendix A we present the theoretical framework of the association between risk aversion and optimal insurance following Mossin's (1968) theorem. Schlesinger (2006) confirms the results of Mossin (1968) in the case of upper-limit insurance policies. This is a relevant result in our context, because long-term care schemes typically have an upper limit for the amount of their coverage (e.g., \$100 per day).

purchases.¹²⁹ Szpiro (1985) presents explicit expressions for the amount of insurance coverage by considering the role of risk aversion in optimal insurance choice.

Several studies analyze the link between risk aversion and insurance demand and find mixed results. Zietz (2003) provides a comprehensive review of theoretical and empirical studies addressing the relationship between risk aversion and life insurance demand and reports mixed results (i.e., negative, positive, and insignificant associations). For LTCI, Eling and Ghavibazoo (2019) document the most important determinants of demand for LTCI. They also report mixed results for the association between risk aversion and LTCI demand. We use SHARE to jointly investigate the link between willingness to take financial risks (as a proxy for risk aversion) and insurance ownership for both LTCI and life insurance products across many countries.

The standard economic theory on risky choices assumes that risk preferences are stable over time and across different domains (Stigler and Becker, 1977). This assumption has been the cornerstone of economic models built over many decades. There is an ongoing debate on the stability of risk preferences in the literature (Schurer, 2015). Some authors found evidence that exogenous shocks such as financial crises or natural catastrophes might change individuals' risk preferences over the life cycle (Schildberg-Hörisch, 2018). Background risks are also found to alter the individuals' risk preferences (see, e.g., Guiso et al., 2002, on unemployment uncertainty; Guiso and Paiella, 2008 on individual background risks, and Courbage et al., 2018, on health background risk). Furthermore, studies report that individuals become more risk-averse as they get older.¹³⁰ There is also a growing literature on the stability of risk preferences among various risk preference measures. Chuang and Schechter (2015) review the experimental

¹²⁹ Although risk aversion has long played a key role in individuals' decision-making under uncertainty, higher-order risk attitudes, such as temperance and prudence, are also found to be crucial in financial decisions (Eeckhoudt and Schlesinger, 2013). In the expected utility framework, risk aversion refers to the second derivative of the von Neumann–Morgenstern utility function. Prudence (Kimball, 1990), defined as the positive third derivative (i.e., the convexity of marginal utility), implies precautionary saving motives in existence of background risk. Temperance (Kimball, 1992) is defined as a negative fourth derivative of the utility function, referring to less risky investment in existence of greater background risk. Consistent with theoretical models, Noussair et al. (2014) provide the first evidence regarding the prevalence of prudence and temperance in an experiment. They report a positive correlation between prudence and savings, and a negative correlation between temperance and riskiness of portfolio choices. Trautmann and Van de Kuilen (2018) provide a review of fast-growing experimental literature on higher-order risk attitudes. SHARE does not contain questions that would allow us to analyze higher-order risk attitudes.

¹³⁰ Josef et al. (2016) analyze the stability and changes in risk-taking propensity of individuals among survey respondents aged 18 to 85 in the German Socio-Economic Panel Study (SOEP). They show that individuals' risk-taking propensity can be considered as a personality trait with moderate stability across time which typically decreases with age. Dohmen et al. (2017) find that willingness to take risk linearly decreases until age 65; and above this age, the decrease would be slower. Schurer (2015) reports that risk tolerance drops for all socioeconomic groups from late adolescence up to age 45; and after that, other socioeconomic gradients emerge that influence the rate of decrease in risk tolerance. It might be also possible that cohort effects make the effects of age on risk aversion more complicated (Outreville, 2014).

studies on stability of preferences. They also test the stability of risk, time and social preferences, using both experimental and survey measures, and find that survey measures of preferences are more stable over time compared to experimental measures. For the purpose of our study, we use survey measure of financial risk preferences from SHARE and consider different age groups and insurance domains.

In previous studies on risk attitudes, self-reported willingness to take financial risks is used as a valid measure of risk attitudes (see, e.g., Kapteyn and Teppa, 2011; Barasinska et al., 2012). Dohmen et al. (2011) compare several survey measures of risk attitudes in different contexts (such as car driving, financial matters, sport/leisure, career, and health) and find that individuals' self-reported willingness to take risks is a useful all-round measure of risk attitudes. In our analysis, we choose individuals' self-reported willingness to take financial risks as our main measure of respondents' financial risk attitudes (see Section 3.1.4 for more details). Hence, based on theoretical studies using standard classical utility theory, we can expect a significant negative association between willingness to take financial risks and ownership of both LTCI and life insurance, even though empirical studies have mixed or inconclusive results.

3 Data and methodology

3.1 Data

3.1.1 Sample

We use data from SHARE, a multidisciplinary longitudinal and cross-national follow-up survey comprising separate modules for different variables (e.g., health-related, labor market, demographical, income, assets and housing, social network, and risk attitudes). SHARE data are available from seven waves collected between 2004 and 2018. We use Wave 5 in which the question about ownership of LTCI was first added. SHARE Wave 5 collects data for non-institutionalized individuals and their spouses who are sampled to be nationally representative of the population aged 50 or above at the time of interview. The survey uses standardized questions across countries and includes more than 66,000 respondents. Its design is based on the U.S. Health and Retirement Study (HRS) and the English Longitudinal Study of Ageing (ELSA)¹³¹.

¹³¹ A detailed description of the methodologies of data collection of SHARE can be found in Börsch-Supan et al. (2013). The SHARE data can be accessed and downloaded for free after registration at this link: <http://www.share-project.org/data-access.html>.

To maximize the sample size in the analysis, we extract two subsamples from Wave 5, one containing all individuals who have reported whether they have private LTCI and the other containing all individuals who have reported whether they have life insurance. Furthermore, we separate our life insurance analysis into term life and whole life insurance ownership. We only include respondents aged between 50 and 90 because there are few responses to the financial risk preference question in the survey by individuals aged 90 or above. We apply all five imputations provided by SHARE to fill missing entries in the relevant variables. We then drop observations with missing values in any of the remaining variables relevant to our study.

3.1.2 Long-term care insurance subsample

We limit our analysis to six countries that have private markets for LTCI: Czech Republic, France, Israel, Italy, Spain, and Switzerland.¹³² The LTCI subsample consists of 21,912 observations. Since 2013, SHARE respondents have answered the following question: *Do you have any of the following public or private long-term care insurances?* with the following possible answers: *Public, Private mandatory, Private voluntary/supplementary, None*. Based on this question, we define a binary variable indicating whether an individual holds private voluntary or supplementary LTCI.

We also include several health and disability measures relevant to LTCI demand, such as an individual's ability to perform activities of daily living (ADL) and instrumental activities of daily living (IADL). SHARE asks individuals to rate their ability to perform six ADL items related to basic functional living: bathing, eating, toileting, dressing, transferring, and continence. SHARE participants also rate their ability to perform seven IADLs needed for living independently: cooking, shopping, using the telephone, cleaning, accessing transportation, taking medicines, and managing personal finances. These variables have been used in other studies that analyze the demand for LTCI (see, e.g., Courbage and Roudaut, 2008; Courbage et al., 2020). We construct two binary variables indicating whether individuals reported having at least one limitation in each of ADL or IADL.¹³³

¹³² We follow Bonsang and Schoenmaeckers (2015) and exclude: Austria, Belgium, Slovenia, and Sweden because of spurious or missing data; Denmark because the Danish SHARE does not distinguish between private mandatory and private voluntary LTCI; and Luxembourg because at the time of the survey, no private market for LTCI existed. Furthermore, in SHARE there is no available data for LTCI ownership in Germany.

¹³³ We note that many private insurance providers do not offer LTCI to individuals with ADL/IADL limitations at the inception of the insurance contract, but since there is no information in the dataset regarding when private LTCI is purchased (i.e., either before or after experiencing such limitations), we include all the respondents with/without ADL/IADL limitations in our analysis.

3.1.3 Life insurance subsample

The life insurance subsample comprises 33,892 observations in 14 countries (Austria, Belgium, Czech Republic, Denmark, France, Germany, Israel, Italy, Luxembourg, Netherlands, Slovenia, Spain, Sweden, and Switzerland).¹³⁴ For our main analysis, we use two separate binary variables indicating whether individuals own whole life insurance or term life insurance. We differentiate these two types of life insurance since whole life insurance products include a savings component while term life insurance ownership only provides pure life insurance coverage.¹³⁵ For analysis of term life insurance, it is more likely that employers provide group term life insurance policies for their employees (Hwang, 2017). Since the SHARE questionnaire does not ask whether the respondent purchased term life insurance individually or via a group life policy offered by their employer, we limit our analysis of term life insurance to non-workers at the time of interview (i.e., those who are not employed or not self-employed). For specific life insurance demand controls (in both term and whole life insurance analysis), we additionally include a binary indicator of praying frequently to proxy for being religious, which previous studies identified to be a determinant of life insurance demand (see, e.g., Outreville, 2014).

3.1.4 Willingness to take financial risks

Our main explanatory variable is self-reported willingness to take financial risks, which is elicited in SHARE with the following question: *When people invest their savings they can choose between assets that give low return with little risk to lose money, for instance a bank account or a safe bond, or assets with a high return but also a higher risk of losing, for instance stocks and shares. Which of the statements on the card comes closest to the amount of financial risk that you are willing to take when you save or make investments?*

1. *Take substantial financial risks expecting to earn substantial returns*
2. *Take above average financial risks expecting to earn above average returns*
3. *Take average financial risks expecting to earn average returns*
4. *Not willing to take any financial risks.*

This question has also been included in other surveys, such as the U.S. Survey of Consumer Finances (SCF) and the China Household Finance Survey, and it is widely used in many studies

¹³⁴ Owing to a lack of responses regarding insurance ownership, we removed Estonia from our analysis of whole life insurance, and Estonia, Italy, and Spain from our analysis of term life insurance.

¹³⁵ Nam and Hanna (2019) find a positive link between risk aversion and whole (i.e., cash-value) life insurance and a negative link between risk aversion and term life insurance.

on risk attitudes.¹³⁶ In terms of reliability, Grable and Lytton (2001) find that this risk attitude question has a high degree of face and construct validity in investment choice attitudes. Hanna and Lindamood (2004) find a significant positive correlation between the above risk-taking question and the more theory-based risk aversion measure based on income gambles. Dohmen et al. (2011) also suggest that self-reported qualitative survey measures of risk-taking are meaningful measures of risk attitudes that can be correctly mapped into actual choices in lotteries with monetary incentives, and hence, they are behaviorally a valid measure of risk preferences. Dohmen et al. (2011) also find that self-reported willingness to take risks in a specific context provides a stronger measure within this particular domain of risky behavior: For example, they report that self-reported willingness to take risks in financial matters is a better predictor of portfolio choices than willingness to take risks in general. Kapteyn and Teppa (2011), comparing several different measures of risk preferences (i.e., theory-based risk aversion questions based on income gambles suggested by Barsky et al., 1997, with other ad hoc questions such as self-reported risk aversion), show that simple risk preference questions have the highest explanatory power regarding decisions in actual portfolios. To further test the predictability of the above willingness to take financial risks question on actual risky asset ownership (i.e., stock), we follow Bonsang and Dohmen (2015) and Banks et al. (2020) and report these predictions in our supplementary material (Table C1).

Owing to the categorical nature of the willingness to take financial risks question, we define four binary variables for the financial risk preference categories. Relatively few individuals report being willing to take above average and substantial financial risks (the percentages of individuals who are willing to take above average and substantial risks are 0.98% and 1.93% in the LTCI subsample, and 1.06% and 3.30% in the life insurance subsample, respectively). Therefore, we follow previous studies (e.g., Bucciol et al., 2018; Courbage et al., 2018) and create a binary variable called “taking no financial risks (TNFR)” which is equal to one if the respondent selects category 4 (*Not willing to take any financial risks*), and zero otherwise. We use this variable to analyze interactions and demographic and socioeconomic groups in the robustness tests and our supplementary material.

3.1.5 Control variables

In addition to the product-specific control variables discussed above, we include control variables identified in the literature as relevant determinants of the demand for both life

¹³⁶ See, for example, Banks et al. (2020), Bonsang and Dohmen (2015), Courbage et al. (2018), and Bucciol et al. (2018) who use SHARE. Kim et al. (2020) provide a review of the studies using the same self-reported risk attitude question in the SCF.

insurance and LTCI. We include the following demographic and socioeconomic indicators for each respondent: age, gender, marital status, years of education, number of children, and household size.¹³⁷ The economic factors considered are total annual household income, total household net wealth (in five 20 percentiles of wealth),¹³⁸ and homeownership.¹³⁹ Other factors we include in both datasets are binary indicators for self-reported health status (Courbage and Roudaut, 2008, Sloan and Norton, 1997), self-reported subjective life expectancy¹⁴⁰ (Zietz, 2003), and being retired. Vigorous physical activity and drinking are incorporated as proxies of risky behaviors.¹⁴¹ We further include body mass index (BMI) in four binary levels and number of chronic diseases¹⁴² as health indicators, which could affect the demand for insurance. We also control for measures of cognitive ability relevant to insurance ownership by combining three cognitive tests collected in SHARE.¹⁴³ As we suspect that risks involved in purchasing insurance products such as LTCI and life insurance might not be purely financial (Barsky et al., 1997), we control for other important determinants that might influence insurance purchasing decisions (such as health risks). For the case of LTCI, limitations in ADLs and IADLs represent morbidity related risks, while controlling for self-reported subjective life expectancy could capture the mortality risks that might influence purchase of life insurance products.

3.2 Methodology

We empirically test whether risk attitudes have an association with holding LTCI or whole life and term life insurance. In so doing, we control for individual demographic and socioeconomic explanatory variables relevant to the demand for LTCI and life insurance along with controls

¹³⁷ Marital status, number of children, and household size are included as proxies for bequest motives.

¹³⁸ We adjust the net worth variable (i.e., “hnetw”) in SHARE by subtracting savings for long-term investments (i.e., variable “slti”), which includes the face value of life insurance policies and might cause endogeneity issues in the regression analysis.

¹³⁹ For the impact of homeownership on insurance demand, see, for example, Davidoff (2010) for LTCI, and Zietz (2003) for life insurance.

¹⁴⁰ The survey question on subjective life expectancy asks “What are the chances that you will live to be age T or more?” The age T is chosen conditional on current age of the respondent, and the response ranges between 0% and 100%. We create a binary variable for life expectancy, which is 1 if the individual reports a more than 70% chance that they will live for 10 years or more years and 0 otherwise.

¹⁴¹ For example, Courbage et al. (2018) use similar variables as determinants of risky behavior. While being a smoker is also considered an important determinant of risky behavior, due to frequent non-responses in the dataset for this question, adding it would have resulted in a huge decrease in the number of observations.

¹⁴² The question regarding chronic diseases includes 16 conditions (such as high blood pressure, cholesterol, blood sugar, etc.).

¹⁴³ The three tests measure: numeracy, that is, the respondent’s performance in numerical operations based on a series of four questions on basic computations; verbal fluency, that is, the respondents’ ability to read and understand text by relating the number of different animals they can name in one minute; and episodic memory, that is, the respondents’ ability to distinguish situations and facts at different time distances via the number of recalled words out of 10. We define cognitive skills as the (normalized) first component in a principal component analysis of the scores from the numeracy, fluency, and memory tests given in SHARE. See, for example, Bonsang and Dohmen (2015) and Courbage et al. (2018) for constructing a similar variable.

for country of residence. To test the effects of willingness to take financial risks on insurance demand we consider the following probit regression:

$$Y_{i,j,k} = \sum_j \beta_{0,j,k} C_j + \beta_{1,k} WTR1_{i,j,k} + \beta_{2,k} WTR2_{i,j,k} + \beta_{3,k} WTR3_{i,j,k} + \sum_n \beta_{n,j,k} X_{i,j,k} + \varepsilon_{i,j,k} , \quad (1)$$

where the binary variable Y equals one if a respondent has insurance, and zero otherwise; subscript i refers to the individual; and k is an index equal to zero, one, and two for LTCI, term life insurance, and whole life insurance, respectively. C is the vector of country fixed effects with j as country indicator, $WTR1$ to $WTR3$ are binary indicators for different non-zero levels of willingness to take financial risks, from substantial to average risks respectively (we omit the most risk-averse group “not willing to take any financial risks” as the reference group). X refers to a vector of demographic and socioeconomic variables and ε is the error term. All else being equal, we expect that the coefficients $\beta_{1,k}$ to $\beta_{3,k}$ for taking any level of financial risk ($WTR1$ to $WTR3$) will be negative, indicating a negative link between willingness to take financial risks and insurance ownership.

To examine the existence of multicollinearity issues between the explanatory variables, we check the variance inflation factors (VIF) of independent variables in our model, and find that these range from 1.01 to 1.87 for all models. Since all VIFs are below five, we conclude that multicollinearity is not a problem in our models.

4 Results

4.1 Descriptive statistics

Table B1 in Appendix B reports the definitions and descriptive statistics of the relevant variables for the LTCI and life insurance subsamples. On average, around 10% of the LTCI subsample report having LTCI. In the life insurance subsample, the number of insurance holders is 16% and 11% for whole life and term life insurance, respectively. The average age at interview for the LTCI subsample is around 67 years, and for the life insurance subsample, the average age is around 70 for term life insurance and 67 for whole life insurance. In our supplementary material (Tables C2 and C3), we report additional descriptive statistics of the variables and the number of respondents in each country per product.

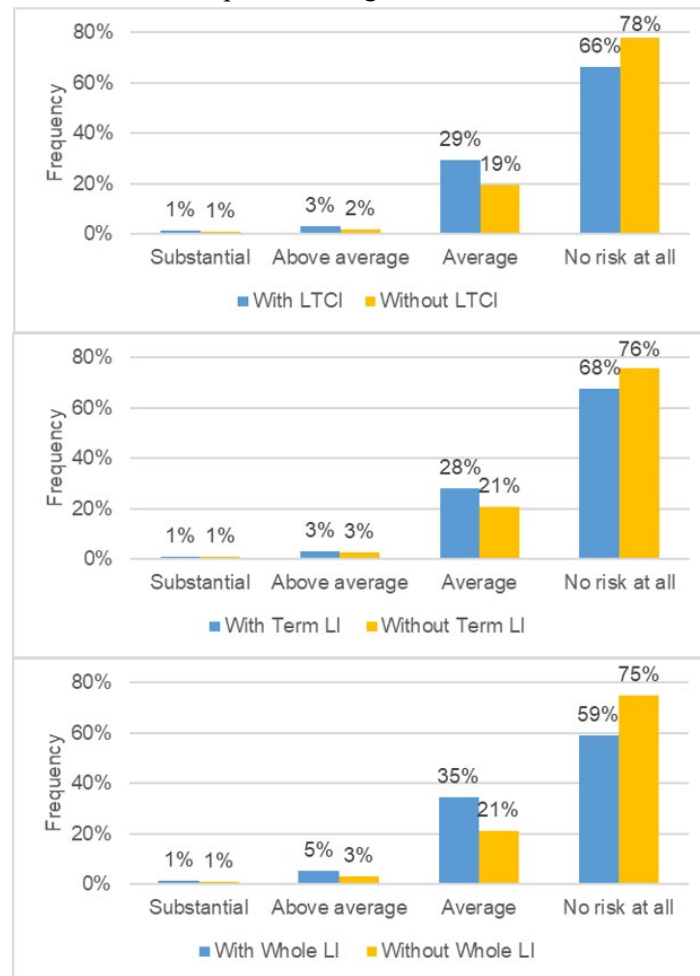
In both subsamples, the majority of the respondents prefer not to take any financial risks (77% for LTCI and around 75% for life insurance). However, those who have insurance are

substantially less risk-averse than those without insurance. The average percentage of respondents not willing to take any financial risks in each product is: 1) LTCI: 66% for insurance holders compared to 78% for non-insurance holders; 2) term life insurance: 68% for insurance holders compared to 76% for non-insurance holders; and 3) whole life insurance: 59% for insurance holders compared to 75% for non-insurance holders.

4.2 Main results

We start by showing that those who are more willing to take financial risks (i.e., less risk-averse) have more insurance compared to respondents with no willingness to take financial risks. Fig. 1 shows the frequency of responses for ownership of LTCI, whole life, and term life insurance. Those who are willing to take average and above average financial risks have on average more insurance compared to those with no willingness to take any financial risks.

Figure 1. Insurance ownership and willingness to take financial risks from SHARE



Note: "LTCI" is long-term care insurance, "Term LI" is term life insurance, and "Whole LI" is whole life insurance. For all three insurance products, the difference in means for the categories willingness to take no financial risks at all and average financial risks are statistically different from 0 ($p=0.001$).

The main regression results are presented in Table 1.¹⁴⁴ Compared to individuals with no willingness to take any financial risks in the reference category, willingness to take average financial risks is positively and significantly associated with insurance holding of all three products. It can be seen that the average marginal effects of willingness to take average financial risks on LTCI, term life,¹⁴⁵ and whole life insurance ownership are 0.011, 0.025, and 0.044, respectively. The link between taking above average financial risks is only significant for whole life insurance holding (at the 1% significance level). These results show that the significance and association between willingness to take more financial risks on insurance holding decrease as the level of willingness to take risks increases towards substantial risk.¹⁴⁶

Table 1. Models for insurance holding

Dependent variable	LTCI		Term LI		Whole LI	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Willingness to take financial risks						
Substantial risks (1)	0.007 (0.018)	0.006 (0.016)	0.011 (0.023)	-0.011 (0.018)	0.073** (0.023)	0.028 (0.019)
Above average risks (2)	0.046** (0.016)	0.018 (0.012)	0.042** (0.016)	0.009 (0.012)	0.110*** (0.014)	0.038** (0.011)
Average risks (3)	0.029*** (0.005)	0.011** (0.004)	0.054*** (0.006)	0.025*** (0.005)	0.092*** (0.005)	0.044*** (0.005)
<i>Ref=No risk at all (4)</i>						
Household size		0.000 (0.003)		0.010*** (0.003)		0.014*** (0.003)
Female		-0.001 (0.003)		-0.003 (0.004)		-0.007 (0.004)
Age		0.004 (0.003)		-0.010* (0.004)		-0.016*** (0.003)
Age squared		-0.031 (0.022)		0.033 (0.029)		0.087*** (0.022)
Number of children		-0.004** (0.001)		0.001 (0.002)		0.001 (0.001)
Married		-0.006 (0.004)		0.019*** (0.005)		0.024*** (0.004)
Log(income)		0.015*** (0.002)		0.017*** (0.003)		0.016*** (0.003)
Wealth level 2		0.015* (0.007)		0.020* (0.008)		0.023** (0.007)
Wealth level 3		0.027**		0.025**		0.033***

¹⁴⁴ We provide full results, including the models using binary variable of taking no financial risks (TNFR) as main explanatory variable, in our supplementary material (Table C4).

¹⁴⁵ We further tested the models for term life insurance for respondents who were currently working and found no significant link between willingness to take financial risks and ownership of term life insurance. This result might indicate that many of the currently working respondents are insured via their employers in group term life insurance schemes regardless of their financial risk preferences. The results are available upon request.

¹⁴⁶ The results using survey weights provided in SHARE lead to similar findings in terms of the signs and significance of coefficients for levels of financial risk and are available upon request.

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		(0.008)		(0.009)		(0.008)
Wealth level 4		0.033***		0.026**		0.034***
		(0.008)		(0.010)		(0.008)
Wealth level 5		0.041***		0.012		0.047***
		(0.009)		(0.010)		(0.009)
<i>Ref=Wealth level 1</i>						
Cognitive skills		0.005**		0.011***		0.004*
		(0.002)		(0.002)		(0.002)
Years of education		0.004***		0.002**		0.003***
		(0.000)		(0.001)		(0.001)
BMI level 1		0.020		-0.023		-0.006
		(0.017)		(0.015)		(0.017)
BMI level 3		0.009*		0.005		0.002
		(0.004)		(0.004)		(0.004)
BMI level 4		0.017**		0.003		0.004
		(0.005)		(0.005)		(0.005)
<i>Ref=BMI level 2</i>						
Vig. physical activity		-0.012**		0.003		0.013**
		(0.003)		(0.004)		(0.004)
Healthy		0.008		-0.006		0.002
		(0.004)		(0.005)		(0.005)
Drinking		-0.006		0.004		-0.001
		(0.004)		(0.005)		(0.005)
Number of chronic diseases		-0.005***		-0.001		0.001
		(0.002)		(0.002)		(0.001)
Homeownership		-0.009		0.008		0.008
		(0.006)		(0.006)		(0.006)
Retired		0.008		0.003		-0.022***
		(0.004)		(0.006)		(0.005)
Life expectancy		0.010**		0.009*		0.012**
		(0.003)		(0.004)		(0.004)
ADL		0.007				
		(0.007)				
IADL		-0.010				
		(0.005)				
Frequent prayer				-0.003		-0.007
				(0.004)		(0.004)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	21,912	21,912	20,203	20,203	33,892	33,892
Pseudo R ²	0.15	0.18	0.05	0.12	0.07	0.12

Notes: "LTCI" is long-term care insurance, "Term LI" is term life insurance, and "Whole LI" is whole life insurance. Average marginal effects are reported with standard errors in parentheses. Columns (i) and (ii) are based on the LTCI subsample, and columns (iii)–(vi) are based on the life insurance subsample. France is the reference country. In columns (iii) and (iv), Spain and Italy are removed, and current workers are excluded. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

Among the demographic and socioeconomic variables in the model for LTCI holding, number of children has a significantly negative effect¹⁴⁷ and years of education¹⁴⁸ has significantly positive average marginal effects. Among the economic variables, both income and wealth (i.e., wealth level 3 and above) have a significantly positive link to ownership of LTCI, but the link for homeownership remains insignificantly negative. Regarding health-related variables, those with higher cognitive skills,¹⁴⁹ fewer chronic diseases, more vigorous physical activity, and a higher subjective life expectancy are more likely to have LTCI. The average marginal effects of BMI levels 3 and 4 are also significantly positive (at the 5% and 1% significance levels, respectively). While the ADL and IADL variables have positive and negative coefficients (similar to the findings reported by Courbage and Roudaut, 2008), these coefficients are insignificant as individuals with initial health issues are often excluded from purchasing LTCI.

The significance of the country fixed effects (reported in Table C4 in our supplementary material) shows that compared to France as the reference, countries with a higher prevalence of family care in their LTC scheme (i.e., Czech Republic, Italy, and Spain) have a significantly negative association with LTCI ownership, whereas in other countries (i.e., Switzerland and Israel) there is a significantly positive link to ownership of LTCI. Fuino et al. (2020), using SHARE, analyze the characteristics of individuals reporting ADL limitations and those of respondents who use formal care. They also suggest that, among the countries in our analysis, in Czech Republic, Italy, and Spain there exist a higher prevalence of LTC family care schemes (compared to Switzerland and France).¹⁵⁰

For ownership of life insurance (both term life and whole life insurance), we find a negative association for age and a positive association for years of education, in line with Lin and Grace (2007). Also, income has a significant positive link to both products with a larger average marginal effect for term life insurance (0.017 compared to 0.016 for whole life insurance), whereas the positive association between wealth and life insurance holding is more pronounced for whole life insurance, both in impact and significance. Among the other controls, household size,¹⁵¹ being married, cognitive skills, vigorous physical activity (only for whole life insurance

¹⁴⁷ Cramer and Jensen (2006) and Zweifel and Strüwe (1998) find similar results and argue that older adults perceive children as a substitute for formal LTC.

¹⁴⁸ See, for example, Eling and Ghavibazoo (2019) for a list of studies that find a positive link between education and demand for LTCI.

¹⁴⁹ We also tested the models using numeracy score as a proxy for financial literacy (Jappelli and Padula, 2013) instead of cognitive skills. The association between willingness to take financial risks and insurance ownership remains very similar to our main results both in size and significance. The results are available upon request.

¹⁵⁰ Israel is not discussed by Fuino et al. (2020).

¹⁵¹ See, for example, Millo and Carmeci (2015) for similar results.

holding), and life expectancy have significant positive average marginal effects. Being retired has only a significant negative link to ownership of whole life insurance.

The results from Table 1 do not confirm our expectation about the negative association between willingness to take financial risks and insurance ownership.

4.3 Robustness tests

4.3.1 Risky asset ownership

It is possible that respondents have difficulty answering hypothetical questions regarding risk preferences (Sloan and Norton, 1997).¹⁵² Thus, we consider another variable that measures revealed financial risk preferences. We follow Bonsang and Dohmen (2015) in constructing a binary indicator equal to one for those who own stocks directly, and zero otherwise. We also construct another binary variable indicating indirect stock ownership, which equals one if the respondent claims to have either stocks, mutual funds, or an individual retirement account (IRA).¹⁵³

In Table 2, we use stock ownership and indirect stock ownership instead of willingness to take financial risks and find similar results to our main findings in Table 1 for both term life insurance and whole life insurance ownership. However, in contrast to the significantly positive link we find in Table 1 for the association between willingness to take financial risks and ownership of LTCI, in column (i) of Table 2, it can be seen that there is no significant association between stock ownership and LTCI holding. However, the average marginal effects of indirect stock ownership are significantly positive (0.025) as illustrated in column (ii), confirming a partially significant positive link in our base model. Directly or indirectly owning stocks has a significantly positive association with term life insurance ownership, as reported in columns (iii) and (iv), and whole life insurance ownership, as reported in columns (v) and (vi) of Table 2. In line with our previous findings in Table 1, the average marginal effects of risky asset ownership are larger in size for ownership of whole life insurance (i.e., 0.031 and

¹⁵² Sloan and Norton (1997) suggest that this issue could be the reason why they found an insignificant association between risk aversion and the demand for LTCI in their study.

¹⁵³ Bonsang and Dohmen (2015) implicitly assume that mutual funds and IRAs carry some stocks. The same assumption is used in Bucciol et al. (2018) using SHARE to investigate the role of trust in risky investments among Europeans. Although including IRA in indirect stock ownership variable is tricky (due to existing heterogeneity among definition of IRA in various European countries and institutional settings, and the possibility that having IRAs might be mandatory in some of countries) we follow the above studies and assume that having IRA partially resembles indirect risky asset ownership.

0.068 for direct and indirect stock ownership, respectively) compared to ownership of term life insurance (i.e., 0.023 and 0.05 for stock and indirect stock ownership, respectively).¹⁵⁴

Table 2. Models for insurance holding using stock and indirect stock ownership

Dependent variable	LTCI		Term LI		Whole LI	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Stock ownership	0.002 (0.006)		0.023** (0.007)		0.031*** (0.006)	
Indirect stock ownership		0.025*** (0.005)		0.050*** (0.005)		0.068*** (0.005)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
N	14,317	14,317	19,887	19,887	33,402	33,402
Pseudo R^2	0.16	0.16	0.12	0.12	0.12	0.13

Notes: “LTCI” is long-term care insurance, “Term LI” is term life insurance, and “Whole LI” is whole life insurance. Average marginal effects are reported with standard errors in parentheses. Columns (i) and (ii) are based on the LTCI subsample, and columns (iii)–(vi) are based on the life insurance subsample. France is the reference country. For columns (iii) and (iv) Spain and Italy are removed, and current workers are excluded. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

The significant positive relationship between stock ownership and life insurance holding supports the results of Cavapozzi et al. (2013), who find that those who already have a life insurance policy are more likely to invest in stocks or mutual funds in the future.¹⁵⁵ Cavapozzi et al. (2013), using life-history information of respondents in SHARE, argue that this is consistent with behavioral models in which economic agents first avoid poverty by purchasing life insurance, and then invest in riskier assets to gain higher economic returns. Luciano et al. (2016), based on the Survey of Household Income and Wealth (SHIW) in Italy, report similar results: They find that being a stockholder significantly and positively affects ownership of both traditional¹⁵⁶ and term life insurance. They argue that such a relation between stock ownership and life insurance signals that people who are more familiar with financial investments have more diversification needs and are therefore willing to purchase life insurance. Furthermore, Luciano et al. (2016) find a negative association between risk aversion and ownership of both traditional and term life insurance (with partial significance in some models).

¹⁵⁴ We additionally tested the regression models in Table 2 using numeracy score instead of cognitive skills. The association between holding risky asset and insurance ownership remains similar (results are available upon request).

¹⁵⁵ In the context of health insurance, Love and Smith (2010) and Goldman and Maestas (2013) also find a positive association between having health insurance and investment in risky assets. They argue that as risk exposure decreases, individuals tend to invest more in risky assets.

¹⁵⁶ In the SHIW, traditional life insurance guarantees a lump sum benefit or an annuity upon survival of the subscriber.

As emphasized by Bonsang and Dohmen (2015), there might be heterogeneities in the answers to our financial risk preferences question, since it is possible that the willingness to take financial risks question captures the financial investment preferences of the individuals instead of reflecting their pure risk preferences. For instance, it might be possible that those with no direct (or indirect) investment in stocks report more frequently that they do not want to take any risks at all, regardless of their inherent risk preferences. If holding risky assets (such as stocks) directly influences the insurance purchase decision (as argued by Luciano et al., 2016), then the relationship between the willingness to take financial risks question and insurance ownership might be (partially) influenced by the current risky asset structure of the respondents. In an attempt to rule out such an effect from the question about willingness to take financial risks (although we cannot eliminate this effect thoroughly), we exclude respondents who report having stocks directly or indirectly and run the same models. In Table 3, we present the average marginal effects of financial risk preferences on insurance take-up for respondents who have no risky assets. While the results are similar to our main findings in Table 1, the levels of significance are lower.

Table 3. Models for insurance holding for individuals without stocks

Dependent variable	LTCI		Term LI		Whole LI	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Willingness to take financial risks						
Substantial risks (1)	-0.008 (0.019)	-0.005 (0.018)	-0.027 (0.018)	-0.022 (0.019)	0.014 (0.022)	-0.019 (0.018)
Aboveaverage risks (2)	0.003 (0.016)	-0.022 (0.012)	0.014 (0.017)	-0.011 (0.018)	0.022 (0.014)	0.016 (0.018)
Average risks (3)	0.013* (0.005)	0.006 (0.006)	0.020*** (0.006)	0.017* (0.007)	0.042*** (0.005)	0.034*** (0.006)
<i>Ref=No risk at all (4)</i>						
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
N	13,187	9,493	17,225	12,747	28,942	20,628
Pseudo R^2	0.16	0.17	0.12	0.13	0.12	0.11

Notes: "LTCI" is long-term care insurance, "Term LI" is term life insurance, and "Whole LI" is whole life insurance. Average marginal effects are reported with standard errors in parentheses. Columns (i), (iii), and (v) are restricted to those who hold no stocks. Columns (ii), (iv), and (vi) are restricted to those who hold no indirect stocks. Columns (i) and (ii) are based on the LTCI subsample, and columns (iii)–(vi) are based on the life insurance subsample. France is the reference country. For columns (iii) and (iv) Spain and Italy are removed, and current workers are excluded. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

4.3.2. Interactions and homogenous groups

We further run model specifications in which the samples are grouped according to certain demographic and socioeconomic characteristics. In Table 4, the respondents are categorized

with respect to gender, marital status (i.e., married or in a registered partnership), size of household (i.e., living alone or with other family members), having children, higher education (i.e., ten or more years of education), a higher numeracy score¹⁵⁷ (a score of four or five out of five in the numeracy test), and good health (including good, very good, or excellent health) or otherwise. The results in Table 4 confirm our main findings from Table 1 that there is a significant positive association between willingness to take financial risks for whole life insurance among all categories of respondents, while such an association is less clear for ownership of LTCI and term life insurance. For LTCI ownership, the results from Table 4 might suggest that certain groups can be better targeted for financial and insurance literacy improvement programs. We report the models: Including possible interactions between age and no willingness to take financial risks (Table C5),¹⁵⁸ samples with homogenous groups of income and wealth quartiles (Table C6)¹⁵⁹ in supplementary material,¹⁶⁰ and we find similar results for insurance ownership (i.e., more significant results for whole life insurance ownership and less significant association for term life insurance LTCI holding).

¹⁵⁷ We run our analysis on homogenous groups of higher and lower numeracy to control for possible impacts of financial literacy on the link between willingness to take financial risks and insurance ownership.

¹⁵⁸ See, for example, Outreville (2014) for references to studies that find a positive link between age and risk aversion.

¹⁵⁹ Courbage et al. (2018), using SHARE, also report that willingness to take financial risks increases with wealth, and they argue that individuals exhibit decreasing absolute risk aversion.

¹⁶⁰ Ai and Norton (2003) show that the marginal effects of interaction terms between discrete choices in the case of nonlinear models are difficult to interpret as their magnitude and sign might be different across different observations. Therefore, we show the impacts of interactions via linear probability models.

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Table 4. Models for insurance holding based on demographic groups

	Female	Male	Married	Not married	HHsize=1	HHsize>1	Have child	No child	Higher educ.	No higher educ.	Higher numeracy	Lower numeracy	Healthy	Not healthy
Panel A. Dependent variable: Long-term care insurance holding														
Taking no financial risks	-0.005 (0.005)	-0.019** (0.006)	-0.009* (0.004)	-0.018* (0.008)	-0.019 (0.010)	-0.010* (0.004)	-0.011** (0.004)	-0.016 (0.015)	-0.012* (0.006)	-0.015** (0.006)	-0.014* (0.006)	-0.014** (0.005)	-0.011* (0.005)	-0.013* (0.006)
N	11,961	9,951	16,308	5,604	3,796	18,116	19,959	1,953	12,910	9,002	9,849	12,063	13,939	7,973
Pseudo R ²	0.19	0.17	0.18	0.19	0.19	0.18	0.18	0.13	0.17	0.19	0.17	0.18	0.16	0.20
Panel B. Dependent variable: Term life insurance holding														
Taking no financial risks	-0.023** (0.007)	-0.022** (0.007)	-0.024*** (0.007)	-0.020** (0.007)	-0.013 (0.007)	-0.026*** (0.006)	-0.021*** (0.005)	-0.032* (0.014)	-0.025*** (0.006)	-0.016 (0.009)	-0.029*** (0.007)	-0.017* (0.007)	-0.027*** (0.006)	-0.012 (0.008)
N	11,455	8,748	12,050	8,153	6,661	13,542	18,091	2,112	13,475	6,728	11,285	8,918	12,586	7,617
Pseudo R ²	0.12	0.12	0.12	0.11	0.11	0.11	0.12	0.15	0.12	0.12	0.13	0.10	0.12	0.12
Panel C. Dependent variable: Whole life insurance holding														
Taking no financial risks	-0.040*** (0.006)	-0.044*** (0.007)	-0.046*** (0.006)	-0.033*** (0.007)	-0.038*** (0.008)	-0.043*** (0.006)	-0.040*** (0.005)	-0.062*** (0.013)	-0.049*** (0.006)	-0.034*** (0.007)	-0.051*** (0.006)	-0.054*** (0.007)	-0.049*** (0.006)	-0.026*** (0.008)
N	18,461	15,431	21,710	12,182	9,230	24,662	30,132	3,760	22,558	11,334	18,318	15,574	22,772	11,120
Pseudo R ²	0.13	0.11	0.12	0.12	0.11	0.12	0.12	0.14	0.10	0.15	0.10	0.13	0.11	0.13
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Average marginal effects are reported with standard errors in parentheses. Panel A is based on the LTCI subsample, and Panels B and C are based on the life insurance subsample. France is the reference country. For Panel B Spain and Italy are removed, and current workers are excluded. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

4.3.3 Ownership of supplementary health insurance

As a further robustness test, we investigate the association between willingness to take financial risks and ownership of supplementary health insurance.¹⁶¹ The subsample is extracted from SHARE wave 5 based on available answers to ownership of supplementary health insurance. The number of observations in this subsample is 51,366 and the countries included in the analysis comprise Austria, Belgium, Czech Republic, Denmark, France, Germany, Israel, Italy, Luxembourg, Netherlands, Slovenia, Spain, Sweden, and Switzerland. The control variables for this analysis are the same as the ones in our main analysis for LTCI, except that subjective life expectancy is removed. Table 5 reports that both taking average and above average financial risks are positively associated with ownership of supplementary health insurance. These results confirm the positive association we found between willingness to take financial risks and ownership of insurance in our main analysis.

Table 5. Models for insurance holding

Dependent variable	Supplementary Health Insurance		
	(i)	(ii)	(iii)
Willingness to take financial risks			
Substantial risks (1)	0.174** (0.066)	0.089 (0.068)	
Above average risks (2)	0.408*** (0.037)	0.224*** (0.038)	
Average risks (3)	0.293*** (0.017)	0.133*** (0.018)	
<i>Ref=No risk at all (4)</i>			
TNFR			-0.142***
Country fixed effects	Yes	Yes	Yes
Control variables	No	Yes	Yes
N	51,366	51,366	51,366
Pseudo R^2	0.37	0.40	0.40

Notes: Average marginal effects are reported with standard errors in parentheses. The subsample is extracted from wave 5 based on available answers to ownership of supplementary health insurance. France is the reference country. Control variables are the same as the ones in our main analysis for LTCI, except that life expectancy is removed. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

5 Discussion

We find a significant positive association between willingness to take average financial risks and insurance ownership, which is supported by different robustness tests. To compare our results with the literature, we summarize the recent studies incorporating a measure of risk

¹⁶¹ The question in SHARE asks: “Do you have any supplementary health insurance that pays for services not covered by your basic health insurance/national health system/ third party payer?”

aversion in their analysis of life insurance and LTCI demand in Table B2 in Appendix B. For both life insurance and LTCI, positive, negative, and insignificant associations between risk aversion and ownership of insurance are found. Table B2 lists the studies that either focus on the impact of risk aversion on insurance demand or include a measure of risk aversion as a covariate in their analysis of insurance demand. Such risk aversion measures are questions about preferences via gambling over lifetime income or qualitative questions about taking financial risks and receiving a proportionate reward.¹⁶²

Previous studies have suggested different explanations for a negative link between risk aversion and LTCI demand. Boyer et al. (2017) find that LTCI products might be seen as a risky investment by individuals due to the risks related to insurance payouts, lapsing and premium increases. Costa-Font and Rovira-Forns (2008) argue that higher risk aversion might lead to a larger probability of insuring LTC via alternative means of self-insuring, such as protective savings. It might be useful in future studies to analyze the role of monetary amounts of individuals' asset structure (i.e., both financial and non-financial assets and the amount of risky and non-risky investments) on insurance ownership.

Consumers' low demand for other long-horizon insurance products, for example, life annuities and reverse mortgages, also suggests that individuals might have difficulty deciding on the purchase of coverage for long-term probabilistic outcomes, preferring to stay with their current status quo and remain uninsured (Brown and Finkelstein, 2011). This might imply that the role of reference points (i.e., being uninsured) is more relevant to the demand for insurance compared to the impact of risk aversion. Gottlieb and Mitchell (2020), using narrow framing and loss aversion, find a negative but insignificant relationship between risk aversion and LTCI holding and use prospect theory to argue that the correlation between risk aversion and LTCI can have a negative sign.¹⁶³

A positive association between willingness to take financial risks and ownership of life insurance could be due to the perceived riskiness of such products. Baek and DeVaney (2005),

¹⁶² Outreville (2014) discusses the difficulties in measuring risk attitudes and the alternative use of socio-demographic proxies, such as gender, instead. See, e.g., Dragos et al. (2020) using other proxies, such as amount of deposits and frequency of engaging in games (i.e., gambling, lottery and betting activities), analyze the link between risky behavior and life insurance purchase decision. Since we use a direct question about self-reported risk willingness to take financial risks, we compare our results with those using direct risk aversion questions rather than with proxies.

¹⁶³ Gottlieb and Mitchell (2020) define narrow framers as people whose preferences include both consumption and gain-loss utility from prospect theory. While consumption smoothing should increase the demand for insurance for risk-averse individuals, the concavity of gain-loss utility induces individuals to buy less insurance, which might explain why the risk aversion coefficient is not only statistically insignificant but also has the "wrong" sign.

using a similar risk attitude question in SCF, also find a positive association between willingness to take risks and owning cash-value life insurance.¹⁶⁴ Giesbert et al. (2011) also find that risk-averse households are less likely to participate in micro-life insurance in Ghana because they perceive it as a risky investment, as they don't understand the terms and conditions of the contract. Our results contradict the findings of Hwang (2017) regarding the differences between financial riskiness of term and whole life insurance. We find that the association between willingness to take financial risks and whole life insurance holding is stronger than the former's association with term life insurance (i.e., willingness to take both average and above average financial risks is positively and significantly associated with whole life insurance ownership compared to term life insurance). Hwang (2017) argues that whole life insurance comprises a saving component, which makes it financially a less risky product compared to term life insurance. Term life insurance is a pure protection product and the insured will lose the premiums if no loss occurs. Hwang (2017) finds a significant negative link between risk aversion and life insurance demand. However, he reports that such significance disappears when a variable for loss aversion is included in his analysis. Using prospect theory, he argues that an individual might view insurance as a risky investment that is profitable only if the indemnity received from the insurance company exceeds the premium paid. There is a growing literature using prospect theory to address insurance purchasing decisions (see, e.g., Zheng, 2020; McIntosh et al., 2019; Eeckhoudt et al., 2018). Unfortunately, SHARE does not ask specific questions to test the hypotheses derived from prospect theory.

Since we find a positive association between willingness to take financial risks and insurance ownership, we suspect that individuals' financial literacy or their familiarity with financial products might play a role in this association. Financial literacy is found to influence both retirement planning (Lusardi and Mitchell, 2007) and financial risk preferences (see, e.g., Van Rooij et al., 2011 on the role of financial literacy and stock market participation). We have incorporated various control variables relevant to financial literacy (such as education and cognitive skills) and ran robustness tests (i.e., separating individuals based on higher and lower numeracy score) to control for the impact of financial literacy on the association between willingness to take financial risks and insurance ownership. Similar to our main results, we find positive link between willingness to take financial risks and insurance holding for both homogenous groups of higher and lower numeracy, with more significance for whole life

¹⁶⁴ Baek and DeVaney (2005) suggest that such a question mainly addresses saving and investment behavior rather than purely risk aversion.

insurance. Future research should incorporate a more accurate measure of financial literacy to control for its impact on the link between risk attitudes and insurance ownership.

Furthermore, we do not account for supply-side factors relevant to insurance products. Such factors comprise differences in products in terms of period, amount of coverage, age limitations, and health examination requirements. Knowledge of supply-side factors might help to better disentangle the effects of products' complexities from the effects of individuals' risk attitudes on insurance ownership. Future survey-based research could ask non-insurance holders to list their reasons for not purchasing insurance, possibly with pre-defined answers about product complexity, supply-side factors such as high premiums and product exclusions, receipt of informal care from family, or coverage via public schemes.

Our study is subject to several limitations which also open avenues for potential future research. First, the current questionnaire in SHARE does not allow us to test the impact of risk attitudes on insurance ownership quantitatively. Future research should incorporate incentivised risk aversion question, such as the one designed by Holt and Laury (2002), or hypothetical lifetime income gamble question used in Barsky et al. (1997), to analyze the differences between individuals' risk attitudes across different insurance products. Furthermore, the impacts of higher-order risk attitudes, such as temperance and prudence, on insurance ownership cannot be investigated based on qualitative risk attitude questions. In addition, the lack of appropriate questions in SHARE on other behavioral factors, such as narrow framing, loss aversion, or time preferences, does not allow us to test alternative models beyond utility theory.

Lastly, an insufficient number of repeated responses to the risk attitude question across different waves in SHARE prevents us from analyzing the relationship between risk attitudes and insurance ownership in a panel study framework. There are previous studies that suggest that purchasing insurance encourages individuals to take more financial risks. Cavapozzi et al. (2013) argue that life insurance purchase could be analogous to the investment in bonds in life-cycle models for individuals with bounded rationality. In such life-cycle models, an optimal portfolio strategy is driven by first investing in low-risk assets (to protect against worst-case scenarios) and, later on, in more risky assets such as stocks (Binswanger, 2011). Luciano et al. (2016) document a positive association between risky asset ownership and life insurance in Italy and refer to such an association as diversification needs in financial markets. Analyzing the temporal structure of insurance ownership and risk attitudes across different waves of the survey could have allowed us to see if any changes in insurance ownership influence individuals' willingness to take financial risks, encouraging more risky investment.

6 Conclusion

While many theoretical studies emphasize the importance of role of risk attitudes on the demand for insurance, there are inconclusive and ambiguous results on the link between risk aversion and LTCI and life insurance demand among empirical studies. This paper uses results from the well-established standard utility theory framework as a benchmark and applies it to a large cross-country dataset obtained from SHARE, to test the effects of individual willingness to take financial risks, as a proxy for risk aversion, on the ownership of private LTCI, term life insurance, and whole life insurance.

We find that willingness to take financial risks is positively associated with insurance ownership, with lower significance for term life insurance and LTCI than for whole life insurance. Our results are robust across many model specifications; we test our models using self-reported risky asset ownership instead of self-reported willingness to take financial risks, and we also limit the analysis to respondents with no risky assets. Moreover, we examine the possible financial risk preference heterogeneities among demographic and socioeconomic groups and test the potential interactions between willingness to take financial risks and age groups. We provide robust evidence of our main findings for whole life insurance, while the results are less robust for LTCI and term life insurance.

Our findings motivate the need for further empirical studies on portfolio choices for retirement. Future research could examine whether insurance products, such as life insurance and LTCI, are perceived as: 1) risk-mitigation tools, that is, they might stimulate more investment in risky assets; and 2) risky investments per se, that is, the complexities associated with insurance coverage, payout, lapses, products' long-term dimensions, or the possible excess of premiums paid over indemnity make them a risky investment.

The results of this study have important implications for researchers and practitioners. Our findings suggest that analyzing the association between risk aversion and individuals' insurance purchase decisions via classical utility theory (looking at the first two moments of the utility function) should be cautiously done as it is plausible that higher-order risk attitudes play a role in this relationship. Alternatively, more research is needed to investigate such a relationship using frameworks other than expected utility theory (e.g., prospect theory). Furthermore, practitioners might benefit from our study by redesigning their marketing strategies to enhance individuals' understanding of such products in terms of financial riskiness. Such strategies should aim to increase customers' knowledge of how insurance products help reduce financial

risks. This is especially crucial for whole life insurance as we find that, across different demographic and socioeconomic groups, individuals with no willingness to take any financial risks have less whole life insurance, signaling that whole life insurance is perceived to be financially risky. However, the existing heterogeneities regarding the link between willingness to take financial risks and insurance ownership for LTCI and term life insurance might call for more diverse marketing strategies to better address the financial risk perception of certain potential customers.

Appendix A. Theoretical framework

To illustrate the association between risk aversion and optimal insurance, we revisit the basic theory of insurance demand in a single-period expected-utility setting (Mossin, 1968) using the notations from Schlesinger (2013). We assume that an individual has an initial wealth $W > 0$, and the random variable $\tilde{x}$ denotes the amount of a loss. For this random loss, the individual can decide to retain the financial risk and cover the losses from her wealth, or she can transfer the risk to an insurance company by paying a fixed premium P determined by the market. The risk neutral insurer accepts to compensate (fully or partially) the loss (referred to as indemnity).

To avoid bankruptcy issues, we assume $0 \leq x \leq W$, and the insurance indemnity is contingent only on x and is defined by $I(x)$. We also assume that the indemnity $I(x)$ is nondecreasing in x , $0 \leq I(x) \leq x$, and both parties can observe the realization of $\tilde{x}$ costlessly, and they agree on the distribution of the random variable $\tilde{x}$. We assume that the individual is risk-averse with von Neumann-Morgenstern utility of final wealth which is given by $u(\cdot)$, with the assumption that u is twice differentiable everywhere, with $u' > 0$ and $u'' < 0$.

In the case of proportional coinsurance, the insurer pays a fixed proportion, say a of the loss. Hence, $I(x) = ax$ and the individual retains a fraction $1 - a$ of the loss. In the case of full insurance (i.e., $a = 1$), the insurer pays an indemnity that is equal to the full amount of the loss. The assumption $0 \leq I(x) \leq x$ is equivalent to $0 \leq a \leq 1$. The insurance premium is also defined as a function of the indemnity as follows:

$$P[I(\cdot)] = E[I(\tilde{x}) + c[I(\tilde{x})]]. \quad (2)$$

In Equation (2), E denotes the expectation operator and $c(\cdot)$ is the cost function, and $c[I(x)]$ denotes the cost of paying indemnity $I(x)$, comprising any market-based charges for assuming the risk $I(\tilde{x})$. In the baseline and for the sake of simplicity, we consider the case of perfect competition in which $c[I(x)] = 0 \forall x$, which implies that the insurer receives an expected profit of zero, and the premium is given by fair premium. The simplest case of Equation (2) is to consider the expected cost be proportional to the expected indemnity as below:

$$P(a) = E(a(\tilde{x}) + \lambda a\tilde{x}) = a(1 + \lambda)E\tilde{x}, \quad (3)$$

where λ is loading factor, $\lambda \geq 0$. The consumer's final wealth is expressed as a random variable dependent on the choice of level of coverage a ,

$$\tilde{Y}(a) \equiv W - a(1 + \lambda)E\tilde{x} - \tilde{x} + a\tilde{x}. \quad (4)$$

The individual's objective is to maximize her expected utility by choosing a :

$$\max_a E[u(\tilde{Y}(a))], \quad (5)$$

where we impose the constraint that $0 \leq a \leq 1$ for not having over insurance. To solve Equation (5), we use the first-order condition for the unconstrained objective:

$$\frac{dEu}{da} = E[u'\tilde{Y}(a) \cdot (\tilde{x} - (1 + \lambda)E\tilde{x})] = 0. \quad (6)$$

Based on the assumption that $u'' < 0$, the second-order condition for a maximum holds and d^2Eu/da^2 is negative everywhere, meaning that the satisfying a^* is a global maximum.

For full insurance ($a = 1$), dEu/da will be evaluated as:

$$\begin{aligned} \left. \frac{dEu}{da} \right|_{a=1} &= Eu'(W - a(1 + \lambda)E\tilde{x})(\tilde{x} - (1 + \lambda)E\tilde{x}) \\ &= -\lambda(E\tilde{x})u'(W - a(1 + \lambda)E\tilde{x}). \end{aligned} \quad (7)$$

Based on the assumption that $u' > 0$, the right-hand side of Equation (7) will be negative for any $\lambda > 0$ and zero for $\lambda = 0$. Hence, full insurance is optimal only if the loading factor is zero.

The case in which no insurance is optimal can be derived by:

$$\begin{aligned} \left. \frac{dEu}{da} \right|_{a=0} &= Eu'(W - \tilde{x})(\tilde{x} - (1 + \lambda)E\tilde{x}) = E[u'(W - \tilde{x})\tilde{x} - (1 + \lambda)E\tilde{x}u'(W - \tilde{x})] \\ &= -\lambda Eu'(\tilde{Y}(0) \cdot E\tilde{x} + Cov(u'(\tilde{Y}(0)), \tilde{x})). \end{aligned} \quad (8)$$

The concavity of $E[u(\tilde{Y}(a))]$ in a in Equation (8) yields:

$$\left. \frac{dEu}{da} \right|_{a=0} = -\lambda Eu'(\tilde{Y}(0) \cdot E\tilde{x} + Cov(u'(\tilde{Y}(0)), \tilde{x})). \quad (9)$$

which is called Mossin's Theorem. The covariance term in Equation (9) is positive and independent from the value of λ ; hence there exists a unique value of λ such that the derivative in Equation (9) equals zero. This value of λ leads to optimal zero coverage, $a^* = 0$. The results from (7), (8) and (9) are in line with Mossin (1968) Theorem that for proportional insurance with a fair price ($\lambda = 0$), the full coverage ($a^* = 1$) is optimal for risk-averse individuals. In the existence of positive premium loading ($\lambda > 0$) partial insurance is optimal ($a^* < 1$).

Now we show that an increase in an individual's degree of risk aversion at all levels of wealth always leads to an increase in the optimal level of insurance coverage.

Let F denote the distribution of loss $\tilde{x}$, which by assumption, falls into in the interval $[0, W]$. a^* denotes the optimal level of coverage based on original utility function u . Furthermore, let v denote a uniformly more risk-averse utility function. Following Pratt (1964) we know that there exists a function $g: \mathbb{R} \rightarrow \mathbb{R}$ such that $v(y) = g[u(y)]$, where $g' > 0$ and $g'' < 0$. Since v is a risk-averse utility function, $Ev(\tilde{Y}(a))$ is concave in a . Then we have the following:

$$\begin{aligned}
 \frac{dEv}{da} \Big|_{a_u^*} &= \frac{dEg[u]}{da} \Big|_{a_u^*} \\
 &= \int_0^W g'[u(Y(a_u^*))] u'(Y(a_u^*)) (x - (1 + \lambda)E\tilde{x}) dF \\
 &> g'[u(y_0)] \left\{ \int_0^{x_0} u'(Y(a_u^*)) (x - (1 + \lambda)E\tilde{x}) dF \right. \\
 &\quad \left. + \int_{x_0}^W u'(Y(a_u^*)) (x - (1 + \lambda)E\tilde{x}) dF \right\} = 0
 \end{aligned} \tag{10}$$

where $x_0 \equiv (1 + \lambda)E\tilde{x}$, and $y_0 = W - a^*(1 + \lambda)E\tilde{x} - x_0 + ax_0$.

The above inequality results from the concavity of g , and the equality of the last expression to zero follows by the first-order condition for a_u^* . Since $Ev(\tilde{Y}(a))$ is concave in a , it can be implied from inequality (10) that $a_v^* > a_u^*$. Hence, higher risk-averse individuals purchase more insurance.

Appendix B. Descriptive statistics and literature review

Table B1. Variable definitions and descriptive statistics

	Long-term care insurance subsample				Life insurance subsample				Total Whole LI	With Whole LI	Without Whole LI	Sig.
	Total LTCI	With LTCI	Without LTCI	Sig.	Total Term LI	With Term LI	Without Term LI	Sig.				
Long-term care insurance holding (binary)	0.10	1.00	0.00	-	-	-	-	-	-	-	-	-
Term life insurance holding (binary)	-	-	-	-	0.11	1.00	0.00	-	-	-	-	-
Whole life insurance holding (binary)	-	-	-	-	-	-	-	-	0.16	1.00	0.00	-
Taking no financial risks (binary, not taking any level of risk=1)	0.77	0.66	0.78	***	0.75	0.68	0.76	***	0.75	0.59	0.75	***
Household size (discrete)	2.24	2.13	2.26	***	1.85	2.06	1.82	***	2.05	2.21	2.01	***
Female (binary, female=1)	0.55	0.53	0.55	*	0.57	0.54	0.57	*	0.55	0.5	0.55	***
Age at interview in years (continuous)	66.76	66.46	66.79	***	70.14	65.92	70.65	***	66.6	62.72	67.35	***
Age squared divided by 1,000 (continuous)	4.54	4.50	4.55	***	4.99	4.40	5.07	***	4.53	4.01	4.63	***
Number of children (discrete)	2.21	2.28	2.21	***	2.16	2.16	2.16	***	2.12	2.13	2.12	***
Married (binary, married, or registered partnership=1)	0.74	0.74	0.75	***	0.60	0.71	0.58	***	0.641	0.72	0.63	***
Years of education	10.44	11.87	10.29	***	11.17	11.66	11.11	***	11.23	12.42	11.01	***
Annual income (continuous)	18.93	26.81	18.08	***	21.76	21.35	21.80	***	21.93	24.24	21.50	***
Net wealth (continuous)	129.37	226.79	118.92	***	123.78	129.39	123.10	***	125.44	141.94	122.39	***
Cognitive skills (continuous)	-0.35	0.04	-0.39	***	-0.01	0.43	-0.06	***	0.02	0.47	-0.06	***
Vigorous physical activity (binary, intense physical activity at least once a week=1)	0.52	0.56	0.51	***	0.54	0.62	0.53	***	0.58	0.69	0.56	***
Healthy (binary, excellent, very good, or good health=1)	0.64	0.75	0.625	***	0.62	0.67	0.62	***	0.67	0.75	0.66	***
Number of chronic diseases (discrete)	1.72	1.45	1.75	***	2.00	1.75	2.03	***	1.74	1.48	1.79	***
BMI level 1 (binary, underweight=1)	0.01	0.02	0.01	**	0.01	0.01	0.01		0.01	0.01	0.01	
BMI level 2 (binary, normal weight=1)	0.35	0.37	0.35		0.36	0.34	0.36		0.37	0.39	0.37	**
BMI level 3 (binary, overweight=1)	0.43	0.42	0.43		0.41	0.42	0.41		0.41	0.41	0.41	
BMI level 4 (binary, obese=1)	0.21	0.19	0.21	*	0.22	0.23	0.22		0.21	0.19	0.21	**
Homeowner (binary, homeowner=1)	0.78	0.81	0.78	***	0.65	0.75	0.64	***	0.71	0.75	0.70	***
Drinking (binary, drink at least five times per week=1)	0.23	0.21	0.23	**	0.23	0.23	0.23		0.22	0.211	0.22	*
Retired (binary, retired=1)	0.58	0.56	0.58	*	0.84	0.81	0.84	***	0.58	0.43	0.61	***
Life expectancy (binary, more than 70% chance of living 10 years or more=1)	0.49	0.58	0.48	***	0.46	0.57	0.44	***	0.53	0.62	0.51	***
ADL (binary, at least one ADL difficulty=1)	0.09	0.07	0.10	***	-	-	-	-	-	-	-	-
IADL (binary, at least one IADL difficulty=1)	0.14	0.10	0.14	***	-	-	-	-	-	-	-	-
Frequent prayer (binary, pray more than once in a week=1)	-	-	-	-	0.33	0.28	0.33	***	0.33	0.26	0.34	***
N	21,912	2,122	19,790		20,203	2,187	18,016		33,892	5,285	28,607	

Note: “LTCI” is long-term care insurance, “Term LI” is term life insurance, and “Whole LI” is whole life insurance. For term life insurance, Spain and Italy are removed, and current workers are excluded. The difference in means (among insurance holders and non-insurance holders) statistically different from zero is reported under the “Sig.” columns based on *t*-tests for continuous variables and Chi-Square tests for binary variables, with *, **, and *** denoting statistical significance at the 5%, 1%, and 0.1% levels, respectively. Monetary amounts are PPP-adjusted, divided by household size and in thousand Euros.

Essay II Willingness to take financial risks and insurance holdings

Table B2. Literature review: The link between risk aversion and insurance demand

Study	Link	Data	Analysis	Product(s)	Risk aversion measure
Panel A. Life insurance (LI)					
Barsky et al. (1997)	+	HRS 1992	Emp.	LI in general	GOLI
Gutter and Hatcher (2008)	+	SCF 2004	Emp.	Term/Whole LI	WTR Financial (4 levels)
Nam and Hanna (2019)	+	SCF 1992–2013	Emp.	Whole LI	WTR Financial (4 levels)
Baek and DeVaney (2005)	-	SCF 2001	Emp.	Term/Whole LI	WTR Financial (4 levels)
Giesbert et al. (2011)	-	Own survey in Ghana 2008	Emp.	Term	WTR General (5 levels)
Luciano et al. (2016)	-	SHIW 2012	Emp.	Term/Traditional LI	WTR Financial (4 levels)
Nam and Hanna (2019)	-	SCF 1992–2013	Emp.	Term LI	WTR Financial (4 levels)
Luigi Guiso and Paiella (2004)	0	SHIW 1995	Emp.	LI	Expected investment gain
Liebenberg et al. (2012)	0	SCF 1983–1989	Emp.	Term/Whole LI	WTR Financial (4 levels)
Heo et al. (2013)	0	NLSY 2004–2008	Emp.	Whole LI	GOLI
Mulholland et al. (2016)	0	SCF 1992–2010	Emp.	Whole LI	WTR Financial (4 levels)
Hwang (2017)	0	HRS 2012	Emp.	Term/Whole LI	GOLI
Song et al. (2019)	0	NLSY 2006–2012	Emp.	Whole LI	WTR 8 domains
Nagy et al. (2020)	0	Own survey in Romania 2018	Emp.	LI	Risky lottery vs. fixed pay-off
Panel B. Long-term care insurance (LTCI)					
Schaber and Stum (2007)	+	Own survey of U.S. employees 1994	Emp.	Group LTCI	WTCL
Chatterjee and Fan (2017)	+	HRS 2012	Emp.	Private LTCI	GOLI
Akaichi et al. (2020)	+	SLTCAP 2014	Emp.	Private LTC	WTR General (10 levels)
Stum (2008)	-	Own survey of U.S. employees 2000	Emp.	Private LTCI	WTCL
Allaire et al. (2016)	-	SLTCAP 2014	Emp.	Private LTCI	WTR General (10 levels)
Gousia (2016)	-	SHARE 2013	Emp.	Private LTCI	WTR Financial (4 levels)
Boyer et al. (2017)	-	Own survey in Canada 2016	Emp.	Private LTCI	WTR Financial (4 levels)
Sloan and Norton (1997)	0	HRS 1992/1994	Emp.	Private LTCI	GOLI
Costa-Font and Rovira-Forns (2008)	0	Survey of Catalans 1999	Emp.	Private LTCI	Risk attitudes (10 levels)
Davidoff (2010)	0	HRS 2004	Emp./Theo.	Private LTCI	-
Boyer et al. (2019)	0	Own survey in Canada 2016	Emp.	Private LTCI	WTR Financial (4 levels)
Gottlieb and Mitchell (2020)	0	HRS and own survey 2012 in U.S.	Emp./Theo.	Private LTCI	Lotteries with large stakes

Notes: Emp. (Theo.) denotes studies showing an empirical (theoretical) link. + (-, 0) denotes a positive (negative, insignificant) link between risk aversion measure and insurance demand. WTR is willingness to take risks. GOL is gamble over lifetime income. WTCL is willingness to take chance of not needing long-term care. HRS is Health and Retirement Study in the U.S. SCF is the U.S. Survey of Consumer Finances. SHIW is Survey of Household Income and Wealth in Italy. NLSY is National Longitudinal Survey of Youth in the U.S. SLTCAP is Survey of Long-term care Awareness and Planning in the U.S.

Appendix C. Supplementary material

Table C1. Models for stock ownership

Dependent variable	Stock ownership			
	(i)	(ii)	(iii)	(iv)
Willingness to take financial risks				
Substantial risks (1)	0.124*** (0.034)		0.181*** (0.025)	
Above average risks (2)	0.197*** (0.027)		0.220*** (0.015)	
Average risks (3)	0.089*** (0.007)		0.119*** (0.005)	
<i>Ref=No risk at all (4)</i>				
Taking no financial risks (TNFR)		-0.092*** (0.006)		-0.122*** (0.005)
Age	0.010** (0.004)	0.010** (0.004)	0.006* (0.003)	0.006* (0.003)
Age squared	-0.072** (0.025)	-0.071** (0.025)	-0.045* (0.019)	-0.044* (0.019)
Female	-0.013*** (0.003)	-0.014*** (0.003)	-0.015*** (0.003)	-0.016*** (0.003)
Years of education	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)	0.004*** (0.000)
Married	0.007 (0.004)	0.007 (0.004)	0.016*** (0.004)	0.016*** (0.004)
Household size	0.008** (0.003)	0.008** (0.003)	0.015*** (0.002)	0.015*** (0.002)
Number of chronic diseases	0.000 (0.001)	0.000 (0.002)	-0.001 (0.001)	-0.001 (0.001)
Retired	0.001 (0.004)	0.001 (0.004)	0.008 (0.004)	0.008 (0.004)
Log(income)	0.012*** (0.003)	0.012*** (0.003)	0.010*** (0.002)	0.010*** (0.002)
Wealth level 2	0.053*** (0.012)	0.053*** (0.012)	0.080*** (0.009)	0.079*** (0.009)
Wealth level 3	0.087*** (0.013)	0.086*** (0.013)	0.120*** (0.010)	0.120*** (0.010)
Wealth level 4	0.102*** (0.014)	0.102*** (0.014)	0.174*** (0.011)	0.174*** (0.011)
Wealth level 5	0.171*** (0.017)	0.172*** (0.017)	0.263*** (0.012)	0.264*** (0.012)
<i>Ref=Wealth level 1</i>				
Country fixed effects	Yes	Yes	Yes	Yes
N	14,317	14,317	33,402	33,402
Pseudo R ²	0.24	0.23	0.25	0.25

Notes: Average marginal effects are reported with standard errors in parentheses. Columns (i) and (ii) are based on the LTCI subsample, and columns (iii) and (iv) are based on the life insurance subsample. France is the reference country. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

Essay II Willingness to take financial risks and insurance holdings

Table C2. Additional descriptive statistics

	Long-term care insurance subsample			Life insurance subsample					
	LTCI			Term LI			Whole LI		
	Min.	Max.	Med.	Min.	Max.	Med.	Min.	Max.	Med.
Long-term care insurance holding	0	1	0	-	-	-	-	-	-
Whole life insurance holding	-	-	-	-	-	-	0	1	0
Term life insurance holding	-	-	-	0	1	0	-	-	-
Financial risk aversion	0	1	1	0	1	1	0	1	1
Household size	1	12	2	1	11	2	1	12	2
Female	0	1	1	0	1	1	0	1	1
Age at interview in years	50	90	66	50	90	70	50	90	66
Age squared divided by 1,000	2.5	8.1	4.36	2.5	8.1	4.9	2.5	8.1	4.36
Number of children	0	17	2	0	17	2	0	17	2
Married	0	1	1	0	1	1	0	1	1
Years of education	0	25	11	0	25	11	0	25	11
Annual income	0.64	389.84	10.10	771.81	397.51	12.25	0.712	399.01	12.41
Net wealth	-235.92	9,756.10	73.65	-85.33	2,917.40	71.66	-86.33	2,927.39	72.94
Cognitive skills	-4.81	6.66	-0.3	-4.81	6.66	0.04	-4.81	6.66	0.10
Vigorous physical activity	0	1	1	0	1	1	0	1	1
Health status	0	1	1	0	1	1	0	1	1
Number of chronic diseases	0	13	1	0	11	2	0	11	1
BMI level 1	0	1	0	0	1	0	0	1	0
BMI level 2	0	1	0	0	1	0	0	1	0
BMI level 3	0	1	0	0	1	0	0	1	0
BMI level 4	0	1	0	0	1	0	0	1	0
Homeowner	0	1	1	0	1	1	0	1	1
Drinking	0	1	0	0	1	0	0	1	0
Retired	0	1	1	0	1	1	0	1	1
Life expectancy	0	1	0	0	1	0	0	1	1
ADL	0	1	0	-	-	-	-	-	0
IADL	0	1	0	-	-	-	-	-	0
Frequent prayer	-	-	-	0	1	0	0	1	0
N	21,912			20,203			33,892		

Notes: “LTCI” is long-term care insurance, “Term LI” is term life insurance, and “Whole LI” is whole life insurance. For term life insurance, Spain and Italy are removed, and current workers are excluded. “Min.”, “Max.”, and “Med.” refer to minimum, maximum, and median values for each variable, respectively. Monetary amounts are PPP-adjusted, divided by household size, and in thousand Euros.

Table C3. Number of respondents by country

	Long-term care insurance subsample	Life insurance subsample	
	LTCI	Term LI	Whole LI
Austria	-	2,194	2,652
Belgium	-	2,419	3,402
Czech Republic	4,846	2,645	3,209
Denmark	-	1,416	2,459
France	3,954	1,915	2,437
Germany	-	2,123	3,391
Israel	1,483	517	795
Italy	4,041	-	2,591
Luxembourg	-	743	1,023
Netherlands	-	1,682	2,409
Slovenia	-	1,583	1,888
Spain	5,019	-	3,105
Sweden	-	1,790	2,632
Switzerland	2,569	1,176	1,899
N	21,912	20,203	33,892

Note: “LTCI” is long-term care insurance, “Term LI” is term life insurance, and “Whole LI” is whole life insurance.

Table C4. Models for insurance holding (full models)

Dependent variable	LTCI		Term LI			Whole LI			
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)
Willingness to take financial risks									
Substantial risks (1)	0.007 (0.018)	0.006 (0.016)		0.011 (0.023)	-0.011 (0.018)		0.073** (0.023)	0.028 (0.019)	
Above average risks (2)	0.046** (0.016)	0.018 (0.012)		0.042** (0.016)	0.009 (0.012)		0.110*** (0.014)	0.038** (0.011)	
Average risks (3)	0.029*** (0.005)	0.011** (0.004)		0.054*** (0.006)	0.025*** (0.005)		0.092*** (0.005)	0.044*** (0.005)	
Ref=No risk at all (4)									
Taking no financial risks (TNFR)			-0.011** (0.004)			-0.022*** (0.005)			-0.042*** (0.005)
Household size		0.000 (0.003)	0.000 (0.003)		0.010*** (0.003)	0.010*** (0.003)		0.014*** (0.003)	0.014*** (0.003)
Female		-0.001 (0.003)	-0.001 (0.003)		-0.003 (0.004)	-0.003 (0.004)		-0.007 (0.004)	-0.007 (0.004)
Age		0.004 (0.003)	0.004 (0.003)		-0.010* (0.004)	-0.010* (0.004)		-0.016*** (0.003)	-0.016*** (0.003)
Age squared		-0.031 (0.022)	-0.031 (0.022)		0.033 (0.029)	0.033 (0.029)		0.087*** (0.022)	0.087*** (0.022)
Number of children		-0.004** (0.001)	-0.004** (0.001)		0.001 (0.002)	0.001 (0.002)		0.001 (0.001)	0.001 (0.001)
Married		-0.006 (0.004)	-0.006 (0.004)		0.019*** (0.005)	0.019*** (0.005)		0.024*** (0.004)	0.024*** (0.004)
Log(income)		0.015*** (0.002)	0.015*** (0.002)		0.017*** (0.003)	0.017*** (0.003)		0.016*** (0.003)	0.016*** (0.003)
Wealth level 2		0.015* (0.007)	0.015* (0.007)		0.020* (0.008)	0.020* (0.008)		0.023** (0.007)	0.024** (0.007)
Wealth level 3		0.027** (0.008)	0.027** (0.008)		0.025** (0.009)	0.025** (0.009)		0.033*** (0.008)	0.033*** (0.008)
Wealth level 4		0.033*** (0.008)	0.033*** (0.008)		0.026** (0.010)	0.026** (0.010)		0.034*** (0.008)	0.034*** (0.008)
Wealth level 5		0.041*** (0.009)	0.041*** (0.009)		0.012 (0.010)	0.012 (0.010)		0.047*** (0.009)	0.047*** (0.009)
Ref=Wealth level 1									
Cognitive skills		0.005** (0.002)	0.005** (0.002)		0.011*** (0.002)	0.011*** (0.002)		0.004* (0.002)	0.004* (0.002)
Years of education		0.004*** (0.000)	0.004*** (0.000)		0.002** (0.001)	0.002** (0.001)		0.003*** (0.001)	0.003*** (0.001)
BMI level 1		0.020 (0.017)	0.020 (0.017)		-0.023 (0.015)	-0.024 (0.015)		-0.006 (0.017)	-0.006 (0.017)
BMI level 3		0.009* (0.004)	0.009* (0.004)		0.005 (0.004)	0.005 (0.004)		0.002 (0.004)	0.002 (0.004)
BMI level 4		0.017** (0.005)	0.017** (0.005)		0.003 (0.005)	0.003 (0.005)		0.004 (0.005)	0.004 (0.005)
Ref=BMI level 2									
Vig. physical activity		-0.012** (0.003)	-0.012** (0.003)		0.003 (0.004)	0.003 (0.004)		0.013** (0.004)	0.012** (0.004)
Healthy		0.008 (0.004)	0.008 (0.004)		-0.006 (0.005)	-0.006 (0.005)		0.002 (0.005)	0.002 (0.005)
Drinking		-0.006 (0.004)	-0.006 (0.004)		0.004 (0.005)	0.004 (0.005)		-0.001 (0.005)	-0.002 (0.005)

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		(0.004)	(0.004)		(0.005)	(0.005)		(0.005)	(0.005)
Number of chronic diseases		-0.005***	-0.005***		-0.001	-0.001		0.001	0.001
		(0.002)	(0.002)		(0.002)	(0.002)		(0.001)	(0.001)
Homeownership		-0.009	-0.009		0.008	0.008		0.008	0.008
		(0.006)	(0.006)		(0.006)	(0.006)		(0.006)	(0.006)
Retired		0.008	0.008		0.003	0.003		-0.022***	-0.021***
		(0.004)	(0.004)		(0.006)	(0.006)		(0.005)	(0.005)
Life expectancy		0.010**	0.010**		0.009*	0.009*		0.012**	0.012**
		(0.003)	(0.003)		(0.004)	(0.004)		(0.004)	(0.004)
ADL		0.007	0.007						
		(0.007)	(0.007)						
IADL		-0.010	-0.010						
		(0.005)	(0.005)						
freq.prayer					-0.003	-0.003		-0.007	-0.007
					(0.004)	(0.004)		(0.004)	(0.004)
Austria				0.081***	0.066***	0.066***	-0.026***	-0.022**	-0.023**
				(0.012)	(0.012)	(0.012)	(0.008)	(0.008)	(0.008)
Belgium				0.000	-0.017*	-0.017*	-0.083***	-0.097***	-0.097***
				(0.009)	(0.007)	(0.007)	(0.005)	(0.004)	(0.004)
Czech Republic	-0.095***	-0.085***	-0.085***	-0.020*	-0.022**	-0.022**	-0.117***	-0.107***	-0.108***
	(0.003)	(0.003)	(0.003)	(0.008)	(0.007)	(0.007)	(0.004)	(0.004)	(0.004)
Denmark				0.006	-0.003	-0.004	-0.105***	-0.112***	-0.112***
				(0.010)	(0.009)	(0.009)	(0.005)	(0.004)	(0.003)
Germany				-0.065***	-0.065***	-0.065***	-0.005	-0.035***	-0.035***
				(0.006)	(0.005)	(0.005)	(0.008)	(0.007)	(0.007)
Israel	0.115***	0.112***	0.112***	-0.012	-0.009	-0.010	-0.089***	-0.094***	-0.094***
	(0.010)	(0.011)	(0.011)	(0.013)	(0.013)	(0.012)	(0.007)	(0.005)	(0.005)
Italy	-0.082***	-0.071***	-0.071***				-0.140***	-0.132***	-0.132***
	(0.003)	(0.003)	(0.003)				(0.003)	(0.003)	(0.003)
Luxembourg				-0.050***	-0.062***	-0.062***	-0.071***	-0.098***	-0.098***
				(0.009)	(0.005)	(0.005)	(0.008)	(0.005)	(0.005)
Netherlands				-0.061***	-0.062***	-0.062***	-0.075***	-0.087***	-0.087***
				(0.006)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)
Slovenia				0.120***	0.086***	0.086***	-0.113***	-0.109***	-0.109***
				(0.014)	(0.013)	(0.013)	(0.004)	(0.004)	(0.004)
Spain	-0.057***	-0.046***	-0.046***				-0.117***	-0.116***	-0.116***
	(0.003)	(0.004)	(0.004)				(0.004)	(0.004)	(0.004)
Sweden				-0.010	0.000	-0.001	-0.012	-0.011	-0.011
				(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
Switzerland	0.020***	0.013*	0.013*	-0.066***	-0.063***	-0.063***	-0.093***	-0.098***	-0.098***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)
N	21,912	21,912	21,912	20,203	20,203	20,203	33,892	33,892	33,892
pseudo R ²	0.15	0.18	0.18	0.05	0.12	0.12	0.07	0.12	0.12

Notes: “LTCI” is long-term care insurance, “Term LI” is term life insurance, and “Whole LI” is whole life insurance. Average marginal effects are reported with standard errors in parentheses. Columns (i)–(iii) are based on the LTCI subsample, and columns (iv)–(ix) are based on the life insurance subsample. France is the reference country. For columns (iv)–(vi) Spain and Italy are removed, and current workers are excluded. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

Table C5. Estimates of interactions between age and taking no financial risks on insurance holding

Dependent variable	LTCI	Term LI	Whole LI
	(i)	(ii)	(iii)
Taking no financial risks (TNFR)	-0.012 (0.008)	-0.056*** (0.015)	-0.098*** (0.008)
Age60-69	0.021* (0.010)	-0.061*** (0.016)	-0.088*** (0.009)
Age70-79	0.028* (0.012)	-0.134*** (0.016)	-0.139*** (0.011)
Age80-90	0.012 (0.017)	-0.171*** (0.019)	-0.175*** (0.016)
TNFR * Age60-69	-0.011 (0.011)	0.019 (0.017)	0.053*** (0.010)
TNFR * Age70-79	-0.006 (0.012)	0.040* (0.018)	0.074*** (0.012)
TNFR * Age80-90	0.001 (0.018)	0.066** (0.021)	0.114*** (0.017)
<i>Ref=Age50-59</i>			
Country fixed effects	Yes	Yes	Yes
Control variables	Yes	Yes	Yes
N	21,912	20,203	33,892
R ²	0.123	0.077	0.100

Notes: “LTCI” is long-term care insurance, “Term LI” is term life insurance, and “Whole LI” is whole life insurance. Coefficients and standard errors in parentheses are reported from linear probability models. Columns (i) and (ii) are based on the LTCI subsample, and columns (iii)–(vi) are based on the life insurance subsample. France is the reference country. For columns (iii) and (iv), Spain and Italy are removed, and current workers are excluded. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

Essay II Willingness to take financial risks and insurance holdings

Table C6. Insurance holdings based on quartiles of income and wealth.

	Income.q1	Income.q2	Income.q3	Income.q4	Wealth.q1	Wealth.q2	Wealth.q3	Wealth.q4
Panel A. Dependent variable: Long-term care insurance holding								
Taking no financial risks	0.007 (0.004)	-0.009 (0.006)	-0.013 (0.009)	-0.028* (0.011)	-0.002 (0.006)	-0.005 (0.006)	-0.015 (0.009)	-0.016 (0.009)
N	5,514	5,442	5,479	5,477	5,479	5,477	5,477	5,478
Pseudo R^2	0.19	0.19	0.11	0.14	0.18	0.20	0.15	0.15
Panel B. Dependent variable: Term life insurance holding								
Taking no financial risks	-0.019 (0.010)	-0.027** (0.010)	-0.013 (0.009)	-0.021* (0.009)	-0.023* (0.010)	-0.040*** (0.011)	0.001 (0.010)	-0.024** (0.008)
N	5,059	5,043	5,050	5,051	5,051	5,051	5,050	5,051
Pseudo R^2	0.12	0.13	0.14	0.14	0.10	0.13	0.13	0.14
Panel C. Dependent variable: Whole life insurance holding								
Taking no financial risks	-0.014 (0.007)	-0.022*** (0.008)	-0.031** (0.010)	-0.062*** (0.010)	-0.021*** (0.010)	-0.036*** (0.009)	-0.044*** (0.008)	-0.050*** (0.009)
N	8,473	8,501	8,445	8,473	8,473	8,473	8,473	8,473
Pseudo R^2	0.11	0.12	0.09	0.12	0.11	0.15	0.11	0.12
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Average marginal effects are reported with standard errors in parentheses. Panel A is based on the LTCI subsample, and Panels B and C are based on the life insurance subsample. France is the reference country. For Panel B, Spain and Italy are removed, and current workers are excluded. Quartiles of income and wealth are denoted by q1-q4. *, **, and *** denote statistical significance at the 5%, 1%, and 0.1% levels, respectively.

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Essay III

The interplay between longevity and morbidity on optimal choice of long-term care insurance

Abstract

I investigate the interplay between health state transitions and longevity risk on retirees' optimal decision to purchase long-term care insurance (LTCI). By incorporating a life-cycle model framework, I examine how increased longevity in alternative morbidity scenarios (i.e., morbidity compression/expansion and dynamic equilibrium) influences retirees' optimal choice of LTCI in a setup with consumption floors supported by government subsidies and bequest motives. I use health state transition matrices estimated from the U.S. Health and Retirement Survey dataset and adjust mortality improvements using the Human Mortality Database. The results show a lower optimal purchase of LTCI in the morbidity expansion scenario due to an increase in actuarially fair premium compared to other scenarios. When survival ambiguities are considered, both morbidity compression and expansion reduce the demand for LTCI. In the dynamic equilibrium scenario, the optimal LTCI purchase rate remains almost the same. Such findings emphasize the importance of considering the dynamics and ambiguities of longevity and morbidity rates on the demand for LTCI.

Keywords Long-term care insurance, Longevity, Morbidity

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1 Introduction

Aging comes with a variety of longevity and health risks in addition to the need for care (Ameriks et al., 2020). Long-term care (LTC)¹⁶⁵ expense is one of the greatest financial risks faced by the growing elderly population (Gottlieb and Mitchell, 2020). Based on a survey conducted in the U.S. by Genworth (2020) in 2020, the median annual cost of a private room in a nursing home facility is \$105,000 and ranges from \$68,000 to \$436,000. In addition to the high associated costs, the prevalence of need for LTC is also very high. At least 30–50% of older Americans will enter a nursing at some point (Ameriks et al., 2020), and over half of 50-year-old Americans will live in a nursing home before they die (Hurd et al., 2014; Lockwood, 2018). Therefore, LTC costs can quickly deplete the wealth of retirees.

The population of the elderly has also grown dramatically in many countries due to an increase in life expectancy. This has intensified the importance of financing LTC needs for the elderly population. In the U.S., the number of individuals age 85 and older—the population with the greatest need for LTC—is projected to more than double from 6.6 million in 2019 to 14.4 million in 2040 (Administration on Aging, 2020), and a similar pattern can be found in other countries.¹⁶⁶ Longevity risk is an essential element of pricing and reserving many insurance products and pension funds. According to the American Academy of Actuaries, longevity risk, future morbidity patterns and their interaction are among the most difficult challenges facing the practice of LTCI (American Academy of Actuaries, 2016). If a retiree stays longer in a disabled state, the health costs covered by the insurance provider will be increased, or the individual's wealth used to cover the out-of-pocket LTC costs will be depleted more quickly. Therefore, not only does the extended life expectancy matter, but so does the length of stay in a specific state of health.

Early studies introduced three theories for the decline in mortality at older ages¹⁶⁷: 1) individuals live longer but in worse health (expansion of morbidity); 2) death is delayed, and hence, diseases start later (compression of morbidity); and 3) stable relative length of unhealthy life expectancy¹⁶⁸ (dynamic equilibrium). These three theories have contributed to the

¹⁶⁵ LTC primarily encompasses various degrees of custodial care for individuals having difficulty to perform basic functions of daily living (e.g., bathing and dressing) delivered institutionally (such as in a nursing home or assisted living facility) or at home (Brown and Finkelstein, 2009).

¹⁶⁶ For example, within 30 years, the population of individuals aged over 80 years is predicted to increase more than two times both in Switzerland and in the U.K. (Fuino and Wagner, 2020).

¹⁶⁷ See, e.g., Gruenberg (1977), Fries (1980) and Manton (1982).

¹⁶⁸ Although other definitions for dynamic equilibrium can be found in the literature, I utilize Ai et al.'s (2017) definition of dynamic equilibrium.

development of many studies on health trends (Robine and Michel, 2004). There is no consensus in the literature on which health pattern captures the dynamics of health evolution (Ai et al., 2017).¹⁶⁹ Morbidity patterns also vary greatly across countries (see, e.g., Salomon et al., 2012, and Lee et al., 2020, for cross-country analysis) and over time (see, e.g., Gu et al., 2015, for an international review of disability trends). Hence, multiple feasible scenarios should be considered to analyze the interplay between improvements in mortality and transitions in health state.

Although both the need for LTC and its expenses are high and the classical economic theories predict higher demand for insurance products (see, e.g., Mossin, 1968, and Schlesinger, 2013), such a risk remains mostly uninsured (Brown and Finkelstein, 2007), and the demand for private LTCI is low.¹⁷⁰ In the U.S., only about 10% of retirees purchase LTCI (Lockwood, 2018); and among OECD countries, Colombo et al. (2011) report that the participation rate for private LTCI ranges from 0% (for Czech Republic and Netherlands) to 9.8% (Belgium). Another source of financing LTC that plays an important role is publicly funded programs such as social security. Based on Colombo et al. (2011), LTC is substantially covered publicly in some countries (90% in Netherlands and 70% in the Czech Republic). However, in some developed countries such as the U.S. and the U.K., universal social programs are means-tested and do not cover the costs of nursing home care. The literature calls the controversial results between predictions of demand in standard economic theories and the real demand for LTCI the “LTC puzzle”¹⁷¹ (see, e.g., Brown and Finkelstein, 2007; Pestieau and Ponthière, 2012; Ameriks et al., 2018).¹⁷²

In this study, I investigate the role of an increase in longevity risk and its interplay with health state transitions on retirees’ optimal choice of purchasing private LTCI using the life-cycle framework. The increase in longevity risk raises the question of whether the extended life expectancy occurs in a healthy or an unhealthy state. I set up standard morbidity scenarios found in the literature to analyze the economic impact of an increase in longevity risk and its interaction with health state transitions on the retirees’ optimal demand for private LTCI. In

¹⁶⁹ See, e.g., Yue (2013), Kreft and Doblhammer (2016) and Stallard (2016) for morbidity compression, Crimmins and Beltrán-Sánchez (2011), Solé-Auró and Alcañiz (2015) and Lu et al. (2019) for morbidity expansion and Stallard (2019) for dynamic equilibrium.

¹⁷⁰ For review of studies on demand for LTCI see e.g., Norton (2000), Brown and Finkelstein (2007) and Eling and Ghavibazoo (2019).

¹⁷¹ Apart from classical models in economic literature (i.e., utility theory), recent studies such as Gottlieb and Mitchell (2020) address low demand for LTCI using narrow framing and loss aversion.

¹⁷² A similar puzzle can be found in annuity market, where standard economic theory predicts full annuitization of wealth in older ages, while the empirical studies find controversial results. See e.g., Benartzi et al. (2011), Inkmann et al. (2011), and Peijnenburg et al. (2017) for the discussion on annuity puzzle.

addition, I test the optimal choice of purchasing LTCI when the retiree has survival beliefs that are different from the survival probabilities estimated by the insurance provider.

I find that in the morbidity expansion scenario (where an increase in lifetime health care costs is expected to increase the demand for LTCI) the retirees' optimal choice of purchasing LTCI decreases due to the higher actuarially fair premium calculated in this scenario. The optimal choice of LTCI in the dynamic equilibrium scenario and the morbidity compression scenario remains almost the same as in the baseline model. When survival ambiguities are considered, both morbidity expansion and compression will reduce the optimal choice of LTCI coverage.

This study adds to the literature on the relationship between health shocks and longevity risk (i.e., multistate life tables in which the transition probabilities depend on age and calendar time) such as Majer et al. (2013), Sherris and Zhou (2014) and Li et al. (2017) by uniquely incorporating a life cycle of a retiree and her demand for LTCI. The most relevant study on this topic is by Lakdawalla and Philipson (2002) who conclude that aging might be negatively related to the demand for LTCI in the U.S. as there would be more supply of informal care (i.e., nonmarket care) from elderly spouses. Lakdawalla and Philipson (2002) do not address any possibility of morbidity expansion or compression and its impact on optimal demand for LTCI. To my knowledge, no study investigates the combined effects of health state transitions (and health costs) and longevity risk on the optimal choice of purchasing LTCI. For annuities, while recent literature, such as Ameriks et al. (2011), Pashchenko (2013), Yogo (2016) and Peijnenburg et al. (2017) emphasize the role of health state transitions and health costs on optimal annuitization, only Ai et al. (2017) investigate the interaction between health state transitions and longevity risk on optimal demand for annuities. They find that expansion or compression of morbidity affects the demand for annuities. They report that "increased longevity increases the demand even more when retirees expect an expansion or slight morbidity compression. With health shocks and expectations of severe morbidity compression considered, the opposite effect might occur" (Ai et al., 2017).

In this study, the life-cycle approach allows for the testing of alternative longevity scenarios (i.e., morbidity expansion or compression and dynamic equilibrium) in a setup that also considers other important contributing factors to the LTC puzzle (e.g., bequest motives, Lockwood, 2018; and public insurance, Brown and Finkelstein, 2008). Throughout this study, I follow the standard literature and use limitations in activities of daily livings (ADLs) as a

measure of morbidity expansion or compression. Other measures are introduced in the studies analyzing morbidity trends.¹⁷³

The remainder of the paper is organized as follows. Section 2 describes the analytical framework and the incorporated life-cycle model. Section 3 describes the methodology and the dataset used for the estimation of health and mortality dynamics. Section 4 elaborates on the calibration of health dynamics with increased longevity and scenario construction. Section 5 explains the optimization results and the choice of optimal LTCI. Section 6 summarizes and concludes the paper.

2 Analytical framework

For my analysis, I solve a discrete life-cycle model for retirees that incorporates mortality and health dynamics in the presence of a market for private LTCI. Following previous studies on the demand for LTCI (Brown and Finkelstein, 2008; Lockwood, 2018) my analysis is for a 65-year-old single individual who has just retired, has a stock of initial financial wealth at the beginning of her¹⁷⁴ retirement ($t = 0$), and her maximum lifespan is 100 years ($T = 36$). The retiree maximizes her lifetime utility by opting for the amount of LTCI she purchases at the beginning of retirement (a fraction between zero to 100%) and makes real consumption in each period. This model considers the utility maximization of an individual retiree rather than a married couple. This setup, although it might deviate from reality, is the norm in the consumption and insurance literature (Brown and Finkelstein, 2008; Lockwood, 2018).

2.1 Preferences

I assume that the retiree maximizes a standard utility function U_s based on her real consumption $C_{s,t}$ where the subscript s refers to the retiree's state of care at time t . The utility function is time-separable and has a constant relative risk aversion (CRRA) parameter γ ¹⁷⁵ as:

$$U(c_{s,t}) = \frac{c_{s,t}^{1-\gamma}}{1-\gamma}. \quad (1)$$

¹⁷³ See, e.g., Crimmins and Beltrán-Sánchez (2011) using major diseases and mobility functioning loss, Kreft and Doblhammer (2016) using care need-free life years and Stallard (2016) using chronic disability as a measure of morbidity.

¹⁷⁴ For simplicity, throughout the paper I refer the retiree with female gender while I explicitly analyze both female and male retirees separately.

¹⁷⁵ See e.g., Ai et al. (2017) and Ameriks et al. (2020) using similar utility function in their study.

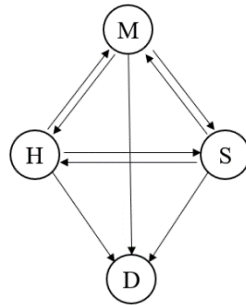
Due to the important role of bequest motives on demand for LTCI, the retiree also receives direct utility from leaving a bequest B_t via $v(B_t) = \frac{\eta}{1-\gamma} (\emptyset + \frac{B_t}{\eta})^{1-\gamma}$, where $\eta > 0$ measures the intensity of the bequest motive and $\emptyset > 0$ is a shifting parameter treating bequest as luxury goods, allowing no bequests for individuals with a low level of wealth.¹⁷⁶

2.2 Health dynamics

LTCI policy indemnifies the insured when the insured becomes functionally disabled based upon a pre-specified definition in the policy (Haberman and Pitacco, 1999). However, there is no uniform definition of eligibility for receiving benefits among insurance providers (Shao et al., 2017). The most frequently used criterion for defining functional disability for LTCI is activities of daily living (ADLs) that the individual cannot perform independently together with cognitive impairment (Haberman and Renshaw, 1996; Pritchard, 2006). The six ADLs are dressing, walking, bathing, eating, transferring and toileting. Following Shao et al. (2017), I model retirees' health dynamics in four health states. Figure 1 depicts "health state transitions: State "H" or state 1 (healthy); "M" or state 2 (mildly disabled) for having difficulty with 1-2 ADLs; "S" or state 3 (severely disabled) for having difficulty with 3-6 ADL difficulties and "D" or state 4 (dead). In addition, the disabled retiree can recover and become non-disabled.¹⁷⁷

LTCI benefits will be paid to the insured upon her entry to state S .¹⁷⁸ While the number of disability states or levels of benefits can be more than one,¹⁷⁹ I follow Xu et al. (2022) and assume that LTCI provides full coverage, and benefit payment takes place only in one state.

Figure 1. Four-state Markov transition diagram



Note: Own illustration based on Shao et al. (2017).

¹⁷⁶ See e.g., Ameriks et al. (2011) and Pashchenko (2013) using similar bequest motive function. Ameriks et al. (2011) mention that $\emptyset$ measures the threshold of consumption above which the bequest motive becomes operative.

¹⁷⁷ For the importance of including recovery rates see e.g., Robinson (1996), Ameriks et al. (2011) and Brown and Warshawsky (2013).

¹⁷⁸ In North America, a typical private LTCI compensates when the insured has difficulties with either 2+ or 3+ ADLs. I follow Shao et al. (2017) and use 3+ ADLs for the state where coverage triggers.

¹⁷⁹ Many LTCI policies also provide a single-level benefit upon becoming functionally disabled (Fong et al., 2015).

2.3 Consumption floor and public long-term care

The retiree receives a base income from social security which provides a minimum level of consumption for each state of health. In this model, if the amount of wealth plus LTCI reimbursement in each period is not enough to cover health care expenses, public LTC will be triggered. In health states H and M , “consumption floor” is defined as C^f ; and in state S where LTC costs might occur, C^{PC} represents “public care level of consumption” to capture the institutional reality of Medicaid (Ameriks et al., 2011). It is also assumed $C^{PC} < C^f$ in order to reflect the retirees’ aversion to publicly provided LTC. This encourages the individuals to keep sufficient wealth to cover potential care costs.

2.4 The optimization problem

An eligible retiree, only at the beginning of her retirement can make a once-and-for-all decision to purchase private LTCI with the fraction ($\%_{LTCI} \in [0,100]$). The decision to purchase LTCI only at the beginning of retirement is inspired by Brown and Finkelstein (2008) and Lockwood (2018).¹⁸⁰

A 65-year-old retiree chooses an optimal consumption path that leads to maximum expected discounted lifetime utility. The model comprises a maximum of 36 periods from age of retirement until the maximum age of 100.

I define the consumer’s constrained dynamic optimization problem as:

$$\text{Max}_{C_{s,t}} \sum_{t=1}^{36} \sum_{s=1}^4 \frac{Q_{s,t}}{(1+\rho)^t} \cdot U_s(C_{s,t}), \quad (2)$$

subject to:

$$(2.1) \ W_0 \text{ is given}$$

$$(2.2) \ W_t \geq 0 \ \forall \ t$$

$$(2.3) \ W_t + BC_{s,t} - C_{s,t} - X_{s,t} - P_{s,t} > 0$$

where W_0 is initial financial wealth at age 65, $C_{s,t}$ is annual real consumption in state s at time t , $Q_{s,t}$ refer to the probability of being in state s at time t , $BC_{s,t}$ refers to full annual benefit

¹⁸⁰ It should be mentioned that in the U.S. market, individuals can purchase LTCI when they are younger. In addition, retirees can purchase LTCI in older ages up to the age of 75 while they are healthy. However, the premiums in older ages are very high. Hence, the standard economic literature uses age of 65 as the base.

received from private LTCI, $X_{s,t}$ denotes occurred annual LTC expenditures¹⁸¹ and $P_{s,t}$ denotes annual premium of the private LTCI calculated at the beginning of retirement and ρ is the discount rate of the utility from consumption. Each year the retiree receives full coverage for occurred LTC expenditure. The constraint (2.2) denotes that no borrowing is allowed (i.e., not to die while in debt and not bequeath negative values).

The retiree enters period t in health state s with W_t . In the case that $s_t = D$, the retiree leaves a bequest $W_t = B_t$. In $s_t = H, M$ the retiree pays a premium $P_{s,t}$ together with any occurring health care costs and chooses a consumption path. However, in $s_t = S$, the retiree does not pay any LTCI premium, and she receives reimbursements for the occurred LTC expenditure and makes consumption.

The retiree's consumption choice $C_{s,t}$ should exceed the floor C^f in states H and M or exceed C^{PC} in state S based on the budget constraint (2.3). If there is no level of consumption $C_{s,t} > C^f$ in health states H and M (or C^{PC} in state S) that satisfies constraint (2.3), the retiree receives a transfer from social security (i.e., Medicaid), consumes C^f (C^{PC}), and gives up the wealth that remained. $I_{s,t}^G$ is an indicator of any social transfer in period t . The retiree's wealth in the next period is:

$$W_{t+1} = \begin{cases} [W_t + BC_{s,t} - C_{s,t} - X_{s,t} - P_{s,t}](1 + r) & \text{if } I_{s,t}^G = 0; \\ 0 & \text{if } I_{s,t}^G = 1. \end{cases} \quad (3)$$

where r is the annual interest rate.

To maximize the expected utility from lifetime consumption subject to the above budget constraints, I use the recursive Bellman equation as:

$$\text{Max}_{C_{s,t}} V_{s,t}(W_t) = \text{Max}_{C_{s,t}} U_s(C_{s,t}) + \sum_{\sigma=1}^4 \frac{q_{t+1}^{s,\sigma}}{1 + \rho} [V_{\sigma,t+1}(W_{t+1})], \quad (4)$$

where ρ is the discount rate. I also denote that $q_{t+1}^{s,\sigma}$ refers to the conditional probability that the individual who is in care state s at time t is in care state σ at time $t + 1$.

I use standard dynamic programming techniques using Python software (Van Rossum and Drake, 2009) to solve the above optimization problem recursively. I start by solving the problem

¹⁸¹ Following Ameriks et al. (2011) I consider out-of-pocket health costs to be deterministic. De Nardi et al. (2010) argue that deterministic process is preferred over stochastic counterpart due to its simplicity and capability of capturing the characteristics of empirical medical expense risk.

for the last period (i.e., age 100) when at the end of the period the retiree definitely dies and leaves the remaining wealth as a bequest. The utility from bequest is reflected in U_s function when the state of health is $s = D$. I then continue to solve the model backward for all sets of discretized wealth, collecting separate decision rules and value function for each year until retirement age.

To see the optimal choice of LTCI, I derive the optimal consumption path over all periods for any initial fraction of LTCI purchased at retirement and any initial wealth level. I then determine the optimal level of LTCI purchase that generates optimal lifetime utility for a 65-year-old retiree.

3 Estimation of health and mortality dynamics

3.1 Health dynamics data and methodology

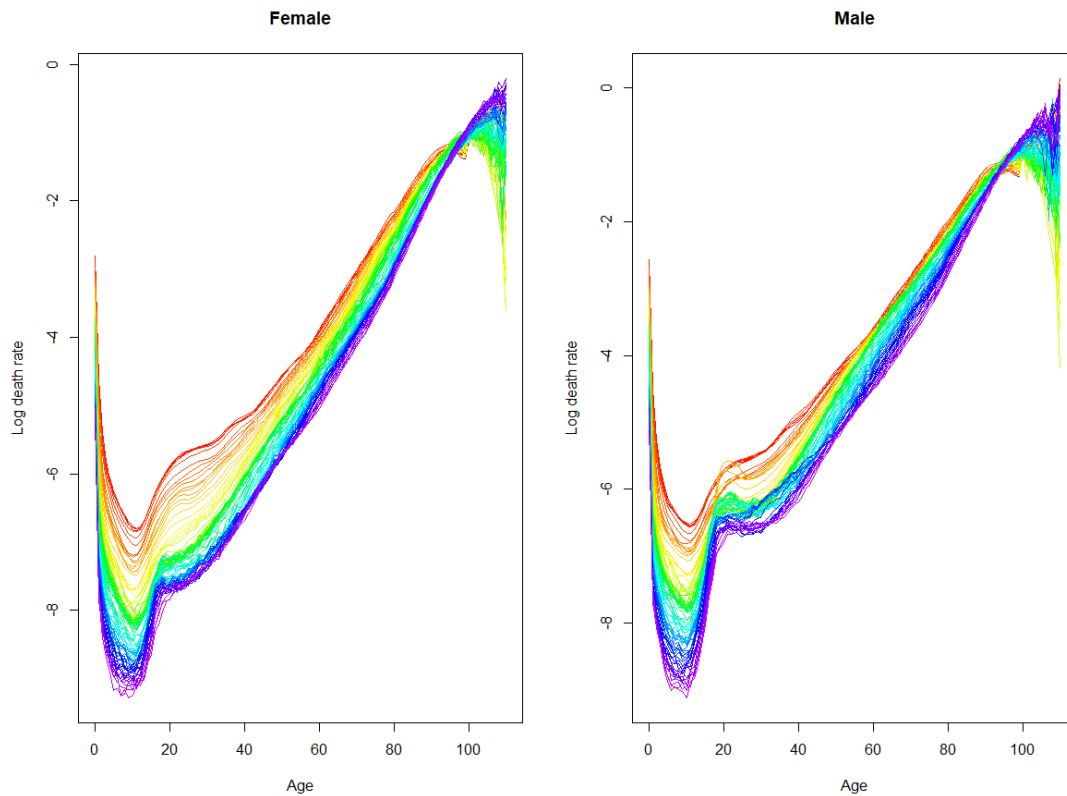
To obtain a consistent probability distribution of various health states, I calibrate health dynamics using estimated health transitions data from the University of Michigan Health and Retirement Study (HRS). The survey is nationally representative of US Americans with age over 50 and their spouses and has been conducted every two years since 1992. The survey collects detailed information on health, assets, pensions, retirement, family structure, and demographics for older households across time and cohorts. Since the questions about ADLs have been consistently asked from 1998 until 2010, I choose this time window for estimating health state transitions (see, e.g., Fong et al., 2015; Shao et al., 2017; Ai et al., 2017 applying the same time window).

Shao et al. (2017) estimate health state transitions for individuals aged 50 and older since they are more vulnerable to functional disability. For my analysis, I extract transitions from the age of 65 to 100 from Shao et al. (2017). Appendix A briefly explains the methodology utilized in Shao et al. (2017) to estimate health state transitions and the use of HRS data.

3.2 Mortality dynamics data and methodology

For mortality projections (and incorporating increased longevity), I use the data from Human Mortality Database (HMD) for the U.S. from 1933 to 2010. Figure 2 depicts the observed improvements in mortality rates. The observed mortality improvements take place almost in all ages and it emphasizes the importance of considering this phenomenon in any mortality-related research.

Figure 2. Observed mortality 1933 - 2010



Note: log of death rate is depicted for females and males from the year 1933 to 2010 (in color red to purple, respectively).

To match the calibrated values of out-of-pocket health costs in various health states (see, e.g., Ameriks et al., 2011), I take the mortality data for a 65-year-old retiree in 2010 and project her mortality to age 100 in the year 2045.

Previous studies in the field of mortality introduced various models to forecast mortality rates (see e.g., Cairns et al., 2008, and Booth et al., 2008, for a review of the most important mortality risk models). To capture mortality projections, I test multiple forecasting models and evaluate their goodness of fit for the U.S. population.¹⁸² The performance of various models using Akaike information criteria (AIC) and the Bayesian information criteria (BIC) is given in Table C1 in Appendix C. Based on the AIC and BIC criteria, the RH model (Renshaw and Haberman, 2006) is found to have the lowest AIC and BIC scores.¹⁸³ Therefore, to estimate mortality projections, I incorporate the RH model for individuals aged 65 to 100.

¹⁸² The respective code in R software is available upon request.

¹⁸³ Residuals of fitting the RH model are depicted in Figure C1 in Appendix C.

4 Calibration of health dynamics with increase in longevity

4.1 HMD-matched health transitions

To examine the effects of increased longevity on optimal choice of LTCI using health state transitions and corresponding health costs, I first ensure that the associated mortality rates from HRS health transition matrix are comparable to the projected mortality. Due to the differences between 2010 HMD life-table mortalities and HRS-estimated mortality rates, I first adjust HRS health transition matrix in a way that the mortality rates match HMD life-table mortalities. Then I incorporate mortality projections in the adjusted health state transition matrix.

The matching process cannot be naively implemented by simply changing the mortality rates in the matrix of health state transitions with the ones from 2010 HMD life-table mortalities. The matching process needs to change the transition matrix entirely so that the obtained mortality rates (i.e., transitions to death state) coincide with HMD mortalities.

Due to a lack of clear guidance on implementing such a matching procedure, Ameriks et al. (2011) propose a procedure to implement the adjustment. Individuals at age 65 have a vector of initial health states α . I utilize the population of living retirees, hence the initial distribution of states 1-4 at age 65 is (0.8482, 0.1039, 0.0477, 0) for females and (0.8863, 0.0838, 0.0298, 0) for males.¹⁸⁴ Following Ameriks et al. (2011), I incorporate an age-adjusted auxiliary matrix $M_0(t)$ and multiply it to HRS health state transitions $H_E(t)$. The fourth element of the vector $\alpha \prod_{t=0}^m [H_E(t)M_0(t)]$ corresponds to mortality rates at age $65 + m$, which I match to the relevant HMD life-table mortalities from the same age.

To construct the auxiliary age-adjusted auxiliary matrix $M_0(t)$, the first principle is that the elements of the matched health state transition matrix should be nonnegative, and all the elements in each row sum to 1 since they are probabilities. The second principle is that the derived probabilities should have a reasonable pattern as the age increases so that with an increase in age, the probability of staying in good health (i.e., state H) decreases and the probability of death increases.

Following Ameriks et al. (2011), I construct the matrix M_0 as follows:

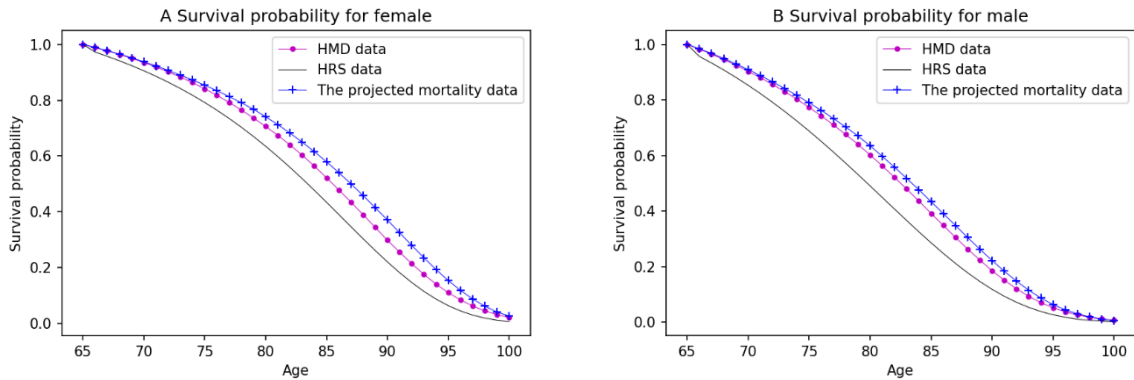
¹⁸⁴ The initial distribution of health states 1-4 are calculated by using exposure years for the age 65 from Shao et al. (2017).

$$M_0 = \begin{bmatrix} 1 - c_1 & c_1 \left(\frac{c_2 c_3}{1 + c_2 + c_2 c_3} \right) & c_1 \left(\frac{c_2}{1 + c_2 + c_2 c_3} \right) & c_1 \left(\frac{1}{1 + c_2 + c_2 c_3} \right) \\ 0 & 1 - c_1 & c_1 \left(\frac{c_2}{1 + c_2} \right) & c_1 \left(\frac{1}{1 + c_2} \right) \\ 0 & 0 & 1 - c_1 & c_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}. \quad (5)$$

In the above auxiliary matrix, c_1 controls for the transition between the death state and three health states. The parameters c_2 and c_3 also control for how fast the shift of probability mass from states H and M to death is compared to health state S to death, in addition, to directly influence the relative probability weighting of health states H, M and S . Following Ai et al. (2017), I keep the values for c_2 and c_3 unchanged using estimated values from Ameriks et al. (2011) equal to $c_2 = 1.3$, $c_3 = 1.3$ for females and $c_2 = 0.8966$, $c_3 = 0.5643$ for males. I then change c_1 for each age to derive the desired mortalities. The advantage of using this matrix is that by changing c_1 , I simultaneously adjust the probabilities relevant to all health states in a uniform manner while incorporating the differences between mortality rates generated by the HRS-estimated health transition matrix and the 2010 HMD life-table mortalities (Ai et al., 2017).

Figure 3 represents the survival probabilities estimated using HRS health state transitions, HMD life table and mortality projections using the RH model from ages 65 to 100. As can be seen, it is expected that the projected survival probabilities will be higher than HRS- and HMD-estimated ones.

Figure 3. Survival probabilities of retirees

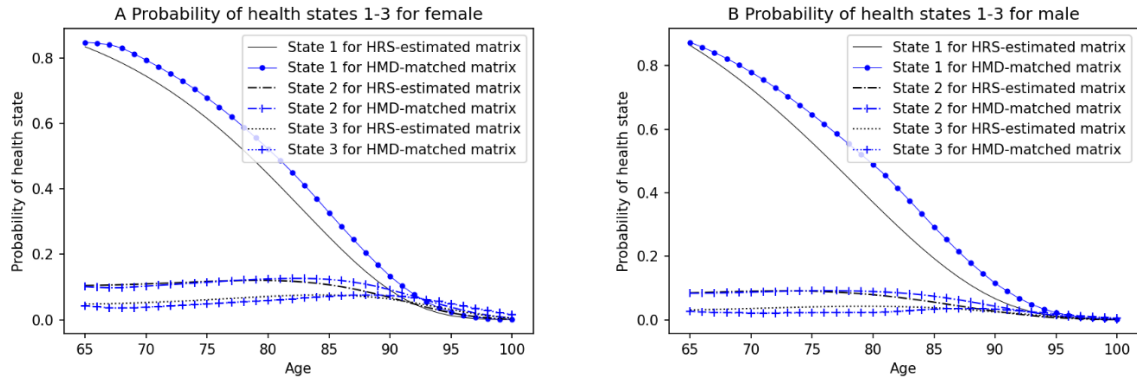


Note: The horizontal and vertical axis depict age and survival probability, respectively. Panel A and B demonstrate survival probabilities of females and males from HRS-estimated matrix, HMD life table and mortality projections, respectively.

I derive the matched health transition matrix $H_A(t) \equiv H_E(t)M_0(t)$ using matched parameters $c_1(t)$ for age $65 + t$ ($t = 0, \dots, 35$). The matched health transition matrix would be the benchmark for the rest of the analysis. Figure 4 illustrates the calibrated probability distribution of health states 1-3 at different ages using HMD-matched transition matrix. It can be seen in

Figure 4 that the probability of being in a healthy state is increased, while other health states (i.e., mildly disabled and severely disabled) are adjusted in the way that the derived mortality from HRS transition matrix coincides with HMD life-table mortalities. The changes in the probability of different health states show a reasonable pattern in the way that the probability of being in state 1 (i.e., healthy) decreases gradually, while the probability of state 2 (i.e., mildly disabled) and state 3 (i.e., severely disabled) slightly increase and then converge at zero as mortality rates increase moderately as age advances.

Figure 4. The probability distribution of health states 1-3 at different ages



Note: The horizontal and vertical axis depict age and probabilities of health states 1-3, respectively. Panels A and B describe the probabilities of health states 1-3 at different ages for females and males, respectively. These probabilities are estimated from the HRS-estimated transition matrix and HMD-matched transition matrix, respectively.

4.2 Health transition matrix with mortality improvement

In this section, I discuss the interplay between health dynamics and increased longevity. A large body of literature suggests that recent advances in medical technology lead to improvement in mortality risk (see, e.g., Rice and Fineman, 2004 for a review). However, previous studies have found contradictory results if such an increase in life expectancy coincides with morbidity compression or expansion. Hence, multiple scenarios for mortality improvement and its interplay with morbidity expansion or compression should be analyzed. To examine this, I follow Ai et al. (2017) and construct four prototype scenarios that take into account compression and expansion of morbidity and dynamic equilibrium incorporating four auxiliary matrices.

In the first scenario, I assume that increase in longevity is associated with reduced mortality rates in the healthy state, denoting morbidity compression. I analyze this scenario by introducing an auxiliary matrix M_1 , and the allocation of increased longevity is captured via parameter d_1 . Parameter d_1 can be adjusted in a way that, at age $65 + m$, the derived mortality rate in the distribution vector of health states, $\alpha \prod_{t=1}^m [H_A(t)M_1(t)]$, is equal to the projected mortality ($m = 0, \dots, 35$). Panel A in Figure 5 (Fig. 6) depicts the increase in the probability

of individuals being in healthy states for females (males). In both Figures 5 and 6, the probability of being in the healthy state (i.e., state 1) increases more compared to other health states to incorporate morbidity compression.

For the second and third scenarios, mortality is reduced in states M and S , respectively. I utilize similar auxiliary matrices M_2 and M_3 , using parameters d_2 and d_3 , respectively, to adjust for probability transfer from health states M and S to death state. Panel B and C in Figure 5 (Fig. 6) illustrates an increase in the probability of being in states 2 and 3 for females (males). For both females and males, the probability of being in state M (i.e., state 2) and state S (i.e., state 3) increases more than changes in the probability of being in state H (i.e., state 1).

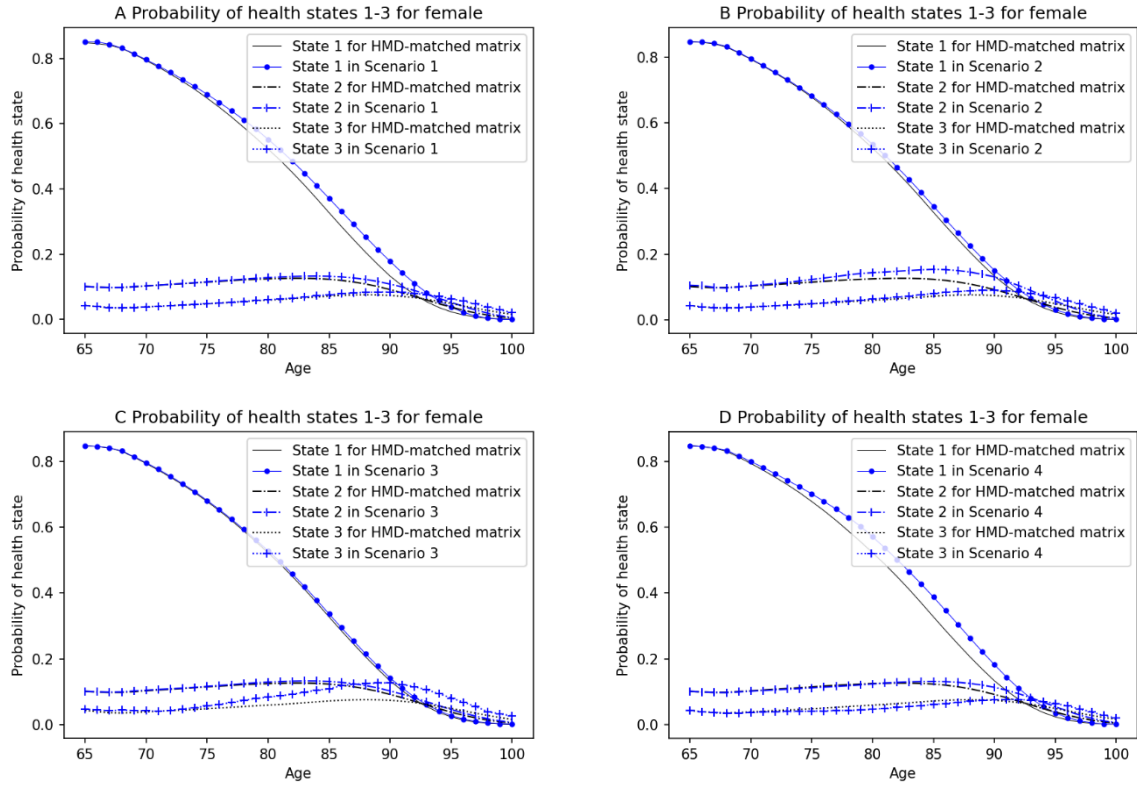
The three auxiliary matrices explained above are as follows:

$$M_1 = \begin{bmatrix} 1 + d_1 & 0 & 0 & -d_1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, M_2 = \begin{bmatrix} 1 & d_2 & 0 & -d_2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, M_3 = \begin{bmatrix} 1 & 0 & d_3 & -d_3 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix},$$

where d_1, d_2 and d_3 are parameters that need to be estimated.

In addition to the above scenarios, I consider an alternative scenario in which all three health states change simultaneously to accommodate the mortality improvements (dynamic equilibrium depicted in panel D of Figure 5 and 6 for females and males, respectively). The utilized auxiliary matrix is borrowed from Ameriks et al. (2011) and is similar to what I used for matching initial health state transitions from HRS with HMD life-table mortalities in the previous section.

Figure 5. The probability of health states 1-3 for females incorporating mortality improvement



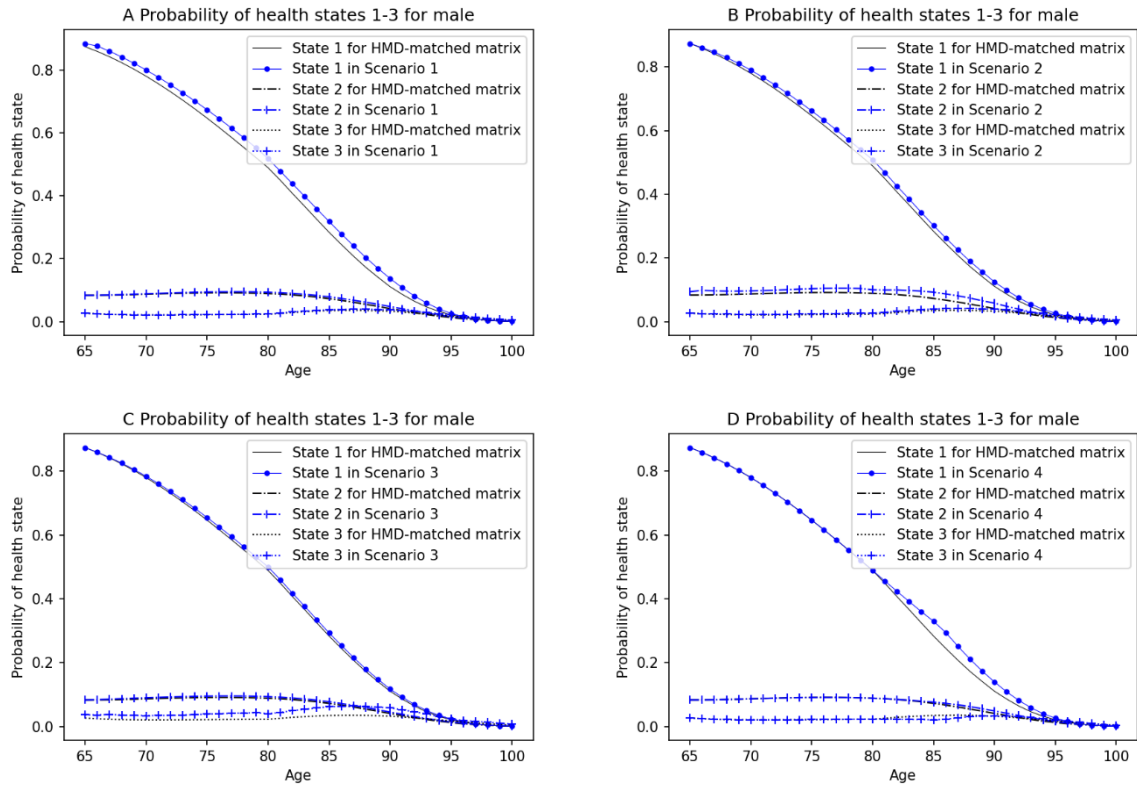
Note: The horizontal and vertical axis depict age and the probabilities of health states 1-3, respectively. Panels A, B, C and D describe the probabilities of different health states for females in scenarios 1-4, respectively. For comparison, the probabilities from the HMD-matched transition matrix for different health states are reproduced in all panels.

The auxiliary matrix is:

$$M_4 = \begin{bmatrix} 1 - d_4 & d_4 \left(\frac{d_5 d_6}{1 + d_5 + d_5 d_6} \right) & d_4 \left(\frac{d_5}{1 + d_5 + d_5 d_6} \right) & d_4 \left(\frac{1}{1 + d_5 + d_5 d_6} \right) \\ 0 & 1 - d_4 & d_4 \left(\frac{d_5}{1 + d_5} \right) & d_4 \left(\frac{1}{1 + d_5} \right) \\ 0 & 0 & 1 - d_4 & d_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

In the matrix, I again consider d_5 and d_6 as constant ($d_5 = 1.3$, $d_6 = 1.1$ for females and $d_5 = 0.8966$, $d_6 = 0.5643$ for males) and adjust d_4 in a way that ultimately, mortality rates from the health transition matrix are equal to projected mortalities (Ameriks et al., 2011).

Figure 6. The probability of health states 1-3 for males incorporating mortality improvement



Note: The horizontal and vertical axis depict age and the probabilities of health states 1-3, respectively. Panels A, B, C and D describe the probabilities of different health states for males in scenarios 1-4, respectively. For comparison, the probabilities from the HMD-matched transition matrix of different health states are reproduced in all panels.

To better explain the role of auxiliary matrices in constructing four scenarios, I compare life expectancy in states 1-3 derived from the HMD-matched transition matrix with the ones constructed in four scenarios in Table 1. While the life span for the retiree remains similar in all the adjusted scenarios, the spent life expectancy in each health state changes to incorporate the compression or expansion of morbidity. For instance, the total life expectancy of females (males) remains similar in scenarios 1-4 while the ratio of life expectancy spent in health state 3 to total life expectancy changes from 0.09 to 0.13 (0.05 to 0.08) across various scenarios. Such ratio is the highest in scenario 3 to reflect morbidity expansion. Scenario 4, which refers to dynamic equilibrium, incorporates mortality improvements so that the life expectancy ratio in state 3 to total life expectancy remains almost the same as the base case. Life expectancy calculations are briefly explained in Appendix B.

Table 1. Life expectancy in health states 1-3

		HMD	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Female	Life expectancy in health state 1 (years)	14.44	15.23	14.77	14.61	15.51
	Life expectancy in health state 2 (years)	3.22	3.47	3.85	3.40	3.44
	Life expectancy in health state 3 (years)	1.85	2.04	2.13	2.76	1.79
	Total life expectancy (years)	19.51	20.75	20.75	20.77	20.74
	Ratio of life expectancy in health state 3 to total life expectancy	0.09	0.10	0.10	0.13	0.09
Male	Life expectancy in health state 1 (years)	13.81	14.55	14.22	14.02	14.20
	Life expectancy in health state 2 (years)	2.18	2.30	2.58	2.31	2.26
	Life expectancy in health state 3 (years)	0.84	0.90	0.96	1.43	0.79
	Total life expectancy (years)	16.84	17.75	17.75	17.76	17.25
	Ratio of life expectancy in health state 3 to total life expectancy	0.05	0.05	0.05	0.08	0.05

Note: The table compares total life expectancy and the time spent in health states 1-3 for a retiree with age of 65 years old under HMD-matched health state transition matrix and adjusted four scenarios where the health state transitions incorporate mortality improvements. Ai et al. (2017) suggest a similar table and incorporate the ratio of life expectancy in health state 3 to total life expectancy as a measure of morbidity compression or expansion.

5 Retirees' optimal choice of long-term care insurance

5.1 Model parametrization

To solve for optimal consumption paths in the defined dynamic programming model as the baseline, I use HMD-adjusted health state transitions together with standard parameters introduced in Table 2. Further, I test optimal consumption paths in alternative scenarios of morbidity compression and expansion.

Table 2. The parameters in the base case

Parameter	Description	Value
Preference (Ameriks et al., 2011)		
η	Intensity of bequest motive	47.6
$\emptyset$	Luxury bequest parameter	7.28
Preference (Brown and Finkelstein, 2008)		
γ	Coefficient of CRRA	3
r	Real interest rate	0.03
ρ	Discount rate of utility of consumption	0.03
$infl$	Price inflation	0.03
$rminfl$	Real medical cost growth (over inflation)	0.015
Consumption (Ameriks et al., 2011)		
C^f	Floor for states H and M	\$ 5,750
C^{PC}	Floor for state S	\$ 2,200
Health Expenditures (Ameriks et al., 2011)		
X_1	Occurred annual expenditures in state H	\$ 1,000
X_2	Occurred annual expenditures in state M	\$ 10,000
X_3	Occurred annual expenditures in state S	\$ 50,000

I employ a two-step grid search method to solve the optimization of purchasing LTCI coverage. First, I discretize the ratio of purchasing LTCI into a grid of 100 over the interval [0,1]. Then for any level of discretized initial wealth, W_0 , on a grid of 30 over the interval [0, 1,200,000], I use Bellman equation (4) and the numerical solution method described in the section “The

optimization problem” to obtain the optimal consumption path for the remaining life of a retiree, leading to the calculation of lifetime utility at age 65.¹⁸⁵

5.2 Optimization

In this section, various benchmark cases with and without bequest motives and consumption floors when the premium is actuarially fair are tested. Figure 7 illustrates the optimal LTCI coverage rate based on the options of including bequest motives and consumption floors.

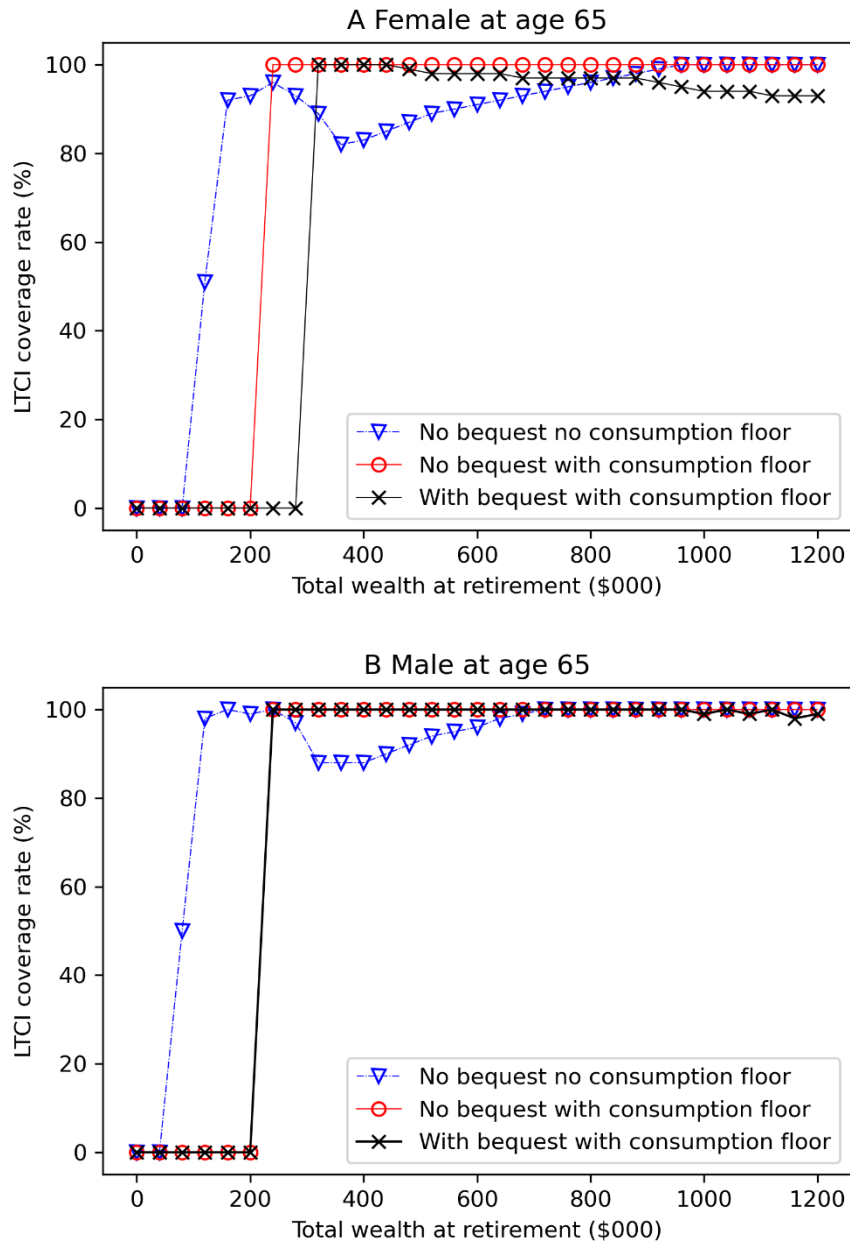
In the baseline (i.e., having no bequest motives and no consumption floor), individuals optimize their lifetime utility by purchasing full coverage as long as they can afford it based on their initial level of wealth. The jump in the optimal LTCI coverage rate is due to the non-linear effects of LTCI on consumption (Xu et al., 2022). By adding consumption floors, the zero level of optimal LTCI consumption at lower levels of wealth is because those with a lower initial level of wealth rely more on government transfers that provide some form of public LTC coverage via minimum consumption floor. Adding bequest motives to the model decreases the demand for LTCI (Zweifel and Strüwe, 1996) in higher levels of wealth for both females and males.¹⁸⁶ For comparison purposes and robustness of the utility maximization model, in Appendix D alternative scenarios of premium loading factors (Fig. D1) and levels of relative risk aversion γ (Fig. D2) are depicted. Based on Figure D1 and D2, a decrease in premium loading factor or an increase in the coefficient of relative risk aversion increase the demand for LTCI coverage rate among retirees.¹⁸⁷

¹⁸⁵ I discretize wealth for each level of initial financial wealth using 60 grids. The respective code in Python 3 is available upon request.

¹⁸⁶ Bequest motives can have two offsetting effects on the demand for LTCI. According to Pauly (1990), the motive to leave bequest increases the demand for LTCI, since purchasing the insurance adds to the amount that is left by those who die after being severely disabled. On the other hand, Lockwood (2018) claims that the opportunity cost of precautionary savings will be reduced, hence lowering the demand for LTCI.

¹⁸⁷ For brevity in Appendix D, optimal choices are shown only for females.

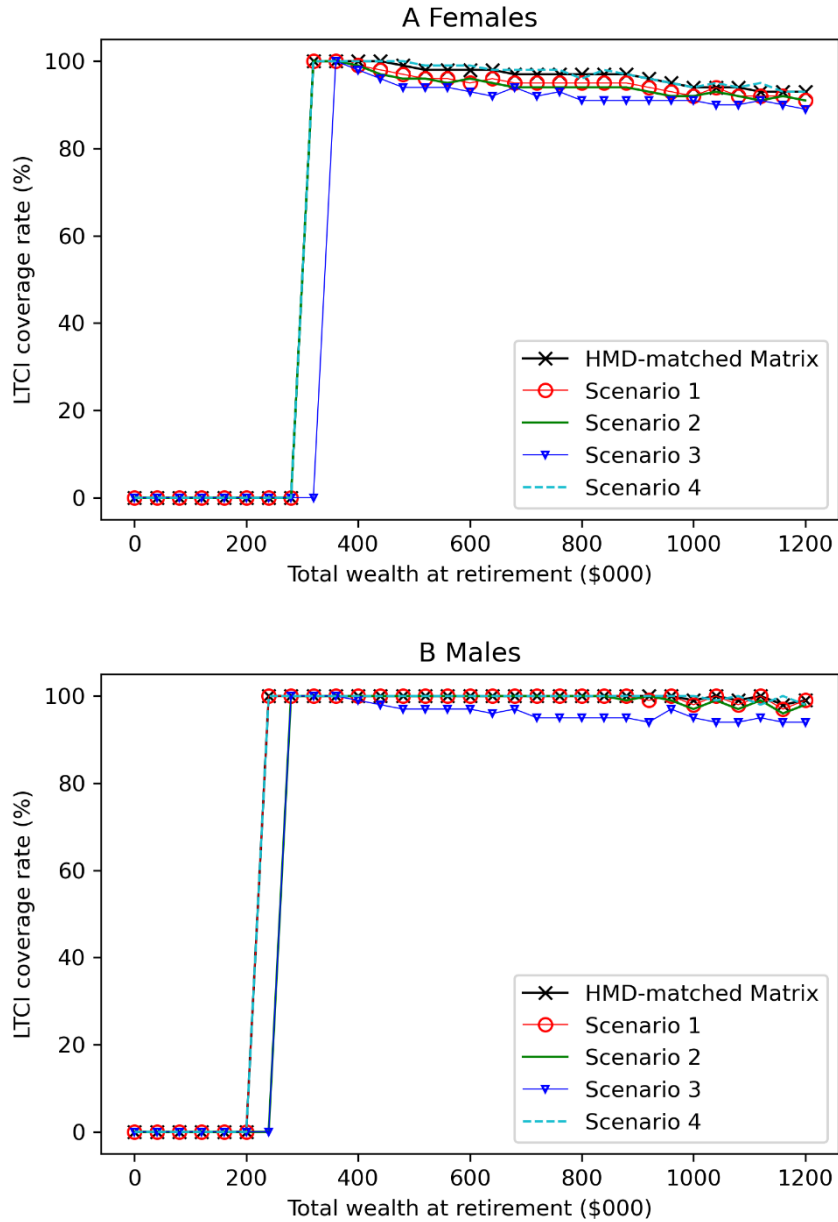
Figure 7. Optimal LTCI coverage using various benchmarks



Note: The horizontal and vertical axis represent the retirees' wealth level and LTCI coverage rate, respectively. Panel A and B demonstrate LTCI coverage rates using various benchmarks for a 65-year-old female and male retiree, respectively.

For the rest of the analysis, I include both bequest motives and consumption floors in the baseline model to test alternative morbidity scenarios. I analyze the optimal choice of purchasing LTCI in scenarios 1-4 explained in section 4.2 by incorporating four longevity-adjusted health state transition matrices. The results are illustrated in panels A and B of Figure 8 for females and males, respectively.

Figure 8. Optimal LTCI with increased longevity



Note: The horizontal and vertical axis represent the retirees' wealth level and LTCI coverage rate, respectively. Panel A and B demonstrate LTCI coverage rates in scenarios 1, 2, 3 and 4 for a 65-year-old female and male retiree, respectively.

For both females and males in Figure 8, morbidity expansion (i.e., scenario 3) leads to a lower LTCI coverage rate. A lower purchase of LTCI coverage rate in scenario 3 (compared to other scenarios) is due to the reason that the associated actuarially fair insurance premium calculated in scenario 3 is higher than in other scenarios, and a higher premium lowers the demand for LTCI. While in scenario 3, the retiree receives benefits for a longer period, where if no insurance was purchased, she should have paid a higher amount of out-of-pocket expenses, the increase in fair premium seems to have more of a dampening effect on optimal lifetime utility, leading to less purchase of LTCI. These findings are confirmed using alternative benchmarks

where bequest motives or consumption floors are excluded from the life-cycle model. Figure D3 and D3 in Appendix D illustrate the results using alternative benchmarks.

For a retiree in scenarios 1 and 2 (where life expectancy is longer in states 1 and 2, respectively) the ratio of life expectancy in state 3 to total life expectancy remains similar, and lifetime health care expenditures not covered by insurance increases, hence the optimal rate of insurance purchase remains similar to the benchmark while it is slightly lower for scenario 2 (the retiree spends more on out-of-pocket health care costs from living longer in state 2).

Comparing optimal purchase of LTCI in scenario 4 (i.e., dynamic equilibrium) with the baseline model confirms that as long as the ratio of life expectancy in each health state to total life expectancy remains similar, the optimal choice of LTCI will also remain the same. For females, the ratio of life expectancy in state 1 to total life expectancy is 0.74 for the baseline model and 0.75 for scenario 4, and 0.82 for males in both the baseline model and scenario 4 (see Table 1). Hence, the optimal choice will remain the same.

All these results are based on a strong assumption that a rational agent who maximizes her lifetime utility can accurately estimate her future life expectancy, and she properly smooths her consumption by purchasing LTCI at retirement. With this assumption, longevity improvement has a minor impact on the demand for LTCI unless the increase in life expectancy occurs with morbidity expansion. In such a case, the above results confirm that the retiree will purchase less LTCI. This assumption might deviate from reality if the retiree has subjective mortality beliefs different from the one estimated from mortality tables. Caliendo et al. (2020) refer to this issue as survival ambiguity,¹⁸⁸ and argue that it is unlikely for individuals to know their exact survival probabilities since many factors influencing the probabilities cannot be observed.

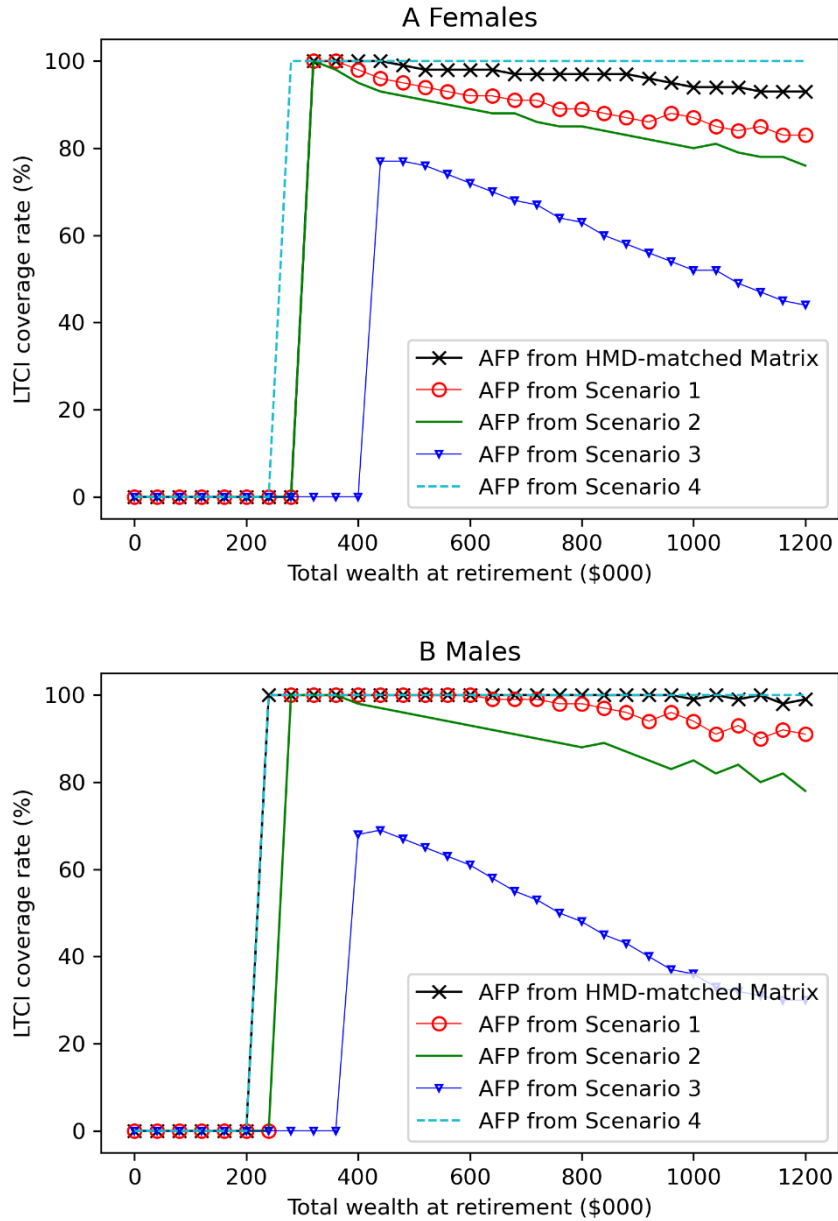
In this section, to examine the impact of survival ambiguities, I provide a simplified examination using constructed scenarios from the previous section. I assume that retirees' beliefs about their survival probabilities and health state transitions only follow HMD-matched health state transitions and use such transition rates to maximize their lifetime utility.¹⁸⁹ However, the insurance provider takes into account mortality improvements and various scenarios of morbidity expansion/compression (i.e., the previously constructed four scenarios)

¹⁸⁸ The term ambiguity refers to the case that the probability distribution of length of life is unknown to individuals (Caliendo et al., 2020).

¹⁸⁹ It should be noted that assuming HMD-matched health state transitions as the base for retirees' survival beliefs can be subject to criticism since previous studies find that people's survival beliefs can deviate from mortality tables. Using a new survey evidence, Heimer et al. (2019) document that survival is underestimated (overestimated) by the young (old). Since I do not have access to retirees' subjective survival probabilities, I use HMD-matched health state transitions for retirees' survival beliefs.

to calculate actuarially fair premium. Therefore, using actuarially fair premiums from four scenarios, the lifetime utility maximization is done incorporating HMD-matched health state transitions. Panel A and B in Figure 9 illustrate the results.

Figure 9. Optimal LTCI using different actuarially fair premiums



Note: The horizontal and vertical axis represent the retirees' wealth level and LTCI coverage rate, respectively. Panel A and B demonstrate LTCI coverage rates for a 65-year-old female and male retiree, respectively. In all the models, HMD-matched health state transitions are used for utility maximization while actuarially fair premium (AFP) calculated for scenarios 1, 2, 3 and 4 are tested.

Figure 9 shows that, compared to the baseline model where actuarially fair premium is calculated according to HMD-matched health state transitions, if the retiree pays premiums according to alternative scenarios of morbidity compression/expansion, her optimal choice of purchasing LTCI decreases. The decrease in optimal LTCI coverage rate is the highest for the morbidity expansion scenario. However, the results show that if actuarially fair premium is

calculated based on the dynamic equilibrium scenario, the increase in life expectancy has less (for females a minor positive) impact on the optimal choice of insurance coverage rate.

It can be inferred from these results that if the subjective survival belief of retirees is different from survival probabilities used by the insurance provider for premium calculation, both scenarios of morbidity compression and expansion might lead to the lower optimal purchase of LTCI. Hence, it is essential for insurance providers, researchers and policymakers to consider survival ambiguities as one of the reasons contributing to the low demand for LTCI among elders (see, e.g., Heimer et al., 2019, on the effect of subjective mortality beliefs on the demand for annuities).

6 Summary and conclusion

This study examines the interplay between health state transitions and longevity risk on retirees' optimal choice of purchasing LTCI. For this purpose, health state transitions estimated from the HRS for the U.S. American retirees is utilized, and HMD for the U.S. population is used to project mortality improvements. To examine the interactions between longevity and morbidity over a retiree's life-cycle, a calibration version of health dynamics where longevity improvement coincides with multiple morbidity scenarios (i.e., morbidity expansion/compression and dynamic equilibrium) is constructed. To study the impact of morbidity scenarios on the optimal choice of purchasing LTCI, a discrete choice life-cycle framework with bequest motives and government subsidies and the choice of purchasing private LTCI at the beginning of retirement is employed.

I find a lower purchase of LTCI for retirees in the morbidity expansion scenario compared to all other scenarios. This is due to an increase in actuarially fair premium when retirees remain severely disabled for longer. While a similar study on annuities (see., e.g., Ai et al., 2017) suggest that an increase in health care costs due to morbidity expansion leads to higher demand for annuities, our results indicate negative impacts of morbidity expansion on the optimal choice of purchasing LTCI. The main reason is the differences in LTCI premium calculation compared to annuity premium. Annuity premium is derived from the total life expectancy regardless of various morbidity scenarios. However, due to the nature of LTCI, the amount of time spent in a severely disabled state directly determines the premium, influencing optimal consumption and purchase of LTCI. When longevity improvement is considered while the ratios of life expectancy in various health states remain similar to the baseline model (i.e., dynamic equilibrium), the optimal choice of purchasing LTCI will also remain almost the same.

When survival ambiguities are considered, both morbidity expansion and compression lead to a lower purchase of LTCI. In other words, if actuarially fair premium is calculated by taking into account life expectancy improvements while the retiree does not consider life expectancy improvements in her lifetime utility maximization, both scenarios of morbidity expansion and compression reduce the optimal choice of purchasing LTCI. The optimal choice will remain rather similar in the dynamic equilibrium scenario.

The results of this study are crucial for insurance providers, LTC service planners and researchers. Insurance providers benefit from the findings by utilizing retirees' subjective survival beliefs in analyzing the market for LTCI. LTC service planners can improve the financial literacy of retirees and enhance existing biases in retirees' survival beliefs to help them to make better financial decisions later in life. The results also contribute to and fill the gap in the literature on LTC puzzle by analyzing the interplay between increases in longevity and changes in health state transitions with survival ambiguities.

As with any other study, this research is subject to several limitations that warrant further research. First, although the results of this study confirm a lower demand for LTCI in morbidity expansion scenario, the dynamicity of health trends should not be neglected. Stallard (2016) argues that expecting an indefinite continuance of morbidity compression in the U.S. should be cautiously addressed due to pauses, cessation or slowdown of morbidity improvements recently detected in HRS data. Therefore, both LTC service providers and major players in the LTC market should take into account such dynamics in their planning and product design to meet the current and future needs of the elderly population.

Second, the estimated health transition matrix from HRS cannot fully capture inherent cohort effects in health state transitions. A longer time series of data is needed to consider cohort effects. Third, the life-cycle model can be expanded to consider other retirement products, such as annuities, lifecare annuities and reverse mortgages. Fourth, future studies should consider behavioral biases¹⁹⁰ such as framings, loss aversion, ambiguity aversion and time preferences that might influence the demand for LTCI. Lastly, to analyze the survival ambiguities of retirees and their role in the optimal choice of purchasing LTCI, I simply assumed a benchmark for retirees' survival beliefs in her life-cycle model and I tested alternative actuarially fair premiums from various morbidity scenarios. Future studies should use a more accurate estimation of the retirees' survival beliefs using designed surveys.

¹⁹⁰ See, e.g., Bonsang and Costa-Font (2020).

Appendix A. Estimation of health transition matrix from HRS

In their baseline scenario, Shao et al. (2017) use the data from individuals age 50 and older who were alive and healthy during the 1998 wave survey of HRS with valid responses to the questions on ADLs in the following waves. The number of respondents in the baseline is 14,742 who have fully responded in the next waves until 2010. HRS asks individuals about six ADL items: dressing, walking, bathing, eating, transferring in/out of bed and toileting. They categorize individuals who responded to ADL questions by “yes,” “can’t do,” or “don’t do” as having a particular ADL disability. They also rely on exact dates of death included in the dataset for estimation of transitions to death state.

The methodology used in Shao et al. (2017) to calculate health state transitions is as follows. First, it is assumed that health dynamics is a time-continuous inhomogeneous Markov process with age-dependent transition intensities. They consider the four-state Markov process with health states H, S and M as transient states and death state D as absorbing. I denote nine transition intensities (six among three health states and three from health states to death state) following Fong et al. (2015) by:

$$P_{i,j}(x, x+t) = \Pr\{S(x+t) = j | S(x) = i\} \quad t \geq 0, \quad i, j \in \{H, M, S, D\} \quad (6)$$

$$\mu_{i,j}(x) = \lim_{t \rightarrow 0^+} \frac{P_{i,j}(x, x+t)}{t}. \quad (7)$$

In the above equations, $P_{i,j}$ is the transition probability from state i to state j , and x is the time unit in years from the time of retirement. The instantaneous transition intensities ($\mu_{i,j}$) are age-dependent and are assumed to be integrable on compact intervals.

In the next step, using HRS 1998-2010, Shao et al. (2017) assume that empirical age-dependent health transition intensities for four health states are constant in each age interval, and the amount of time until transition follows an exponential distribution. They further assume that health transitions between each pair of states H, M and S occur, on average, halfway between two known survey dates, while mortality transitions utilize exact dates of death. The analysis time is measured in months and they calculate the exposure years in each of the health states H, M , and S , and the number of reported age-specific health transitions, in seven waves of retirees at age 65-100, respectively. Shao et al. (2017) assume that different cohorts of retirees in the data share the same pattern of health dynamics. Then they aggregate the exposure years

in each of the health states H, M and S and the number of reported age-specific health transitions by age. Through dividing the aggregated age-specific exposure years in each of the health states H, M and S by the corresponding transition number, they estimate the empirical age-dependent health transition intensities over four health states from age 65 to age 100.

Next, they adopt Poisson generalized linear model (GLM) to graduate the empirical transition intensities estimated in the previous step. I denote the number of transitions at age x by i_x , which follows Poisson distribution $Poi(m_x)$, where m_x represents the mean of i_x . The mean m_x depends on age as follows:

$$m_x = e_x \sum_{s=0}^k \beta_s x^s, \quad (8)$$

where e_x represents the exposure for x -year-old retiree, and β_s refers to the coefficients for the s th order polynomial function of age, and k is the maximum polynomial order. Using standard maximum likelihood estimation, Shao et al. (2017) estimate Poisson GLM and select the optimal k based on AICs and BIC and residual deviances.

In the final step, the transition probabilities are calculated via Kolmogorov differential equations from the graduated health transition intensities from the previous step. Using three-state Kolmogorov differential equations from Haberman and Pitacco (1999), the four-state Kolmogorov differential equations are written as:

$$\frac{d}{dt}P_{i1}(s, t) = P_{i2}(s, t)\mu_{21}(t) + P_{i3}(s, t)\mu_{31}(t) - P_{i1}(s, t)(\mu_{12}(t) + \mu_{13}(t) + \mu_{14}(t)),$$

$$\frac{d}{dt}P_{i2}(s, t) = P_{i1}(s, t)\mu_{12}(t) + P_{i3}(s, t)\mu_{32}(t) - P_{i2}(s, t)(\mu_{21}(t) + \mu_{23}(t) + \mu_{24}(t)),$$

$$\frac{d}{dt}P_{i3}(s, t) = P_{i1}(s, t)\mu_{13}(t) + P_{i2}(s, t)\mu_{23}(t) - P_{i3}(s, t)(\mu_{31}(t) + \mu_{32}(t) + \mu_{34}(t)),$$

and $P_{i4}(s, t) = 1 - P_{i1}(s, t) - P_{i2}(s, t) - P_{i3}(s, t)$ for $i = 1, 2, 3$.

Appendix B. Life expectancy calculation in different health states

I follow the method suggested by Ai et al. (2017) to calculate life expectancies.

Let's assume that α_{65}^g refer to the initial health distribution vector of gender g over health states 1-4 at age 65. We have:

$$\alpha_{65}^g = [p_{65}^{1,g} \ p_{65}^{2,g} \ p_{65}^{3,g} \ p_{65}^{4,g}],$$

where $p_{65}^{i,g}$ represents the proportion of health state i for gender g at age 65. Since I only assume healthy retirees the $p_{65}^{4,g}$ is zero for both genders. Now I denote health transition matrix from age x to age $x + 1$ as H_x . Then the vector of health distribution for health states 1-4 at age $65 + i$ ($i = 1, \dots, 35$) equals:

$$\alpha_{65+i}^g = \alpha_{65}^g \prod_{j=1}^i H_{65+j} = [p_{65}^{1,g} \ p_{65}^{2,g} \ p_{65}^{3,g} \ p_{65}^{4,g}]',$$

Life expectancy for each health state is calculated as:

$$LE_1^g = \sum_{i \geq 0} \frac{p_{65+i}^{1,g} + p_{65+i+1}^{1,g}}{2}, \quad LE_2^g = \sum_{i \geq 0} \frac{p_{65+i}^{2,g} + p_{65+i+1}^{2,g}}{2}, \quad LE_3^g = \sum_{i \geq 0} \frac{p_{65+i}^{3,g} + p_{65+i+1}^{3,g}}{2},$$

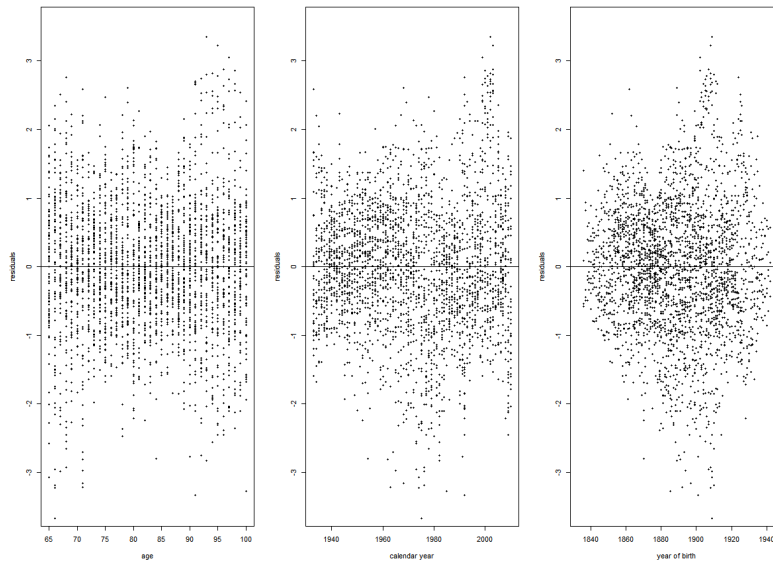
The total life expectancy is:

$$\begin{aligned} LE_{total}^g &= \sum_{i \geq 0} \frac{(p_{65+i}^{1,g} + p_{65+i}^{2,g} + p_{65+i}^{3,g}) + (p_{65+i+1}^{1,g} + p_{65+i+1}^{2,g} + p_{65+i+1}^{3,g})}{2} \\ &= LE_1^g + LE_2^g + LE_3^g. \end{aligned}$$

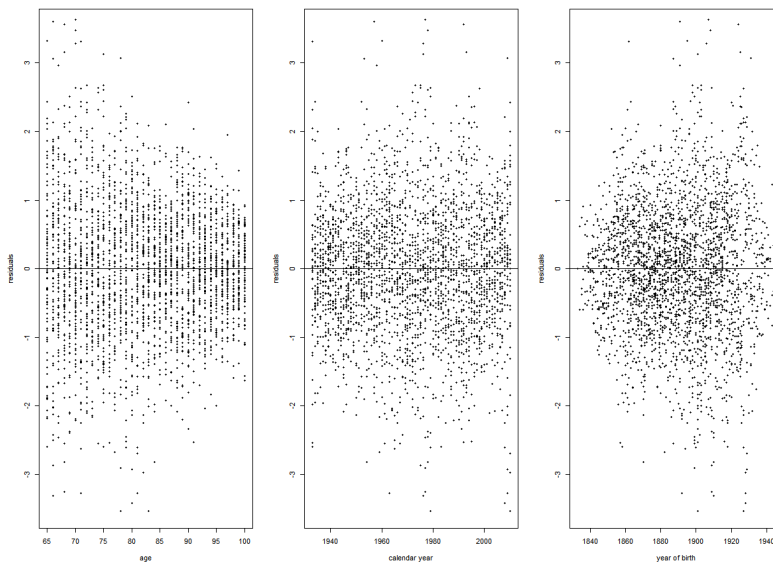
Appendix C. Mortality projection models

I test Lee-Carter (Lee and Carter, 1992), CBD (Cairns et al., 2006), age-period-cohort (APC) (Currie et al., 2004) and RH model (Renshaw and Haberman, 2006). The analysis is done using package StMoMo (Villegas et al., 2018) in Software R. Figure C1 and C2 depict the residuals of fitting the RH model for females and males, respectively. Table C1 provides the relative AIC and BIC criteria for fitting various models. It can be seen that the lowest number for both female and male populations in both criteria belongs to the RH model.

Figure C1. Residuals from fitting RH model to the U.S. population
A Females



B Males



Note: Panel A and B represent the residuals of fitting RH model to the U.S. population aged 65–100 for the period 1933–2010 for females and males, respectively.

Essay III The interplay between longevity and morbidity

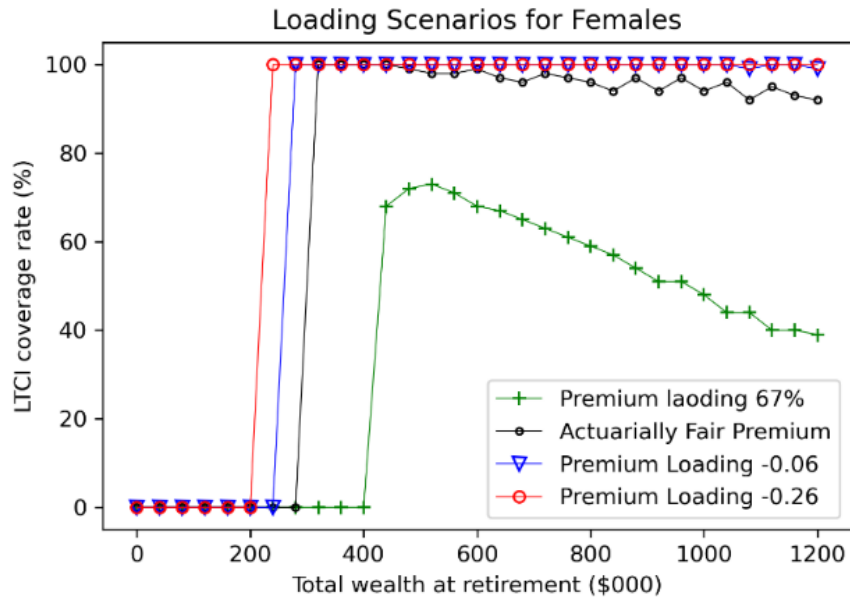
Table C1. AIC and BIC values for fitting different models

	Female		Male	
	AIC	BIC	AIC	BIC
LC	76404.97	77283.49	67847.61	68726.13
CBD	122756.2	123682.2	84076.74	85002.74
APC	94261.65	95555.68	68654.81	69948.84
RH	58917.93	60419.73	45431.94	46976.4

Note: The models are fitted to the U.S. female and male population for ages 65–100 and the period 1933–2010

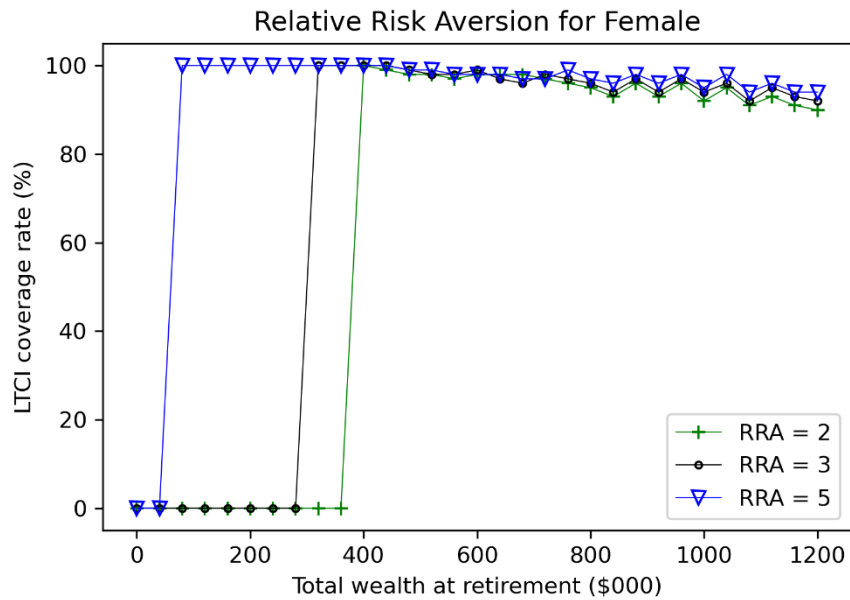
Appendix D. Alternative benchmarks

Figure D1. Loading scenarios on optimal choice of LTCI



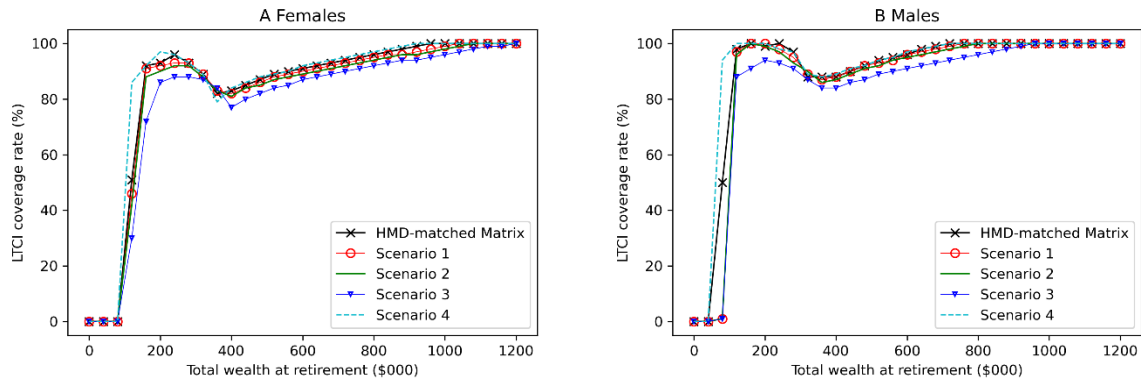
Note: The horizontal and vertical axis represent the retirees' wealth level and LTCI coverage rate, respectively. HMD-matched health state transitions are utilized to depict the role of premium loadings on optimal choice of LTCI. For brevity, optimal choices are shown only for females. Premium loadings are utilized from Brown and Finkelstein (2004). They suggest negative loadings only for females when unisex pricing is utilized for calculating the premiums of LTCI products.

Figure D2. Different scenarios for relative risk aversion



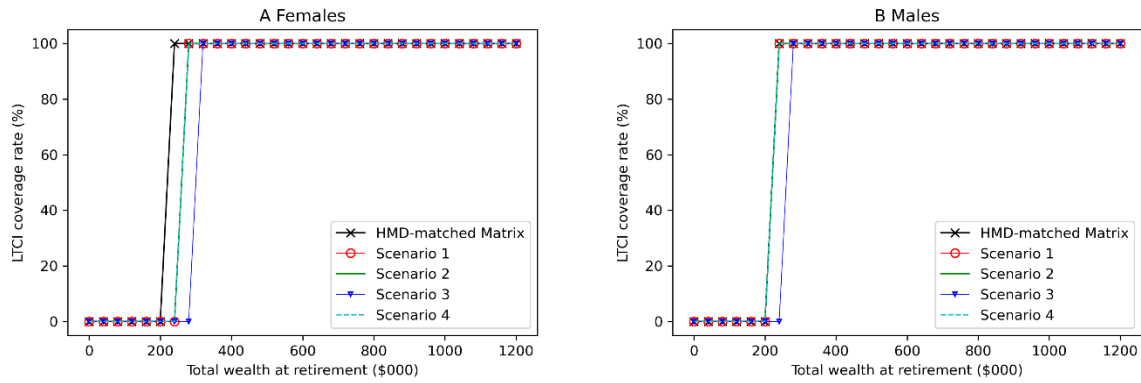
Note: The horizontal and vertical axis represent the retirees' wealth level and LTCI coverage rate, respectively. HMD-matched health state transitions are utilized to depict the role of relative risk aversion (RRA) on optimal choice of LTCI. For brevity, optimal choices are shown only for females.

Figure D3. Optimal LTCI coverage without consumption floors and bequest motives



Note: The horizontal and vertical axis represent the retirees' wealth level and LTCI coverage rate, respectively. Panel A and B demonstrate LTCI coverage rates in scenarios 1, 2, 3 and 4 for a 65-year-old female and male retiree, respectively. Consumption floors and bequest motives are not included in the model.

Figure D4. Optimal LTCI coverage with consumption floors without bequest motives



Note: The horizontal and vertical axis represent the retirees' wealth level and LTCI coverage rate, respectively. Panel A and B demonstrate LTCI coverage rates in scenarios 1, 2, 3 and 4 for a 65-year-old female and male retiree, respectively. Consumption floors are included and bequest motives are not included in the model.

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Summary table on the doctoral dissertation

	Essay I	Essay II	Essay III (Single-authored)
Title	Research on long-term care insurance: Status quo and directions for future research	Willingness to take financial risks and insurance holdings: A European survey	The interplay between longevity and morbidity on optimal choice of long-term care insurance
Author(s)	Martin Eling Omid Ghavibazoo	Martin Eling Omid Ghavibazoo Katja Hanewald	Omid Ghavibazoo
Main topic	Long-term care insurance	Behavioral aspects of insurance	Long-term care insurance
Data	Citation network of 591 articles extracted from Web of Science on March 8, 2018 (published articles between 1984 - 2018)	Survey of Health, Ageing and Retirement in Europe (SHARE), Wave 5 (2013)	- The University of Michigan Health and Retirement Study (HRS) (1998 – 2010) - Human Mortality Database (HMD) for the U.S. (1933 - 2010)
Methodology	Literature review, Citation network analysis, Main path analysis, Text mining	Probit regression	Markov process, Renshaw and Haberman extension of L-Carter model, Discrete life-cycle
Main points	- The important research paths on long-term care insurance are identified. - The identified major research areas are evaluated systematically using standard frameworks. - Established and innovative (insurance) solutions are reviewed.	- Investigate the link between risk attitudes and ownership of long-term care and life insurance using willingness to take financial risks. - Important determinants of demand for long-term care and life insurance are controlled. Robustness tests are done using self-reported risky asset ownership, homogenous groups and using interactions.	- Investigate the impact of life expectancy improvements and its interplay with morbidity scenarios on optimal choice of purchasing long-term care insurance. - Four scenarios of morbidity expansion and compression and dynamic equilibrium are constructed.
Contribution	- The most comprehensive literature review on long-term care insurance is done. - The immense difficulties of insuring long-term care are identified from demand and supply side. - Existing anomalies on determinants of demand for long-term care insurance are detected and categorized. - Future research directions are suggested.	- It helps explain behavioral controversies found to impact the demand for insurance among elders. - It empirically suggests that looking at individuals' risk attitudes and insurance ownership might not be explained via expected utility theory, and other economic theories should be considered.	- It fills the gap in research on the role of mortality improvements, morbidity trends and existence of survival ambiguities on the demand for long-term care insurance. - It suggests another influencing factor that might play role in marginal contribution of insurance in financing long-term care expenses.
Status	Published in <i>Geneva Papers on Risk and Insurance – Issues and Practice</i> (December 2018)	Published in <i>Journal of Behavioral and Experimental Economics</i> (October 2021)	Presentations: - ARIA (2022) in Long Beach - Ph.D. in Finance seminar

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