ARC Centre of Excellence in Population Ageing Research

Working Paper 2024/14

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August 8, 2024

Abstract

Private long-term care insurance (LTCI) is not available in many countries, including Australia, with individuals relying on government aged care and their own retirement savings to meet aged care needs. We consider the design of private LTCI products to cover individual out-of-pocket aged care costs, assess their pricing using a recently published model of chronic illness and disability in Australia, evaluate the capital costs for insurers and their implications for pricing, and analyse the demand for the products through utility analysis. We consider individuals in good health as well as those who are disabled or with chronic illness and incorporate estimated trends in mortality and disability. Although we focus on Australia, the results have important implications and insights for other developed countries. We consider several LTCI products, encompassing stand-alone LTCI and a life care annuity (LCA). We incorporate public aged care co-payments, a comfortable consumption level and the aged pension for Australian retirees, as well as solvency capital requirement (SCR) based on the Solvency II into our analysis. We also include a systematic literature review of LTCI pricing approaches that informs our analysis. We show how the SCR is significant for the stand-alone LTCI premiums, and reduced for the LCA premiums. Our demand analysis illustrates how LTCI products increase individual utility and welfare in most cases, and quantifies how this is impacted by product expense loading, risk aversion, wealth levels, and bequest motives.

1 Introduction

While there are a few countries with active private long-term care insurance (LTCI) markets, in most countries, this is not the case. Private LTCI presents a promising solution to long-term care (LTC) funding challenges by potentially reducing the financial burden on public aged care systems and improving individual welfare through more efficient management of LTC risk. However, developing a robust private LTCI market requires carefully designed models tailored to each country's unique circumstances. In this study, we focus on Australia to contribute to the international literature on the design and pricing of private LTCI, leveraging specific Australian data and context.

Aged care, or LTC, financing is a significant issue impacting many countries as populations age around the world. This financing comes from both government support and private individual savings. Countries differ in both the amount of total aged care expenditure, as well as the mix

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between government and private funding. In many countries, future costs of aged care are increasing as the population ages and there is an increased role for individuals to meet part of the costs as increased pressures are placed on government budgets.

LTC financing systems differ internationally. Dyer et al. [2020] categorised the public LTC systems in 14 developed countries into four groups based on the level of access to LTC (e.g., means testing, limits on entitlement to care) and the reliance on consumer spending (e.g., cost sharing, co-payments). Poland, Singapore and the US have LTC spending at around 0.5% of GDP and are countries with the least amount of public LTC support with low levels of access to LTC and a high reliance on consumer financing. Germany and Denmark spend 4.3% and 1.2% of the GDP, respectively and provide the highest levels of LTC support, the highest level of public access to LTC and the lowest reliance on consumer financing.

Australia, along with Japan, New Zealand, Switzerland, South Korea, the Netherlands and Sweden has a high level of LTC access and mid-to-high level of consumer financing. The average public LTC spending in these countries is 2.5% of GDP, although for Australia it is lower at 1.2%. The LTC financing system in Australia is a hybrid system combining a tax-based universal model and a means-tested system, using the typology in Joshua [2017]. This differs from the social insurance models generally financed by compulsory contributions (e.g., Japan, South Korea), the tax-based universal model (e.g., Denmark, Finland), and the means-tested systems (e.g., UK, US). The Australian government provides universal access to LTC based on assessments (and pays for the majority of aged care), but requires co-payments determined by means testing. As a result, there is potential for private LTCI to more efficiently finance individual co-payments.

The Australian government needs to ensure a sustainable LTC funding model for aged care services including in-home care, residential care and short-term care [Sherris, 2021]. To ensure sustainability, changes to LTC financing will need to address issues such as inter-generational equity, moral hazard, and the significant government deficit from the COVID pandemic as well as the recent trend of high inflation and forecast increases in long-term aged care and health care costs [Ticha, 2022, Sherris, 2021].

The development of a private long-term care insurance (LTCI) market in Australia has the potential to support a more sustainable LTC system. Private LTCI can alleviate the financial strain on public aged care and enhance individual welfare by managing LTC risk more effectively for individuals. Private LTCI must be designed to integrate with the public aged care financing by funding care requirements during waiting periods for a government aged care package, meeting co-payments or paying for the higher quality LTC services (e.g., preference to home care than residential care) [Ticha, 2022, Sherris, 2021]. While the demand for the LTCI is shown to exist, there is little on offer [Wu et al., 2017].

Existing active LTCI markets internationally provide valuable insights. In the US, private LTCI was held by 14% of citizens of 60 years of age or older in 2008 and accounted for approximately 10% of LTC expenditure [Brown and Finkelstein, 2011]. The demand for LTCI complements the Medicaid-funded LTC services targeted at the poor [Dyer et al., 2020]. In France, around five million people (out of the 63 million population) have some form of private LTCI, according to the French Insurers' Federation (FFSA) [Browne, 2011]. Browne [2011] attributes the success of LTCI in France to their financial prudence, regard for LTCI as protecting the legacy or inheritance, and encouragement of LTCI within the competitive bancassurance network. Singapore has a unique opt-out disability insurance scheme, ElderShield that provides basic financial protection to those with severe disabilities needing LTC. While regulated by the government, the scheme is run through designated private insurers and covers 9% of LTC expenditure. In Japan and Germany, private LTCI plays a role for those who opt out of the public LTCI system or require an additional level of coverage although the market is small [Robertson et al., 2014].

There are barriers to the development of an Australian private LTCI market as identified in Browne [2013] based on surveys and interviews with active insurance stakeholders in the Australian market. The top five investor-side barriers, in order of significance, were limited market profitability due to the current market size, regulatory constraints or regulatory uncertainty, uncertainty over future costs of LTC provision, lack of knowledge about LTCI among independent financial advisors, and uncertainty over future design of care provision in Australia and the future role of informal carers. The provider-side barriers were the complexity and high cost of care insurance products, ignorance of the risk of future care needs, a belief that LTC is funded entirely by government funding, behavioural barriers such as optimism, and the unpredictable extent of future care costs and insurance coverage proportions.

High cost is an important issue to consider. LTCI is generally considered expensive as the premium has to cover the solvency capital costs arising from product risks and uncertainties in addition to the insurance costs and other expenses. To assess LTCI uncertainties and risks, LTC costs and the pricing of LTCI products require an actuarial model for the Australian population. There are limited published Australian models, for example, those found in Leung [2004] and Hariyanto et al. [2014]. Costs can also be reduced by innovative design of LTCI products such as a life care annuity or LCA (a life annuity combined with LTCI) which is less sensitive to systematic uncertainties than a stand-alone LTCI [Sherris and Wei, 2021].

Uncertainty in the demand for LTCI products is a barrier to the development of an Australian private LTCI market. To understand demand, we can quantify the increase in welfare from increased and less risky future consumption and wealth from the purchase of LTCI products using utility analysis. Theoretical models do not explain the low demand for private LTCI, although they highlight key factors to consider. De Donder and Leroux [2021] assess LTCI demand in a scenario where individuals have preferences dependent on their health state, and consider both daily life consumption and LTC expenditures. Brown and Finkelstein [2008] use a utility-based model for individuals with an optimal inter-temporal consumption path allowing for uncertainty in LTC expenditures arising from LTC risk, Medicaid rules in the US, and coverage of typical LTCI policies. Ameriks et al. [2020] include health-dependent preferences. They consider preferences for bequest, LTC expenditures, and regular expenses, as well as uncertainties related to health and longevity. Xu et al. [2023] study the impact of housing wealth and individual preferences on the demand for annuities and LTCI showing how home equity decreases LTCI demand, as well as a lack of bequest motives and a lower levels of risk aversion.

In this study, we provide a detailed analysis of the pricing of a range of LTCI products designed for both healthy and chronically ill Australian retirees taking into consideration a comfortable consumption level, aged pensions and public aged care. We use a recently published multi-state Markov model of functional disability and illness, in Park and Sherris [2023]. The model, estimated using Australian data, is used to assess the premium and benefit payments for the private LTCI contracts and to quantify the impact of these LTCI products on an individual's utility. Our analysis includes important factors such as expense loading, capital requirements as well as integration with the public pension and aged care system. We also carry out and provide a summary of a systematic literature review for the development and pricing of LTCI products for both the Australian market and international LTCI markets, which informs our analysis.

With the simulated health transition dynamics, our analysis indicates that the increase in life expectancy is mainly due to a longer duration spent in a chronically ill state. The time spent in either healthy or disabled states tends to be slightly decreasing over time. Additionally, females on average spend more time in all health states compared to males, with the most significant proportional difference observed in the time spent with disability. This trend highlights an increasing life expectancy with deteriorating health conditions, an effect that is more pronounced in females due to their longer life expectancy.

In designing LTCI products and estimating their premiums and demand, we focused specifically on the Australian context. We considered factors such as the monthly co-payment requirement in the Australian public aged care system, which is around \$1,500 with a lifetime limit of \$76,000 (which indicates a necessary financial support for disability), the monthly aged pension payment of approximately \$1,700, and the comfortable consumption level for Australian retirees at about \$5,000 monthly. Additionally, we accounted for the Solvency II capital requirements, which are to protect insurer's fund against potential mortality and disability rate shocks. Our systematic review of LTCI pricing approaches provided insights from various studies, both within and outside Australia.

Our LTCI premium estimations highlight the need to differentiate premiums based on gender and health status, and the importance of incorporating trends into the model. For stand-alone LTCI, premiums are 42% to 60% higher for females than males, -3% to 19% higher when trends are considered, and 1% to 17% higher for healthy individuals compared to those who are ill. For life care annuity (LCA), premiums are 12% to 23% higher for females than males, 16% to 37% higher with trends considered, and 9% to 22% higher for healthy than ill retirees. Furthermore, our estimations highlight the risk pooling benefits of LCA, which result in significantly lower risk margins compared to stand-alone LTCI.

Our utility and demand analysis indicates that potential insured individuals would generally be willing to purchase LTCI products, evidenced by a gain in utility. However, there are exceptions due to high solvency capital requirements and a low projected risk of disability. Results vary based on assumptions such as expense loading, risk aversion, and wealth levels. For wealth levels ranging from $0.6 million to $2.0 million, the utility gain from stand-alone LTCI decreases with increasing initial wealth, remaining positive up to approximately $1.3 million. Conversely, for LCA, utility gain peaks at a certain wealth level, varying with different model assumptions and individual types. Our findings suggest that a private LTCI market in Australia could provide additional funding for the aged care system, thereby enhancing the financial sustainability of public aged care financing.

For the first time, we provide a detailed analysis of potential LTCI products tailored for the Australian market, complementing the current public aged care funding system. Our study assesses individual welfare and preferences using utility measures, evaluates the risk of results through demand analysis, and explores the potential for providing LTCI to a broader group, including healthy males and females and those with chronic illnesses entering retirement. This contribution aims to support the development of sustainable LTCI markets globally by offering evidence-based insights and recommendations.

2 Literature review for LTCI pricing methods

In order to determine the design of LTCI products for the Australian market, as well as the modelling assumptions that ensure international comparability for our results, we conducted a systematic literature review of LTCI pricing methods.

The literature search was conducted via Google Scholar covering five-year period from 1 Jan 2018 to 1 Jan 2023, inclusive of those dates. The search criteria were carefully devised to be comprehensive enough to include any article that potentially has a component of mathematical calculation of any form of LTCI (including products with an LTCI component), and written as ["Life Care Annuities" OR "LTC" OR "Long Term Care Insurance" OR "LTC Insurance") AND "Insurance" AND ("Disability" OR "Illness") AND ("Pricing" OR "Thiele's Differential Equation" OR "Valuation")]. The exclusion criteria used were "not about method of pricing LTCI", "not original research", "not written in English" and "no mathematical framework". From the included studies, we extracted the year of study, country of the used data, description of the studied LTCI products, assumptions for pricing, and pricing model specifications.

The search initially returned 385 articles. Of those, the abstract screening excluded 340 articles followed by the exclusion of further 21 articles based on the full text screening. Reasons for the exclusions include "not about method of pricing LTCI" (296 articles) [1], "not original research" (11 articles), "not written in English" (5 articles), "no mathematical or theoretical framework" (47 articles), and "inaccessible" (2 articles). It finally identified 24 articles for review [Ahmad, 2022,

[1]While LTC is typically for functional disability, in some cases, the boundary between care for illness and LTC is unclear, leading to the inclusion of both in analyses. Perdana et al. [2022] is an example where medical expenses are claimed as LTCI benefit payments.

Atal et al., 2020, Bogataj et al., 2020, Chen et al., 2022b,a, Cui, 2019, De La Peña et al., 2021, 2022, Elyseu, 2020, Esquível et al., 2021, Hsieh et al., 2018, Li, 2019, Lim et al., 2019, Ma et al., 2021, Moosavi and Najafabadi, 2022, Ndubai, 2018, Pasaribu et al., 2019, Perdana et al., 2022, Ramsay and Oguledo, 2020, 2022, Sherris and Wei, 2021, Ventura-Marco et al., 2022, Wan et al., 2021, Xi, 2022]. The flow diagram for the article search is shown in Figure 1.

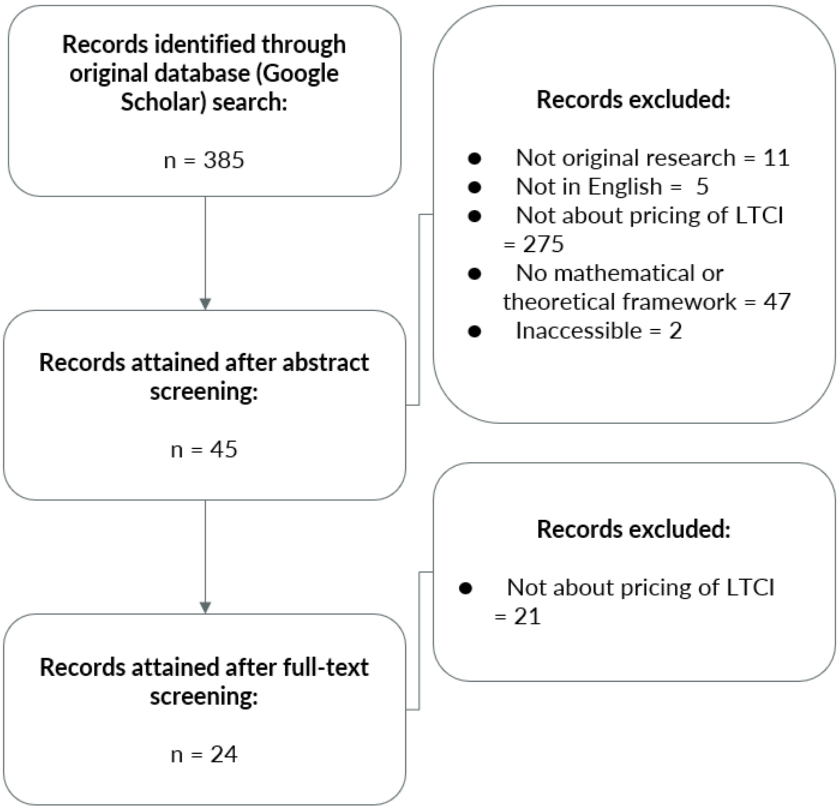

Figure 1: Flow diagram for literature search

Table 1 provides a summary of the main focus of the reviewed articles on LTCI pricing methods. The studies can be categorised into several key areas: the development and evaluation of hybrid LTCI products (e.g., Ahmad [2022], Hsieh et al. [2018], Moosavi and Najafabadi [2022]), the use of advanced statistical and actuarial models (e.g., Cui [2019], Lim et al. [2019], Sherris and Wei [2021]), the incorporation of machine learning techniques (e.g., Ma et al. [2021], Moosavi and Najafabadi [2022]), and the analysis of LTCI product profitability and market suitability (e.g., Bogataj et al. [2020], Elyseu [2020], Ramsay and Oguledo [2022]).

Table 1: Main focus of reviewed articles

Paper	Main Focus
Ahmad [2022]	Pricing of hybrid LTCI policies via decomposing the payment process into different product types and examining the joint distribution of their future payments by calculating its moments and covariance between them. The results are illustrated in a numerical example in a disability model.
Atal et al. [2020]	Assessing the welfare effects of German Long-term Health Insurance (GLTHI) and comparing them to the theoretical optimal dynamic contract.
Bogataj et al. [2020]	Developing a LTCI variant of a reverse mortgage using the liquid amount gained from the drawing period to pay for LTCI.

Paper	Main Focus
Chen et al. [2022b]	Evaluating a care option embedded within a life annuity product using actuarial present value and utility measure.
Chen et al. [2022a]	Addressing the shortcomings of modern LCA products through the utilisation of Tontines.
Cui [2019]	Improving LTC cost estimation through the implementation of the Manchester Method, which utilises the assumption that health state transitions are irreversible.
De La Peña et al. [2021]	Developing a mechanism for transforming the old-age pension into a benefit to help pay for LTC within a private defined benefit (DB) pension scheme.
De La Peña et al. [2022]	Incorporating a mechanism into defined benefit pension schemes that allows for transformative coverage of LTC.
Elyseu [2020]	Developing an LTCI product for a company in Portugal, focusing on profitability.
Esquível et al. [2021]	Applying established methodologies to Portuguese data to obtain transition intensities between dependence states and LTC costs.
Hsieh et al. [2018]	Evaluating hybrid LTCI such as LCA to meet the growing demand for LTCI products in Taiwan. The LCA-GLWB (Life Care Annuity - Guaranteed Lifetime Withdrawal Benefit) is a hybrid product comprising a regular LTCI and a variable lifetime annuity.
Li [2019]	Studying critical care insurance using Canadian data, focusing on modeling mortality rates, estimating transition probabilities, and calculating premium rates.
Lim et al. [2019]	Developing a methodology that allows for multi-state models to be utilised in cases where data is limited or not longitudinal.
Ma et al. [2021]	Using Machine Learning to price health insurance according to the risk levels of each individual, theoretically preventing adverse selection.
Moosavi and Najafabadi [2022]	Developing and evaluating a variable annuity product with a guaranteed lifelong withdrawal option, long-term care coverage, limited hospitalisation coverage, and improved product investment funds.
Ndubai [2018]	Fairly pricing Post Retirement Medical (PRM) insurance using two different methods: Pure Risk Premium vs. Profit Testing Method.
Pasaribu et al. [2019]	Demonstrating how Markov Chain can be used to develop a model of state change in critical illness in the case of a cancer patient and assist in the pricing of Critical Care insurance.
Perdana et al. [2022]	Determining the premium for LTCI products with a multi-state model in Indonesia.
Ramsay and Oguledo [2020]	Developing an LCA product with a variable annuity for the US market as a potential solution to the Annuity Puzzle by providing annual benefits according to the insured's expected life expectancy, LTC benefits, and a death benefit.
Ramsay and Oguledo [2022]	Developing a new LTCI product for the US market that facilitates Medicaid assistance in paying a retiree's LTC expenses, addressing the shortcomings of current LTCI products.
Sherris and Wei [2021]	Developing a multi-state model that includes both functional disability and health status while also accounting for systematic trends and uncertainty, then pricing LTC products according to the results of the model.
Ventura-Marco et al. [2022]	Evaluating a joint LCA for couples based on an actuarial model focusing on costs, utility, and implications of transforming retirement benefit into an LCA.
Wan et al. [2021]	Deriving the optimal insurance portfolio for retirees comprising annuity, critical illness insurance, and LTCI given initial wealth and pension.

Paper	Main Focus
Xi [2022]	Addressing the high burden of caring for disabled and/or ill elderly in China due to the one-child policy's 4-2-1 family structure through a new type of LTCI product, family joint LTCI.

The majority of the included studies were published in or after 2021 (14 studies). Although there are countries from which more studies sourced data including the US [Hsieh et al., 2018, Moosavi and Najafabadi, 2022, Ramsay and Oguledo, 2020, 2022, Sherris and Wei, 2021] and China [Chen et al., 2022a, Cui, 2019, Ma et al., 2021, Wan et al., 2021, Xi, 2022], the studies were also conducted for other countries including Switzerland [Chen et al., 2022b], Canada [Li, 2019], Portugal [Elyseu, 2020, Esquível et al., 2021], Spain [De La Peña et al., 2021, 2022], Australia [Lim et al., 2019, Ventura-Marco et al., 2022], Indonesia [Pasaribu et al., 2019, Perdana et al., 2022], Slovenia [Bogataj et al., 2020], Kenya [Ndubai, 2018], and Germany [Ramsay and Oguledo, 2020].

Each study defined the specific conditions which activated the benefit payments to the LTCI policyholder. A number of studies based these conditions on activities of daily living (ADL), which are defined as fundamental skills for performing basic needs such as eating and dressing [Hsieh et al., 2018, Sherris and Wei, 2021, Moosavi and Najafabadi, 2022, Wan et al., 2021, Xi, 2022], or ADL combined with other measures including instrumental activities of daily living (IADL), which are defined as more complex tasks requiring cognitive abilities such as managing personal finance, and cognitive ability [Cui, 2019, Ramsay and Oguledo, 2020, 2022]. The most often used criteria for the activation of benefit payments were whether the insured is unable to perform three or more ADLs [Hsieh et al., 2018, Sherris and Wei, 2021, Wan et al., 2021, Xi, 2022]. For studies focused on critical illnesses, such as cancer or diabetes, the payments were made when the insured is diagnosed with the illness [Elyseu, 2020, Li, 2019, Ma et al., 2021, Pasaribu et al., 2019, Perdana et al., 2022] or when the actual cost of medical care is claimed [Atal et al., 2020, Moosavi and Najafabadi, 2022, Ndubai, 2018].

The selected articles delved into various types of LTCI products, with the most frequently studied type being the Life Care Annuity (LCA) [Chen et al., 2022b, Hsieh et al., 2018, Chen et al., 2022b, Ramsay and Oguledo, 2022, Sherris and Wei, 2021, Ventura-Marco et al., 2022], closely followed by stand-alone LTCI [Cui, 2019, Esquível et al., 2021, Lim et al., 2019, Sherris and Wei, 2021, Xi, 2022]. The stand-alone LTCI typically offers lifelong coverage, providing an annuity or lump-sum payment upon activation of the LTC trigger, and ceases upon the insured's death. The LCA combines the stand-alone LTCI with a life annuity that initiates immediate payments. The preference to examine stand-alone LTCI often stems from its simplicity, whereas the LCA is known for its benefit in mitigating adverse selection. Individuals at higher risk of LTC needs are more inclined to purchase LTCI. Additional variations include stand-alone LTCI with life insurance [Perdana et al., 2022], LCA with life insurance [Ahmad, 2022, Ramsay and Oguledo, 2020], LCA with critical care insurance [Wan et al., 2021], reverse mortgage with LTCI rider [Bogataj et al., 2020], defined benefit pension with LTCI rider [De La Peña et al., 2021, 2022], long-term health insurance [Atal et al., 2020, Moosavi and Najafabadi, 2022, Ndubai, 2018], critical care insurance with life insurance [Elyseu, 2020, Li, 2019, Pasaribu et al., 2019], care-dependent tontines - theoretical product [Chen et al., 2022a], and health insurance with premiums differentiated by risk [Ma et al., 2021].

In the majority of studies, insurance premiums were typically structured as a single upfront lump-sum payment for the entire policy duration. This method allowed researchers to simplify the analysis process and effectively demonstrate the contract's value with a single figure. Other premium payment methods used include recurrent fixed payments over a specified period [Bogataj et al., 2020, De La Peña et al., 2021], both the single upfront lump-sum payment and the recurrent fixed payments [Cui, 2019, Esquível et al., 2021, Ndubai, 2018], and recurrent increasing payments within a specified period [Atal et al., 2020].

There are several assumptions used for the pricing of LTCI that are similarly applied in more than one study. The interest rate was assumed to be fixed at 3% [Esquível et al., 2021, Lim et al., 2019, Sherris and Wei, 2021], 1.75% [Bogataj et al., 2020], 6% [Pasaribu et al., 2019], 2% [Wan et al., 2021], 3.5% as the discount rate [Atal et al., 2020], 1.5% as the risk discount rate or 5% as the force of interest [Li, 2019]. Several studies assumed the inflation rate to be fixed at 3% [Cui, 2019, Ndubai, 2018, Sherris and Wei, 2021]. Two studies applied a three-month waiting period which determines when the LTCI policy becomes effective upon being issued [Ramsay and Oguledo, 2022, Sherris and Wei, 2021]. Two studies which examined joint LTCI products for a couple both assumed independence of health state transitions between the couple [Ventura-Marco et al., 2022, Xi, 2022]. Several studies specifically assumed the amount of administrative cost [Bogataj et al., 2020], initial expense or acquisition cost [Elyseu, 2020, Ndubai, 2018], premium collection charge [Elyseu, 2020], management charge or fund charge [Elyseu, 2020, Hsieh et al., 2018, Moosavi and Najafabadi, 2022, Ndubai, 2018], technical fee [Elyseu, 2020], guaranteed fee [Hsieh et al., 2018, Moosavi and Najafabadi, 2022], and/or loading percentage [Wan et al., 2021].

Among the reviewed studies, only one explicitly considered solvency capital requirement (SCR) in the pricing of LTCI products. Chen et al. [2022a] incorporated the capital requirements of both the China Risk Oriented Solvency System (C-ROSS) and Solvency II as risk loadings in their analysis. The study found that LCA products required higher risk loadings compared to care dependent tontines (CDT). This incorporation of SCR highlights the additional financial safeguards necessary to ensure solvency and stability in LTCI products, emphasizing the importance of regulatory frameworks in the design and pricing of these insurance products.

The reviewed studies employed various types of data, primarily distinguishing between longitudinal and cross-sectional data sets, in pricing LTCI. Longitudinal data, which tracks the same individuals over time, were utilised in several studies, providing a robust foundation for modeling transitions in health status. For example, Atal et al. [2020] used a unique panel of claims data from one of the largest German private insurers, while Chen et al. [2022a], Cui [2019], and Wan et al. [2021] leveraged data from the China Health and Retirement Longitudinal Study (CHARLS). Other studies, such as Li [2019] and Sherris and Wei [2021], used longitudinal data sets from Statistics Canada and the Health and Retirement Study (HRS), respectively.

In contrast, some studies relied on cross-sectional data and/or parameters derived from previous research rather than raw data. Hsieh et al. [2018], for instance, used parameters estimated from the National Long-Term Care Study in the US to generate the transition rate matrix. Lim et al. [2019] provided the method to calculate health state transition matrices using cross-sectional data sets, exemplified with the 2007 National Survey of Mental Health and Well-being. In our previous study Park and Sherris [2023], we also approximated transition intensities using a series of cross-sectional data sets showing changes in the prevalence of functional disability and chronic illness.

There were also instances where data did not play a central role or limitations regarding data were discussed. For example, Ahmad [2022] did not use any data, as the pricing of LTCI was intended solely for illustrating the developed method rather than providing realistic premiums. Bogataj et al. [2020] provided a numerical example using data with limitations, highlighting the need for a comprehensive information system on LTC services that includes data on LTC users and applications for LTC endorsements across home care, assisted-living facilities, and nursing homes. They argued that such comprehensive data would enhance the knowledge of insurance companies and banks regarding cash flows associated with financing LTC expenditure and assisted-living facilities.

For the majority of the studies, a multi-state continuous-time Markov model of the health state transitions was used, mostly to estimate the life expectancy of the insured and time spent in each state. The exceptions include two studies that used a multi-state discrete-time Markov model [De La Peña et al., 2021, Ventura-Marco et al., 2022] and two studies that did not estimate health state transitions [Elyseu, 2020, Ndubai, 2018]. For the studies that used a multi-state Markov model, the number of states was, in descending order of frequency, four [Cui, 2019, Ma et al., 2021, Pasaribu et al., 2019, Wan et al., 2021, Xi, 2022], eight [Li, 2019, Perdana et al., 2022, Ramsay and Oguledo, 2020, 2022], three [Ahmad, 2022, Chen et al., 2022b,a, Lim et al., 2019], six [Bogataj et al., 2020, De La Peña et al., 2021, 2022, Ventura-Marco et al., 2022], seven [Atal et al., 2020, Hsieh et al., 2018, Moosavi and Najafabadi, 2022], and five [Esquível et al., 2021, Sherris and Wei, 2021]. These studies defined the states based on ADLs, a combination of ADLs, IADLs and cognitive impairment, core activity limitation (CAL) or specified illness conditions, aligning with the specified condition triggering the LTCI benefit payments. In several cases, the same definitions for the states are found in multiple studies. For example, all studies with a seven-state model used identical ADL-based states that originated from Pritchard [2006]. The formulation of the pricing model is heavily dependent on the type of LTCI product being evaluated and thus differs for each study. However, all pricing models have the same goal of computing the actuarial present value (APV) of the LTCI products.

We found several papers that have focused on improving and refining the methodological aspects of LTCI pricing methods. For instance, in decomposing the payment process into different product types within hybrid LTCI policies, Ahmad [2022] calculated covariance matrices and demonstrated their use in approximating joint safety margins through multivariate Central Limit Theorem (CLT) approximations. Moosavi and Najafabadi [2022] incorporated machine learning techniques in the development and evaluation of the proposed variable annuity product with guaranteed lifelong withdrawal options, long-term care coverage, and limited hospitalization coverage. By utilizing 12 clinical indicators, this study aimed to enhance the accuracy of the product's pricing and investment fund predictions. Furthermore, Ramsay and Oguledo [2020] and Ramsay and Oguledo [2022] integrated the quality of care initially chosen by individuals as a factor influencing transition intensities in their transition models. This methodological approach was applied in the development of new LTCI products for the US market, addressing the shortcomings of current LTCI products and facilitating Medicaid assistance.

Several papers examined the concept of risk pooling, where different risks from two or more insurance products of different nature are pooled together within a hybrid product. Ahmad [2022], which focused on pricing hybrid LTCI policies by decomposing the payment process into different product types, found a positive covariance between the present values of life annuity and disability annuity, which diminishes as the individual ages. They also identified a similar but negative covariance between the present values of life annuity and death benefit. Hsieh et al. [2018], which evaluated hybrid LTCI such as LCA to meet the growing demand for LTCI products in Taiwan, observed that LCA exhibits smaller variance compared to regular LTCI, indicating more stable risk management within hybrid products. Additionally, Sherris and Wei [2021], which developed a multi-state model including both functional disability and health status while accounting for systematic trends and uncertainty, reported that the presence of systematic uncertainty increases the premiums of LTC products by around 10% but slightly decreases the premiums for LCA. These findings highlight how different risks can interact within hybrid products, influencing both the premiums and the stability of such insurance offerings.

Among the reviewed papers, only a few examined trends related to changes in mortality and health status over time. De La Peña et al. [2021] found that excess mortality for dependent individuals is higher for later generations and females, indicating that mortality for dependent individuals decreases more slowly than general mortality. Additionally, Sherris and Wei [2021] reported significant improvements in mortality and disability, but also an increase in rates of transition to ill health status among the healthy population. This trend increases life expectancy, extends the time spent disabled and in ill health, and delays the onset of disability and/or ill health, ultimately reducing healthy life expectancy as a proportion of total life expectancy. Time trends were found to contribute to around 30% of life annuity and LCA premiums.

Several of the reviewed studies incorporated utility measures to evaluate the effectiveness and attractiveness of various LTCI products and policies. Atal et al. [2020] measured lifetime utility under each contract using the Consumption Certainty Equivalent (CE) and found that the welfare under the German Long-Term Health Insurance (GLTHI) design was 96% of what an income-dependent optimal contract could achieve, compensating for less consumption smoothing with reduced reclassification risk. Chen et al. [2022b] employed a power utility function considering the subjective discount rate, risk aversion, and state-specific utility, although it did not factor in the wealth level. In Chen et al.

[2022a], utility measures demonstrated that care dependent tontines (CDT) could result in lower gross premiums compared to LCA products while maintaining the same expected lifetime utility, with variations in attractiveness based on risk aversion levels. Ramsay and Oguledo [2020] utilised utility analysis to determine the optimal quality of care options and annuity benefit periods for different health groups, factoring in consumption, bequest utility, and survival utility. Similarly, Ramsay and Oguledo [2022] considered utility from consumption, Medicaid look-back penalties, and bequests, and found that it may be optimal for retirees to purchase average quality LTC rather than lower or higher quality care. Ventura-Marco et al. [2022] compared joint LCA and joint life annuities, finding that couples with varying ages and a risk aversion level of 2 preferred joint LCA. Lastly, Wan et al. [2021] estimated utility by accounting for risk aversion, time preference, and bequest motives to inform an optimal insurance portfolio for retirees.

Numerous studies provide valuable insights into the factors influencing the premium and cost of LTCI. Cui [2019] found that the average cost of LTC for the elderly varies significantly by gender and health conditions, with costs for women potentially increasing by up to 75% compared to men, and costs for unhealthy elderly more than doubling compared to healthy elderly. This study also showed that men have relatively lower disability rates but higher mortality rates. Similarly, Perdana et al. [2022] examined differentials in the likelihood of death due to cancer, stroke, and heart disease between males and females, finding higher premiums estimated for males. Sherris and Wei [2021] highlighted that transition rates to and from disability vary greatly depending on health status, with ill individuals more likely to become disabled and less likely to recover. This study found that ignoring health status can lead to overestimating LTC premiums for those in good health by around 10% and underestimating premiums for those in ill health by up to 15%. Females were found to have higher risks of becoming disabled, although there was no significant difference between males and females in recovery rates from disability. Females also have a longer life expectancy but spend more time disabled than males, though the proportion of life expectancy spent in a healthy state is still longer for females.

Insights from these studies also emphasise the importance of detailed reporting and personalised insurance options. Ventura-Marco et al. [2022], for the joint LCA, underscores the significance of reporting joint life expectancy and survivor life expectancy by health state, as this information enhances the transparency of actuarial factors and aids couples in understanding the need for LTC protection. They provided their results in a presentable way indicating that an average couple would need to reduce their regular annuity benefit amount by 20.62% or increase initial lump-sum premium by 25.98% to be entitled to LTC benefits on top of the life annuity. The study also found that lump-sum premiums for separately purchased LCAs are between 1.27% and 3.36% more expensive than joint LCAs. Wan et al. [2021] demonstrated that it is optimal for retirees in China to choose a lower level of medical services due to the high price of advanced medical services, with optimal insurance choices differing based on financial backgrounds. Lastly, Xi [2022] found that combined premiums for couples are lower than the net premiums obtained by simply adding up single gender group premiums.

3 Estimated multi-state Markov model of functional disability and illness

Park and Sherris [2023] estimate a health state transition model of both functional disability and chronic illness status for aged Australians using a series of Australian cross-sectional data. Illness, in addition to disability, are employed to define health states since illness is a significant factor in mortality rates as well as disability incidence and recovery, and it is an important factor in LTCI underwriting [Sherris and Wei, 2021, Brown and Warshawsky, 2013].

To capture the dynamics of how disability and illness of an individual aged 60 or above change over time, we used the five-state Markov model in Figure 2, proposed by Sherris and Wei [2021].

We define disability as needing assistance in two or more ADLs out of six including showering/ bathing, dressing, eating, toileting, incontinence and meal preparation, and illness as having the chronic conditions heart problems, diabetes, lung disease, and stroke. To model transitions between states, we use two models with a proportional hazard specification, a static model with covariates including age and sex, and a trend model captured with a time trend factor. The trend model is given in Equation (1) and the static model is the same but without the time trend.

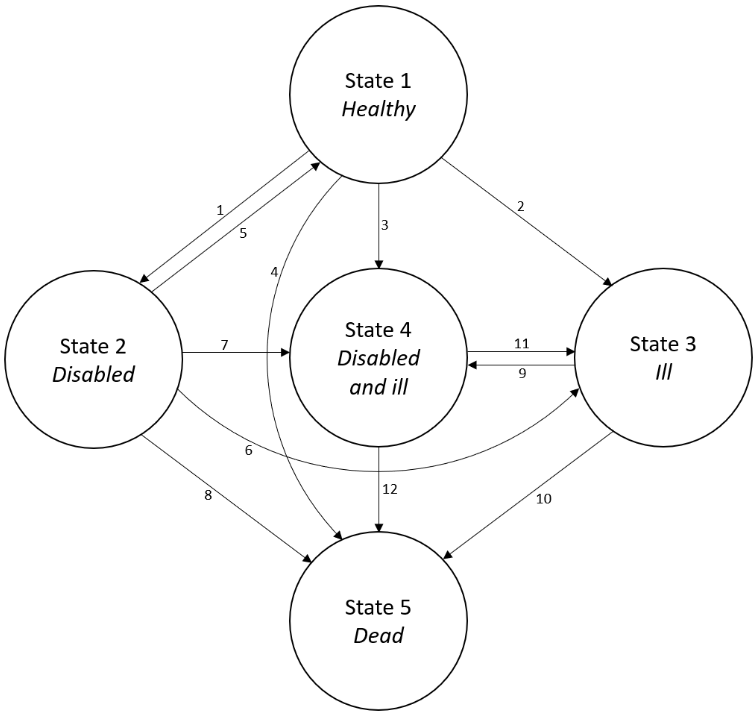

Figure 2: Five-state model

$$ln\{\lambda_{k,s}(t)\} = \beta_s + \gamma_s^{age} x_k(t) + \gamma_s^{female} F_k + \phi_s^{trend} t \tag{1}$$

where $\lambda_{k,s}(t)$ is transition rate at time t for transition type s and individual k, $x_k(t)$ is age of individual k at time t, F_k is an indicator variable for whether individual k is female, and β, γ and ϕ are regression coefficients to be estimated.

Estimation of the models was by numerically estimating the regression coefficients in the equations based on a goodness-of-fit criteria.

Ideally, the estimation of the model requires longitudinal data for the relevant covariates and transitions between states. However, in Australia, only cross-sectional data are available, as is often the case with medical and social science data [Davis et al., 2001].

Main data[2] utilised are from the Survey of Disability, Ageing and Carers, Australia (SDAC) 1998, SDAC 2003, SDAC 2009, SDAC 2013, SDAC 2015 and SDAC 2018, sourced from the Australian Bureau of Statistics. These cross-sectional SDAC data sets provide the prevalence of disability and illness by age and sex in different years. Following Park and Sherris [2023], we estimate the regression coefficients in the model that best explain observed changes in disability and illness prevalence across time based on different age cohorts. The estimated coefficients are given in Table 2 and Table 3 for the static and trend models, respectively.

While there are previous studies that also estimated a multi-state model of disability [Hariyanto

[2]Other data used are those from Estimated Resident Population By Single Year Of Age, Australia 2019 (ERP); and Deaths, Year of registration, Age at death, Age-specific death rates, Sex, States, Territories and Australia, both sourced from the Australian Bureau of Statistics.

Table 2: Estimated coefficients for static model

Transition type	β_s	γ_s^{age}	γ_s^{female}
1. Healthy-Disabled	-9.9141	0.0731	0.2982
2. Healthy-Ill	-4.8888	0.0311	-0.2226
3. Healthy-Disabled and ill	-12.3765	0.1058	0.0999
4. Healthy-Dead	-11.2459	0.0493	-0.7203
5. Disabled-Healthy	0.4314	-0.0206	-0.0369
6. Disabled-Ill	-1.9802	-0.0387	-0.1670
7. Disabled-Disabled and ill	-4.307	0.0125	0.1100
8. Disabled-Dead	-7.952	0.0670	-0.5199
9. Ill-Disabled and ill	-8.1472	0.0665	0.2055
10. Ill-Dead	-9.8289	0.0886	-0.4590
11. Disabled and ill-Ill	-0.0072	-0.0148	0.0027
12. Disabled and ill-Dead	-6.3056	0.0641	-0.4436

Table 3: Estimated coefficients for trend model

Transition type	β_s	γ_s^{age}	γ_s^{female}	ϕ_s^{trend}
1. Healthy-Disabled	-9.9146	0.0864	0.2996	-0.0503
2. Healthy-Ill	-4.8911	0.0287	-0.2244	0.0214
3. Healthy-Disabled and ill	-12.3769	0.1060	0.1002	-0.0596
4. Healthy-Dead	-11.2459	0.0511	-0.7205	-0.0722
5. Disabled-Healthy	0.4348	-0.0144	-0.0334	-0.0090
6. Disabled-Ill	-1.9804	-0.0485	-0.1670	-0.0255
7. Disabled-Disabled and ill	-4.3065	0.0148	0.1097	0.0046
8. Disabled-Dead	-7.9519	0.0833	-0.5209	-0.0120
9. Ill-Disabled and ill	-8.1506	0.0717	0.2015	-0.0367
10. Ill-Dead	-9.8309	0.0964	-0.4723	-0.0691
11. Disabled and ill-Ill	-0.0050	-0.0131	0.0019	0.0071
12. Disabled and ill-Dead	-6.3062	0.0630	-0.4465	-0.0127

et al., 2014, Leung, 2004], we aimed to use more data and rely less on assumptions. We used the data covering a much longer period (note that the other studies used the data for a single year or for two different years) and we employed a less restrictive set of assumptions in order to estimate the model.

4 Pricing Long Term Care Insurance Products

The pricing and analysis for the LTCI products are conducted in four steps: simulations of health transitions for retirees using the estimated model described in Section 3; estimation of the price based on expected present value of benefit payments and solvency capital requirement (SCR) based on Solvency II; measurement of an individual's utility to understand willingness to purchase the products; and demand analysis for the assumptions and utility. The assumptions were carefully developed in the Australian context and reflect assumptions from the literature review in Section 2. They are summarised in Table 4. Detailed procedures for each step are provided below.

4.1 Simulations of health transitions for retirees

Simulations, or micro-simulations, of health transitions for healthy and ill individuals entering retirement at age 65 in their later lives are produced using the transition matrix in Equation (2) with the estimated coefficients. Each simulation comprises 10,000 independent runs of monthly changes of health state until death or reaching the maximum age of 100 based on the probabilities in the transition matrix. The maximum age is required because of the difficulty in calibrating transition rates at very old ages due to limited exposure [Shao et al., 2017, Fong et al., 2015]. Eight sets of simulations were generated for the two genders, male and female, the two initial health conditions, healthy and ill, and the two model types, the static and trend models. The specifications and baseline assumptions of the simulations are given in Table 4.

$$
\begin{aligned}
M_{k,t} = e^{A_{k,t}} &= \begin{bmatrix} \mu_a^* & \mu_{k,1}(t) & \mu_{k,2}(t) & \mu_{k,3}(t) & \mu_{k,4}(t) \\ \mu_{k,5}(t) & \mu_b^* & \mu_{k,6}(t) & \mu_{k,7}(t) & \mu_{k,8}(t) \\ 0 & 0 & \mu_c^* & \mu_{k,9}(t) & \mu_{k,10}(t) \\ 0 & 0 & \mu_{k,11}(t) & \mu_d^* & \mu_{k,12}(t) \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}, \\
A_{k,t} &= \begin{bmatrix} \lambda_a^* & \lambda_{k,1}(t) & \lambda_{k,2}(t) & \lambda_{k,3}(t) & \lambda_{k,4}(t) \\ \lambda_{k,5}(t) & \lambda_b^* & \lambda_{k,6}(t) & \lambda_{k,7}(t) & \lambda_{k,8}(t) \\ 0 & 0 & \lambda_c^* & \lambda_{k,9}(t) & \lambda_{k,10}(t) \\ 0 & 0 & \lambda_{k,11}(t) & \lambda_d^* & \lambda_{k,12}(t) \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}
\end{aligned}
\tag{2}
$$

where λ_a^* to λ_d^* are computed to ensure each row sums to zero, and t is present in the trend model but not in the static model.

4.2 Pricing LTCI products

The pricing of LTCI products is determined as the expected present value (PV) of future benefit payments, plus the risk margin for SCR, plus the expense loading. The prices were calculated as a single upfront lump-sum premium payment to simplify the payment structures as assumed in the majority of studies in our literature review. The pricing as a single premium also makes comparisons between different LTCI products easier since LTCI policies are usually provided with single premium rather than periodic premiums, particularly those with an annuity component. The expected PV is the mean of the present values calculated for each set of monthly simulated health transitions path. The PV is calculated according to Equation (3), using the principle of equivalence.

$$
\begin{aligned}
PV\left(Cost_i\right) = &\sum_t \left(Benefit_{t,i}^{Disabled}(1+g)^{floor\left(\frac{t}{12}\right)}(1+i)^{-\frac{t}{12}}\right) \\
&+ \sum_t \left(Annuity_{t,i}(1+g)^{floor\left(\frac{t}{12}\right)}(1+i)^{-\frac{t}{12}}\right)
\end{aligned}
\tag{3}
$$

where $Benefit^{Disabled}$ is the disability benefit, $Annuity$ is the annuity payment, t is time since retirement in years, g is the payments growth rate, and i is the pricing interest rate.

The disability benefit is payable when the insured is in *Disabled* or *Disabled and ill* state, the disability benefit waiting period has passed, and the lifetime limit for the disability benefit payments has not yet been reached. The annuity payment is payable when the insured is not in *Dead* state for the products that pay annuities along with the disability benefits (e.g., LCA). More descriptions and baseline values of each component of the estimation method are shown in Table 4.

The baseline disability benefit payment amount and lifetime limit are set at \$1,500 per month and \$76,000, respectively, considering the current level of co-payment requirement in the Australian public aged care system [Australian Government Department of Health and Aged Care, 2023]. The payment amount corresponds to the annual co-payment cap of \$6,341 - \$12,683 when using "Home care" service (based on the individual's income), and \$31,707 when using "Residential care" service. The lifetime limit corresponds to the lifetime cap of \$76,097 when using "Home care" or "Residential care" applied to every service recipient. Other assumptions including disability benefit waiting period, growth (or inflation) rate and interest rate were set according to the studies that used these parameters as shown in Section 2.

The risk margin for SCR has been estimated by considering the impact of mortality and disability shocks specified in Solvency II [Shao et al., 2017, Insurance and Authority, 2011]. The mortality shock is given by applying a permanent 20% decrease in mortality rates. The disability shock applies an increase in disability rates of 35% for the first year followed by a permanent increase of 30% for the remaining life, and a permanent decrease of 25% in disability recovery rates. Assuming independence between mortality and disability shocks, the risk margin, RM - the cost to manage additional fund requirements when the shocks occur - is estimated according to the Equation (4).

$$RM = \sum_t c \frac{\sqrt{(SCR_t^M)^2 + (SCR_t^D)^2}}{(1+i)^t} \tag{4}$$

where c is cost of capital, SCR_t^M is additional fund required at t if the mortality shock occurs at t, and SCR_t^D is additional fund required at t if the disability shock occurs at t.

The additional fund requirements (i.e., SCR_t^M and SCR_t^D) are the differences between the expected PV of future benefits at time t using the sets of original simulations above (i.e., best-estimate PV), and those using new sets of simulations with modified transition rates given a shock at time t. The risk margin is computed to represent the "fair value amount that another insurer would require to take over the liabilities" [Shao et al., 2017], assuming independence between the mortality shock and disability shock.

4.3 Measurement of utility

Given the estimated premiums, we have measured an individual's utility gain if the LTCI product is purchased compared to not purchased, at age 65, using a numerical approximation of the recursive utility function as specified by Equation (5). The function estimates the utility at the time of retirement recursively based on consumption after retirement and bequest from remaining wealth at death.

The recursive utility function is known as the Epstein-Zin model which is a generalised form of the power utility model allowing for the separate specification of the two parameters of an individual's preference that differ by nature: the risk aversion and the elasticity of inter-temporal substitution [Epstein and Zin, 1989, 1991, Weil, 1989, Xu et al., 2023]. The risk aversion measures an individual's willingness to equalise outcomes across different states in the future, while the elasticity of inter-temporal substitution measures an individual's willingness to substitute current consumption for future consumption.

Utility estimation involves parameters generally expressed in annual terms including the subjective discount rate and elasticity of inter-temporal substitution. To do this we have annualised the projections of consumption and wealth initially computed on monthly simulation paths.

$$\begin{aligned} U_t|S_t &= \left\{(1-(1+\beta)^{-1})(C_t|S_t)^{1-\rho} + (1+\beta)^{-1}(MU_{t+1})^{\frac{1}{\theta}}\right\}^{\frac{1}{1-\rho}}, \\ MU_{t+1} &= \left[\frac{\sum_i (U_{t+1,i}|S_t)^{1-\gamma} + \sum_j b^\gamma (W_{t+1,j}|S_t)^{1-\gamma}}{N}\right], \\ \theta &= \frac{1-\gamma}{1-\rho}, \rho = \frac{1}{\phi} \end{aligned} \tag{5}$$

where U_t is the utility at time t, S_t is a specified series of health transitions to t, C_t is consumption (exclusive of aged care cost) at t, W_t is remaining wealth at t, MU_{t+1} is mean utility one year later than t, i's and j's are the cases in the simulation set for S_t and the state in the next year being not *Dead* and *Dead*, respectively, N is the sum of the numbers of i's and j's, β is subjective annual discount rate, ϕ is elasticity of inter-temporal substitution, b is strength of bequest motives, γ is relative risk aversion parameter.

The wealth and consumption are determined by several factors. The remaining wealth at a given time is the value of positive wealth contributions to that time minus the value of negative wealth contributions to that time where the values are estimated by accumulating at the interest rate, i. The positive contributions include initial wealth, income, and benefit payment from the respective

LTCI product if purchased. The negative contributions include the upfront LTCI premium payment, consumption as well as the aged care cost if the individual is in states including *Disabled* and *Disabled and ill*. We set the minimum wealth to represent the portion of wealth not to be liquidated until death. When the consumption at a given time cannot be met due to the available wealth being less than the amount of consumption, the consumption is adjusted to equal the amount of available wealth. When the available wealth at a given time is not sufficient to fulfill the required aged care cost, we assumed that the aged care shortage is covered by means other than the use of the individual's wealth (e.g., family or government support).

The baseline consumption amount is set at $5,000 per month to reflect the comfortable consumption level for Australian retirees according to the ASFA retirement standard[3]. The income in retirement is set at $1,700 per month, approximately equal to the current aged pension payment in Australia. The aged care cost of $1,500 per month reflects the current level of co-payment requirement in the Australian public aged care system [Australian Government Department of Health and Aged Care, 2023] in the same way as how we set the LTCI disability benefit payment amount. Summarised descriptions and baseline values of each component of the utility estimation are shown in Table 4.

We employ a simplified approach for projecting an individual's consumption and wealth accumulation, recognising that the actual process is more complex. For instance, our assumptions imply a fixed pension payment and aged care co-payment but these actual payments are determined by asset and income tests. For instance, a single homeowner has a reduced pension if their asset value exceeds $301,750, where the assets include everything that can be turned into cash such as real estate other than the principal home, superannuation investment and other financial investments[4]. We also assume all assets are liquid. Our aim is to capture the impact of LTCI rather than the detailed institutional requirements of the Australian age pension and aged care system.

4.4 Demand analysis

Demand analysis was performed to assess the impact of different key factors and assumptions used in the utility analysis. We show the variability in utility arising from changes in values for a key factor or assumption in our model. While all factors and assumptions in Table 4 are variables in our model, we focused our analysis on those that are of most interest in practice.

[3] https://www.superannuation.asn.au/resources/retirement-standard
[4] https://www.servicesaustralia.gov.au/who-can-get-age-pension?context=22526

Table 4: Factors and assumptions for pricing LTCI products

Factor or assumption	Description	Set value or baseline value
For simulation of health transitions		
Age	Age at retirement	65
Max age	Maximum age for the simulation	100
Retirement year	Year of retirement which applies to the trend model. It is assumed that retirement is at the beginning of the year.	2018
Initial state	Health state at retirement	*Healthy* or *ill*
n	Number of simulation paths to generate	10,000
For interest and growth rates		
Interest rate, i	Annual effective interest rate to calculate present values and future values	3%
Value growth rate, g	Annual growth rate for the payments, wealth and consumption for inflation adjustments	3%
For pricing LTCI product		
Disability benefit	Monthly disability benefit payment from LTCI	\$1,500
Waiting period	Waiting period to be eligible for the disability benefit payments since the purchase of LTCI	3 months
Lifetime limit	Maximum accumulation of disability benefit payments over the life of LTCI	\$76,000
Annuity payment	Monthly annuity payment for annuitants if applicable	\$1,000
Cost of capital, c	Annual effective cost of capital applied to the calculation of solvency capital requirement.	6%
Expense loading	Percentage loading added to the calculated value combining expected present value of benefit payments and the risk margin.	10%
Mortality shock	A permanent decrease in mortality rates at all ages	20%
Disability rate shock	An increase of A% in disability rates at all ages for the first year, a permanent increase of B% at all ages for the following years and a permanent decrease of C% in recovery rates at all ages.	A=35%, B=30%, and C=25%
For utility measure		
β	Subjective annual discount rate	3%
ϕ	Elasticity of annual inter-temporal substitution	0.5
b	Strength of bequest motives	2
γ	Relative risk aversion parameter	3
Income	Monthly income in retirement (e.g., pension)	\$1,700
Aged care cost	Monthly spending for disability if applicable	\$1,500
Initial wealth	Wealth at retirement	\$1,000,000
Minimum wealth	Minimum wealth	\$50,000
Consumption, C	Monthly consumption exclusive of aged care cost.	\$5,000

5 Results and findings

5.1 Simulation

The sets of health transition paths have been generated for male and female retirees based on the static and trend models using simulations. The profiles of the generated paths are shown in Table 5 for healthy retirees and in Table 6 for chronically ill retirees by showing the average time spent in different states in retirement. Table 7 shows the average result combining healthy and ill individuals based on the proportions of healthy and ill Australians in 2018.

Notable findings include that the average remaining life is longer in the trend model compared to the static model, primarily due to the longer time spent in *Ill* rather than *Healthy*, *Disabled* or *Disabled and ill*. For healthy retirees, the time spent in *Disabled* is even slightly shorter with the trend considered[5]. Combining with the finding that females spend more time in all states on average compared to males, with the largest proportional gap in the average time spent with disability, the trend analysis shows increasing life expectancy with a worsening health condition where this effect is amplified for females with longer life expectancy compared to males. This finding aligns with other studies affirming that, in Australia as in other developed countries, women tend to live longer than men but experience higher rates of disability and poor health [Nusselder et al., 2019, Cui, 2019, Sherris, 2021].

Table 5: Averaged time spent in different states in years for healthy retirees aged 65

	Static model		Trend model	
	Male	Female	Male	Female
Remaining life	19.6 (7.4)	22.3 (7.7)	24.3 (8.6)	26.9 (8.2)
Time spent in each state				
Healthy	10.6 (7.7)	12.0 (8.3)	9.9 (7.5)	11.5 (8.2)
Disabled	0.3 (1.2)	0.5 (1.6)	0.2 (0.7)	0.3 (1.1)
Ill	7.8 (6.8)	8.2 (7.4)	13.2 (9.1)	13.6 (9.2)
Disabled and ill	1.0 (1.6)	1.6 (2.1)	1.0 (1.5)	1.6 (2.1)
Time spent in combined state				
Non-ill	10.9 (8)	12.5 (8.8)	10.1 (7.6)	11.8 (8.5)
Non-disabled	18.4 (7.2)	20.2 (7.4)	23.1 (8.6)	25.1 (8.1)

Note: Standard deviations are in parentheses.

Table 6: Averaged time spent in different states in years for ill retirees aged 65

	Static model		Trend model	
	Male	Female	Male	Female
Remaining life	15.1 (8)	18.0 (8.6)	21.2 (10.0)	24.1 (10.0)
Time spent in each state				
Healthy	0 (0)	0 (0)	0 (0)	0 (0)
Disabled	0 (0)	0 (0)	0 (0)	0 (0)
Ill	14.1 (7.7)	16.1 (8)	20.0 (9.7)	22.1 (9.5)
Disabled and ill	1.0 (1.8)	1.9 (2.5)	1.2 (1.8)	2.0 (2.4)
Time spent in combined state				
Non-ill	0 (0)	0 (0)	0 (0)	0 (0)
Non-disabled	14.1 (7.7)	16.1 (8)	20.0 (9.7)	22.1 (9.5)

Note 1: Standard deviations are in parentheses.
Note 2: Time spent in *Healthy* and *Disabled* (i.e., non-ill) states is zero, as our model assumes that chronic illness is not recoverable.

[5]The short time spent with disability in the trend model compared to the static model is discussed in Section 6.

Table 7: Averaged time spent in different states in years for retirees aged 65

	Static model		Trend model	
	Male	Female	Male	Female
Remaining life	17.2 (8.1)	20.3 (8.4)	22.8 (9.6)	25.6 (9.2)
Time spent in each state				
Healthy	5.0 (7.5)	6.5 (8.5)	4.6 (7.1)	6.1 (8.3)
Disabled	0.1 (0.8)	0.3 (1.2)	0.1 (0.5)	0.2 (0.7)
Ill	11 (7.8)	11.8 (8.5)	17 (10)	17.5 (10.3)
Disabled and ill	1.0 (1.7)	1.7 (2.3)	1.1 (1.7)	1.7 (2.2)
Time spent in combined state				
Non-ill	5.2 (7.8)	6.8 (9.0)	4.7 (7.2)	6.3 (8.5)
Non-disabled	16 (7.8)	18.3 (7.9)	21.6 (9.4)	23.7 (8.9)

Note: Standard deviations are in parentheses.

Figure 3 plots survival curves showing the proportions of alive individuals from the different simulation sets. We can see that the proportion of surviving individuals is higher using the trend model than the static model regardless of the gender of individuals, and always higher for females and males. A comparison between the plots between healthy and ill retirees provides that the illness clearly lowers the survival proportions.

Figure 4 shows the proportion of disabled individuals (i.e., those in either *Disabled* or *Disabled and ill*). Note that the curves are not smooth due to the randomness within the simulation process where the proportions are impacted both by death and disability incidence in opposite directions. We can see that the proportions are higher for initially ill individuals at relatively younger ages due to their higher chance of being disabled. However, at older ages, the proportions are higher for initially healthy individuals due to their lower mortality with generally better health conditions.

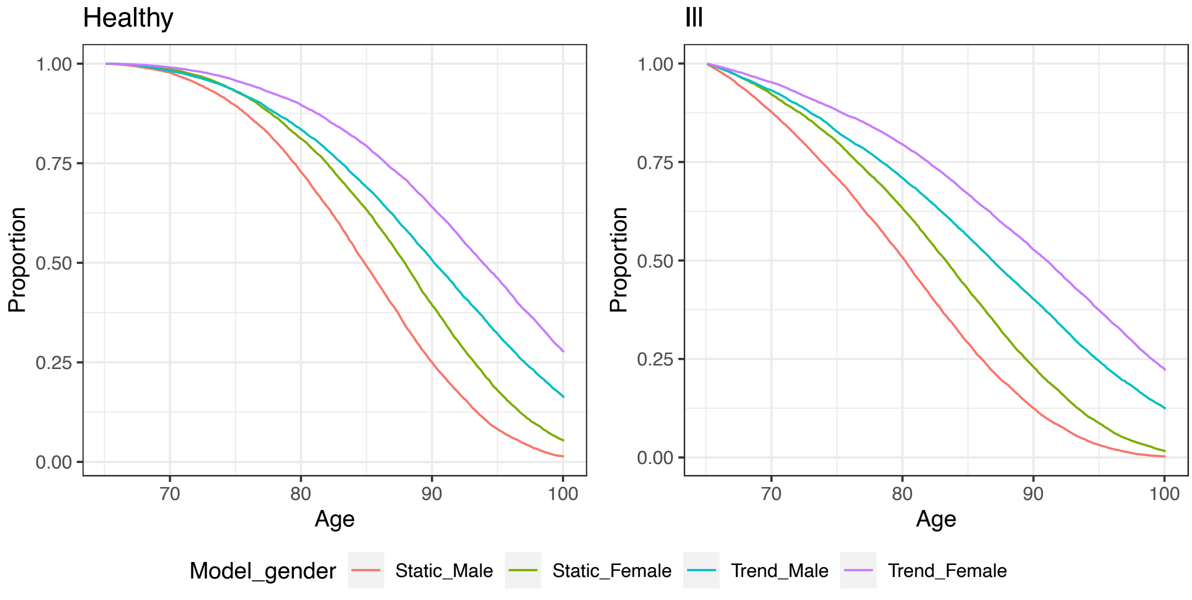

Figure 3: Survival curve

5.2 Estimated LTCI premiums

Of the LTCI products with different designs, we evaluated the stand-alone LTCI and life care annuity (LCA), the two types most frequently studied in literature to ensure comparability. The stand-alone LTCI pays monthly disability benefit to the policyholders who become functionally disabled and

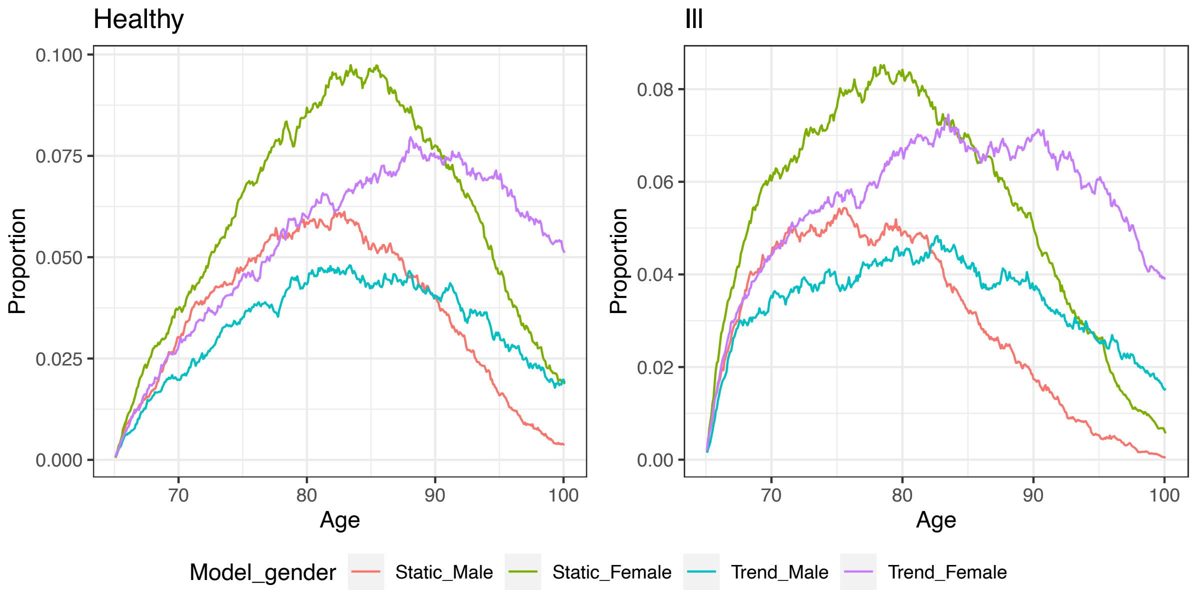

Figure 4: Proportion of disabled individuals

needs care. The waiting period is required to be eligible for the benefit payments, and the payment discontinues if the total accumulated payments reach the lifetime limit. The LCA adds a life annuity component that pays a monthly annuity payment for alive policyholders in addition to the stand-alone LTCI. Compared to separate purchases of the stand-alone LTCI and an annuity product, LCA is known to mitigate concerns of adverse selection by pooling different risks and also help reduce the risk from systematic uncertainties [Sherris and Wei, 2021].

The estimated premiums comprising different cost components of stand-alone LTCI and LCA for healthy and ill retirees are shown in Table 8, 9, 10 and 11. In addition, the proportions of each component are shown in Figure 5. For instance, Table 8 provides that the premium of stand-alone LTCI for a healthy male is estimated at $26,224 using the static model comprising the expected PV of disability benefit of $19,421, the risk margin of $4,419, and the expense loading of $2,384. The findings are summarised as follows.

- For the stand-alone LTCI, the premium for females is 54% to 60% and 42% to 49% greater than males in the static and trend models, respectively.
- For the stand-alone LTCI, the premium based on the trend model is 6% to 19% and -3% to 11% greater than the static model for males and females, respectively.
- For the stand-alone LTCI, the premium for ill retirees is 6% to 17% and 1% to 14% less than healthy retirees for males and females, respectively.
- For the LCA, the premium for females is 16% to 23% and 12% to 15% greater than males in the static and trend models, respectively.
- For the LCA, the premium based on the trend model is 21% to 37% and 16% to 29% greater than the static model for males and females, respectively.
- For the LCA, the premium for ill retirees is 11% to 22% and 9% to 18% less than healthy retirees for males and females, respectively.
- The results highlight significance of the need to differentiate the premiums between males and females, and healthy and ill individuals at the time of retirement, and the importance of incorporating the trend for the model.
- Estimated stand-alone LTCI premiums comprised 14% to 24% of the risk margin, while LCA premiums ranged from 5% to 7% of the risk margin.

There are two reasons why the risk margin percentage is lower for the LCA compared to the stand-alone LTCI. First, the assumed magnitude of the mortality shock (i.e., a permanent decrease in mortality rates) is less than that of the disability shock. The risk margin for the LCA is primarily influenced by the mortality shock considering the portion of the annuity component, whereas for stand-alone LTCI, it is affected heavily by both shocks. Second, we anticipate opposite effects from the two shocks in the LCA's risk margin relating to the annuity component. This is because the cost of an annuity would increase with the mortality shock, while it would decrease with the disability shock, where disabled individuals have a slightly higher mortality.

Table 8: Stand-alone LTCI premium for healthy retirees aged 65

	Static model		Trend model	
	Male	Female	Male	Female
Premium	26,224	40,433	27,672	39,264
Premium component				
Disability benefit	19,421	30,050	18,619	28,100
Risk margin	4,419	6,707	6,537	7,595
Expense loading	2,384	3,676	2,516	3,569

Note: Standard deviations are in parentheses.

Table 9: LCA premium for healthy retirees aged 65

	Static model		Trend model	
	Male	Female	Male	Female
Premium	297,877	345,862	360,606	402,897
Premium component				
Disability benefit	19,421	30,050	18,619	28,100
Annuity	233,530	265,243	288,399	319,692
Risk margin	17,846	19,128	20,805	18,478
Expense loading	27,080	31,442	32,782	36,627

Note: Standard deviations are in parentheses.

Table 10: Stand-alone LTCI premium for ill retirees aged 65

	Static model		Trend model	
	Male	Female	Male	Female
Premium	21,875	34,920	26,114	38,823
Premium component				
Disability benefit	16,406	26,745	18,904	28,308
Risk margin	3,480	5,000	4,836	6,986
Expense loading	1,989	3,175	2,374	3,529

Note: Standard deviations are in parentheses.

Figure 6 plots the SCR at each time t. While all curves show similar decreasing patterns with t, there is no clear ordering by gender and model type for the LCA, compared to the stand-alone LTCI. This primarily highlights the impact of the opposite relative impacts of the mortality shocks[6] at younger ages and older ages. For instance, as females have a longer life expectancy, the shock affects the cost in later years in females more than males. However, at younger ages (where mortality rates are already low even without the shock), the shock of lowering mortality rates impacts the LCA cost for males more than females. This is because males with generally higher mortality have more room for a reduction in deaths than females.

The estimated costs are comparable to the results in Sherris and Wei [2021] which used a similar set of assumptions but employed the US data for a retiree in 2012. The study also used five-state

[6]The mortality rate is the main factor affecting LCA cost.

Table 11: LCA premium for ill retirees aged 65

	Static model		Trend model	
	Male	Female	Male	Female
Premium	232,633	285,170	319,616	367,255
Premium component				
Disability benefit	16,406	26,745	18,904	28,308
Annuity	180,154	213,945	251,844	285,922
Risk margin	14,925	18,555	19,811	19,639
Expense loading	21,148	25,925	29,056	33,387

Note: Standard deviations are in parentheses.

static and trend models of disability and illness[7], and several assumptions the same as ours for the initial and maximum ages for simulations, waiting period for the LTCI, and interest rate. Note that there are also differences from ours including the monthly disability benefit payment set at $3,000, and the absence of a lifetime limit on the payments. This is because we considered the product design for the Australian public LTC system. It is important to note that they did not consider the risk margin and expense loading, which are significant aspects of pricing these products and potential impacts on demand.

Their results with the protection of 3% annual inflation (i.e., the annual 3% growth of benefit payments, the baseline assumption in our analysis) show 71% to 80% higher costs of the stand-alone LTCI for females than males, compared to 42% to 60% in our study. The corresponding percentage range for the LCA is 21% to 28% in their study, compared to 12% to 23% in ours. Their trend model computed 8% to 18% higher costs of the stand-alone LTCI and 18% to 31% higher costs of the LCA than the static model. These are comparable to our results of -3% to 19% higher costs of the stand-alone LTCI and 16% to 37% higher costs of the LCA. They estimated 2% to 16% higher costs of the stand-alone LTCI and 6% to 10% lower costs of the LCA for ill compared to healthy individuals. For this comparison, we estimated 1% to 17% lower costs of the stand-alone LTCI and 9% to 22% lower costs of the LCA.

The outlined differences in the results are attributable to different transition parameters estimated for Australians and Americans, different years of retirement, and several different settings including the disability benefit payment amount and lifetime limit. In particular, the significantly different results regarding the cost of the stand-alone LTCI for ill individuals compared to healthy ones are attributable to the setting of the lifetime limit we use for the disability benefit payment. This is because the chance of accumulating a higher benefit by ill individuals due to their higher likelihood of disablement is limited by the lifetime limit.

5.3 Utility Analysis

To quantify the potential demand for LTCI, we estimated the utility when a LTCI product is purchased compared with the utility when a LTC product is not purchased. We use the estimated premium from the baseline assumptions and settings, as shown in Table 12 to provide an initial analysis. We then extended the analysis to a wide range of circumstances including differing levels of expense loading, risk aversion, wealth and bequest motives in Section 5.4. The comparison between the utility with and without for each type of model, gender and product shows the extent to which an individual would be willing to purchase the product. For instance, based on the static model, a healthy male retiree would be willing to purchase a stand-alone LTCI with higher utility when it is purchased (88,025) compared to when it is not purchased (87,048). There was an increase in utility from the purchase of the LTCI products in all cases for ill retirees and in the majority of cases for healthy retirees. The exceptions are where the expense loading and risk margin included in the

[7]The study also used a frailty model in addition to the static and trend models which additionally incorporates a factor representing systematic uncertainty.

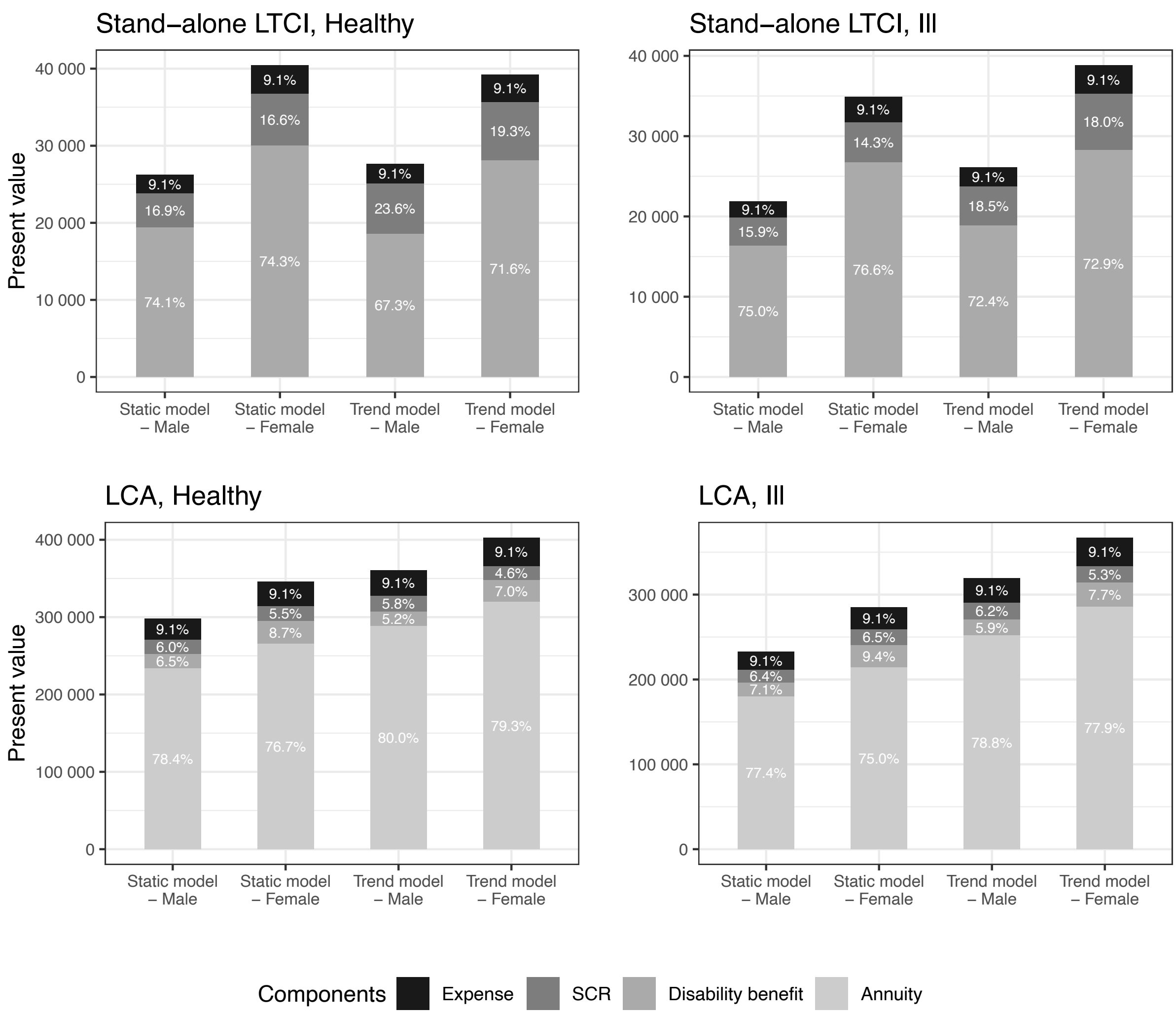

Figure 5: Premium components

premium exceed the value of insuring as captured by the utility.

5.4 Demand analysis

We conduct a demand analysis based on the gain in utility from purchasing an LTCI product under varying assumptions, such as expense loading, risk aversion, initial wealth at retirement, and bequest motives. Additionally, we consider scenarios with "additional consumption", where the monthly consumption is added by an amount proportional to the wealth level at any given time. The gain in utility is measured as the absolute increase in utility achieved by purchasing an LTCI product. Our focus is on comparing the utility gains across different assumptions and settings, rather than assessing the numerical values of the gains.

Figure 7 plots the gain in utility for different levels of the expense loading. This highlights the impact of expense loading on potential demand. All curves are downward sloping as expected, but differ in slope and the maximum expense loading to ensure the gain in utility is positive. For instance, the trend model estimates the gain in utility for the LCA in ill population to be around zero at the baseline expense loading of 10%, but estimates a positive gain when the expense loading is lower. We observe that the expense loading (as percentage of the risk-adjusted expected PV of benefit payments) needs to be relatively low in order for the LCA to provide a gain in utility, unlike the stand-alone LTCI. This is largely because of the larger absolute dollar amount of the expected LCA

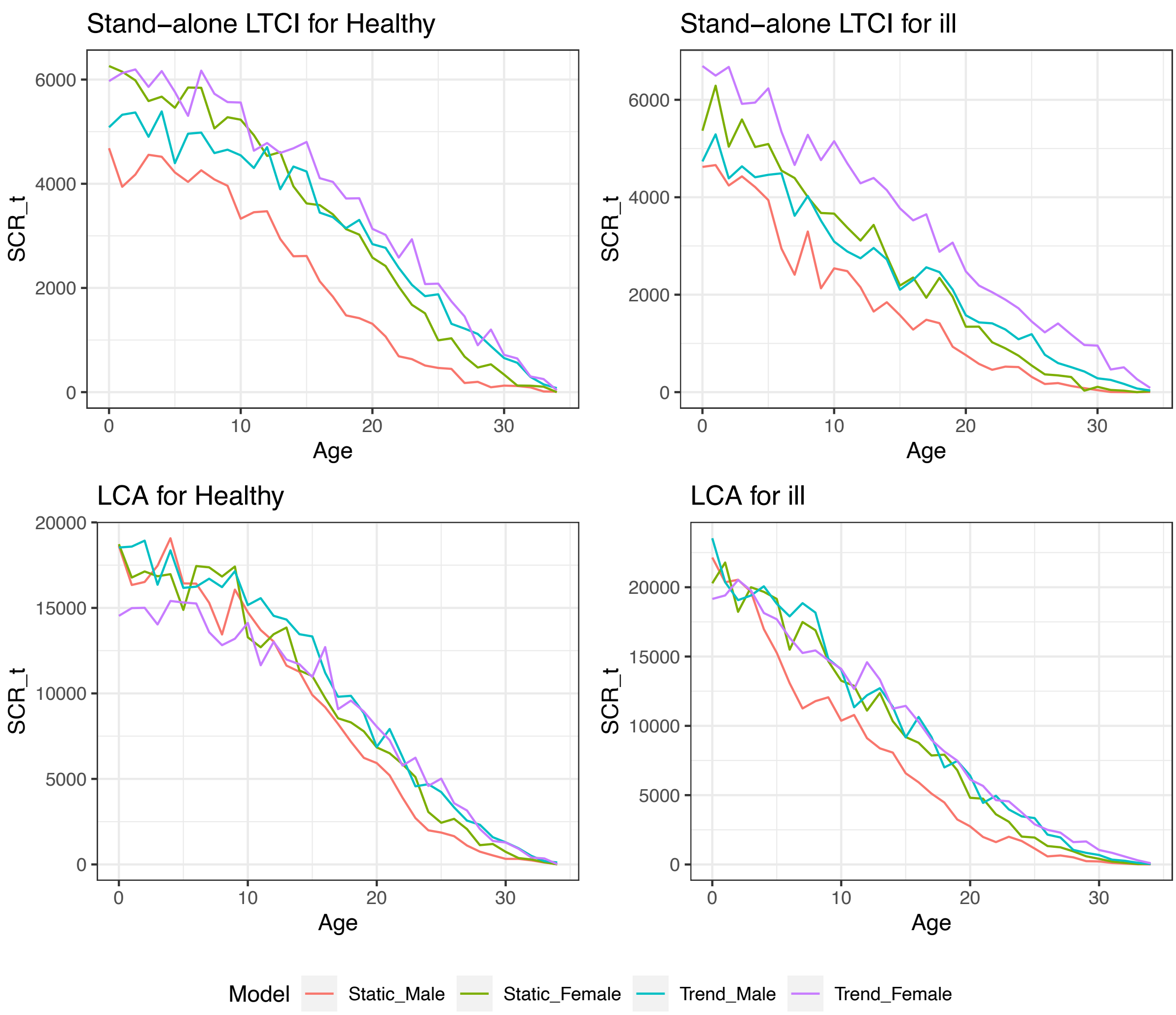

Figure 6: Solvency capital requirement based shock applied at t (SCR_t)

benefit payment compared to the stand-alone LTCI, so that the expense loading is a larger absolute dollar amount with a corresponding larger utility impact. Note that we can also find the certainty equivalent LTCI premiums that equate the utilities with and without the purchase of each product, by identifying the level of expense loading that provides zero gain in utility.

Figure 8 plots the utility gain for different levels of risk aversion, showing increasing gain for higher levels of relative risk aversion in all cases. This analysis highlights the general benefits of insurance for different groups of individuals with potentially different risk-related behaviours in understanding market demand. There are different thresholds of risk aversion levels that result in a positive utility gain. For the trend model, purchasing the stand-alone LTCI always yields a non-negative utility gain within the range of risk aversion levels above two. However, for the LCA, a risk aversion level of around four is required to achieve a non-negative gain for healthy females, a level of five for healthy males, and a level of three for ill males and females. The requirement of a higher risk aversion for the LCA compared to the stand-alone LTCI to show utility gains once again reflects the impact of the larger absolute premium for the LCA.

For the static model cases, plots for the stand-alone LTCI show similar patterns to the trend model cases, except that males should have a risk aversion level of around three to achieve a positive utility gain. This case reflects the relatively small risk of disability in this group of individuals. For the LCA, the positive utility gain is achieved at a much lower risk aversion level compared to the trend model cases. For instance, healthy males with a risk aversion level of three exhibit a positive

Table 12: Utility for healthy and ill retirees aged 65

	Static model		Trend model	
	Male	Female	Male	Female
Stand-alone LTCI, *Healthy*	88,025 (87,048)	79,949 (77,649)	75,498 (74,461)	71,737 (69,020)
LCA, *Healthy*	87,245 (87,048)	76,091 (77,649)	71,479 (74,461)	67,581 (69,020)
Stand-alone LTCI, *Ill*	104,705 (104,456)	92,441 (90,345)	81,297 (79,904)	75,990 (73,215)
LCA, *Ill*	110,678 (99,867)	91,380 (86,642)	78,255 (77,709)	71,569 (71,390)

Note: Utility when LTCI product is not purchased is in parentheses.

utility gain.

The demand analysis for the utility gain by initial wealth level, shown in Figure 9 is important since individuals have a high level of heterogeneity in wealth at retirement. For wealth levels from 0.6 million to 2.0 million dollars, the gain from the stand-alone LTCI decreases with initial wealth level, but remains positive up to around 1.3 million dollars of wealth. This is because the stand-alone LTCI is designed to only cover the co-payment requirement with a lifetime limit, and wealthier individuals are expected to be able to self-insure these payments without any detrimental impact on their consumption or bequest. Having LTCI for these aged care co-payments is of more value to lower-wealth individuals.

For the LCA, the utility gain peaks at a level of wealth and this level varies for the different model assumptions. For instance, healthy and ill males with around 1.2 million dollars of initial wealth have the greatest utility gain compared to the lower or higher wealth levels using the static model without trend improvements. If the trend model is used instead, the peak is at around 1.4 million dollars. The increasing utility up to the peak is explained by the higher absolute LCA premium, especially the significantly larger absolute amount of the risk margin, requiring higher levels of initial wealth. For less wealthy individuals purchasing the LCA consumes proportionally more of their initial wealth, which reduces future consumption and bequest when not living up to old ages or not being disabled. This increasing pattern is also found by Brown and Finkelstein [2008], where they found higher willingness to pay for LTCI for wealthier individuals. In their study, the willingness was positive for those with a wealth percentile above around 50% to 60%, depending on types of LTCI. The decreasing utility after the peak can again be explained by the wealthy individual's ability to self-insure the payment amounts based on their higher level of wealth. Wealth levels are a very significant factor in determining demand for LTCI purchase.

Considering the utility gain from the bequest motive parameter is important since this is expected to have a differing impact with the stand-alone LTCI and LCA. The baseline assumption for the bequest motives we used initially was taken from Xu et al. [2023]. We find that the utility gain generally decreases as the bequest motives increase in all our cases. While LTCI products provide effective financial protection for consumption for disabled or long-lived individuals, the stabilisation of consumption via insurance costs money and hence reduces the remaining bequest amount. For the stand-alone LTCI, despite the decreasing pattern, the gain in utility stays positive in most cases. However, the LCA's gain in utility is only positive for bequest motives less than 1.5 - 2 for healthy individuals, and less than 2 - 5 for ill individuals (except for an ill male on the static model which presents positive gain for the entire range). Higher levels of bequest motive result in reductions in utility, ultimately negative, when purchasing an LCA, reflecting the impact of the heavy life annuity component on the bequest.

To further investigate the effect of the bequest motives on utility, we consider different assumed levels of monthly consumption and the utility impact of the products for different levels of bequest motives, as shown by Figure 11, 12, 13, and 14. This analysis was conducted using the consumption levels ranging from $2,000 to $8,000 and for bequest motives parameter values of 0, 2, 4 and 8. We observe fluctuating curves in many cases because the changes in utility by consumption show different patterns when LTCI is purchased and when it is not purchased. For example, for the static model case on a healthy male with the bequest motive of four, the utility with no purchase of LCA peaks at the consumption level of around $3,000, but the utility with the purchase of LCA peaks at around $4,000[8].

Despite significant fluctuations, some general patterns are found. The gain in utility from a purchase of the stand-alone LTCI increases with the consumption level, and the consumption level to achieve a positive gain in utility is higher for the higher level of bequest motives. In contrast, in many cases for LCA, the gain in utility peaks at a certain level of consumption typically at around $4,000. These heterogeneity in the results are accounted for by differing impacts of the consumption level on usefulness of the LTCI and on bequests. While the higher level of consumption tends to make the LTCI more useful due to the higher chance of not being able to meet their future consumption needs, that higher level of consumption also makes the bequest motives less relevant by depleting wealth more prior to death.

Figure 15 shows the change in utility gain as consumption varies for our initial assumptions. Here, we define a new parameter, "additional consumption" which is the proportion to the wealth level at any time by which extra monthly consumption is to be spent, on top of the baseline consumption. We consider this parameter for more realistic consumption patterns. However, we do not see any impact from the differing consumption pattern. This shows that our demand analysis is robust without consideration of this additional consumption parameter.

[8]Note that these raw utility measures are not presented. Only the gains in utility are presented.

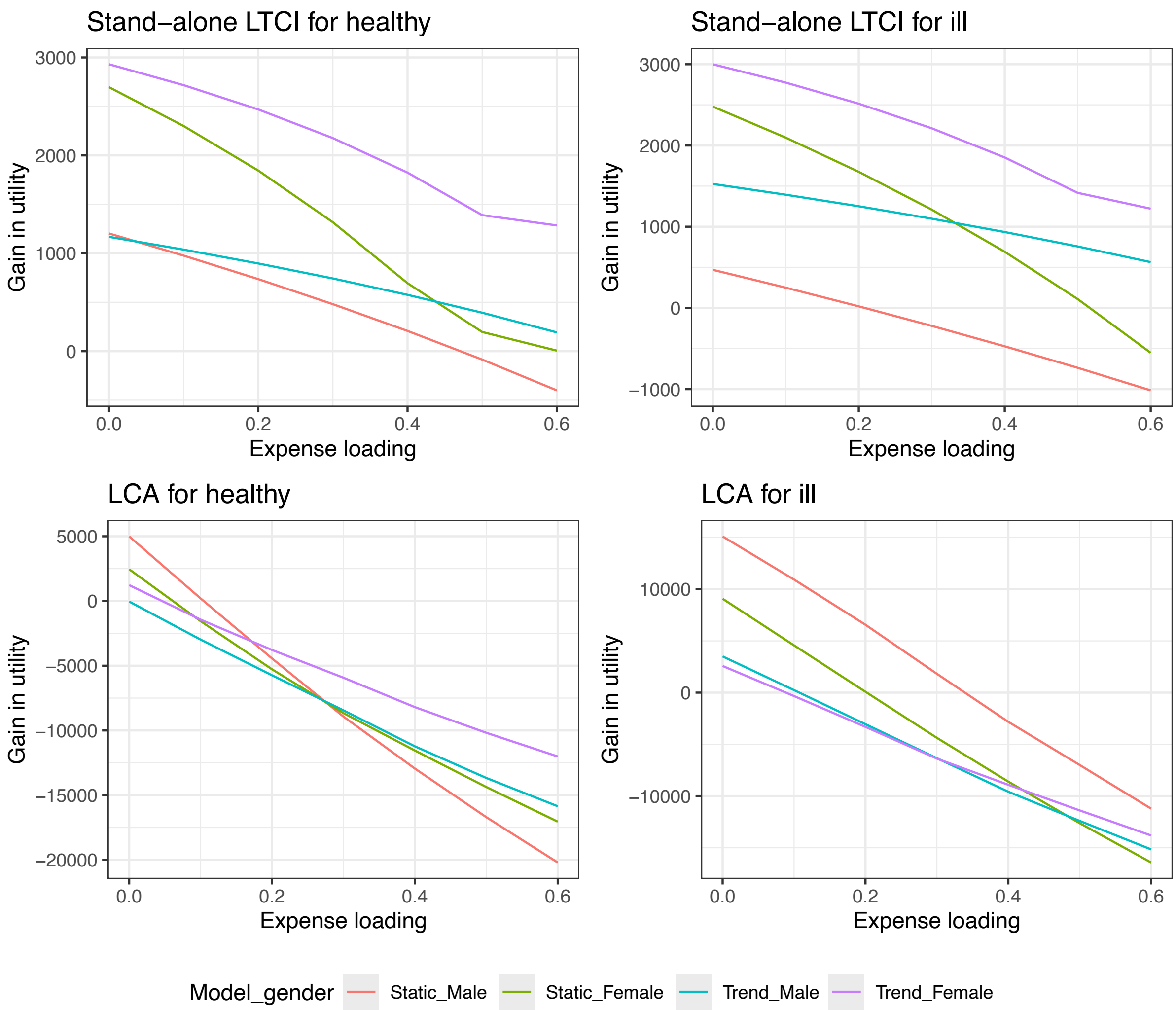

Figure 7: Gain in utility by expense loading

Note: The gain in utility is measured as the utility when the respective product is purchased minus the utility when it is not purchased.

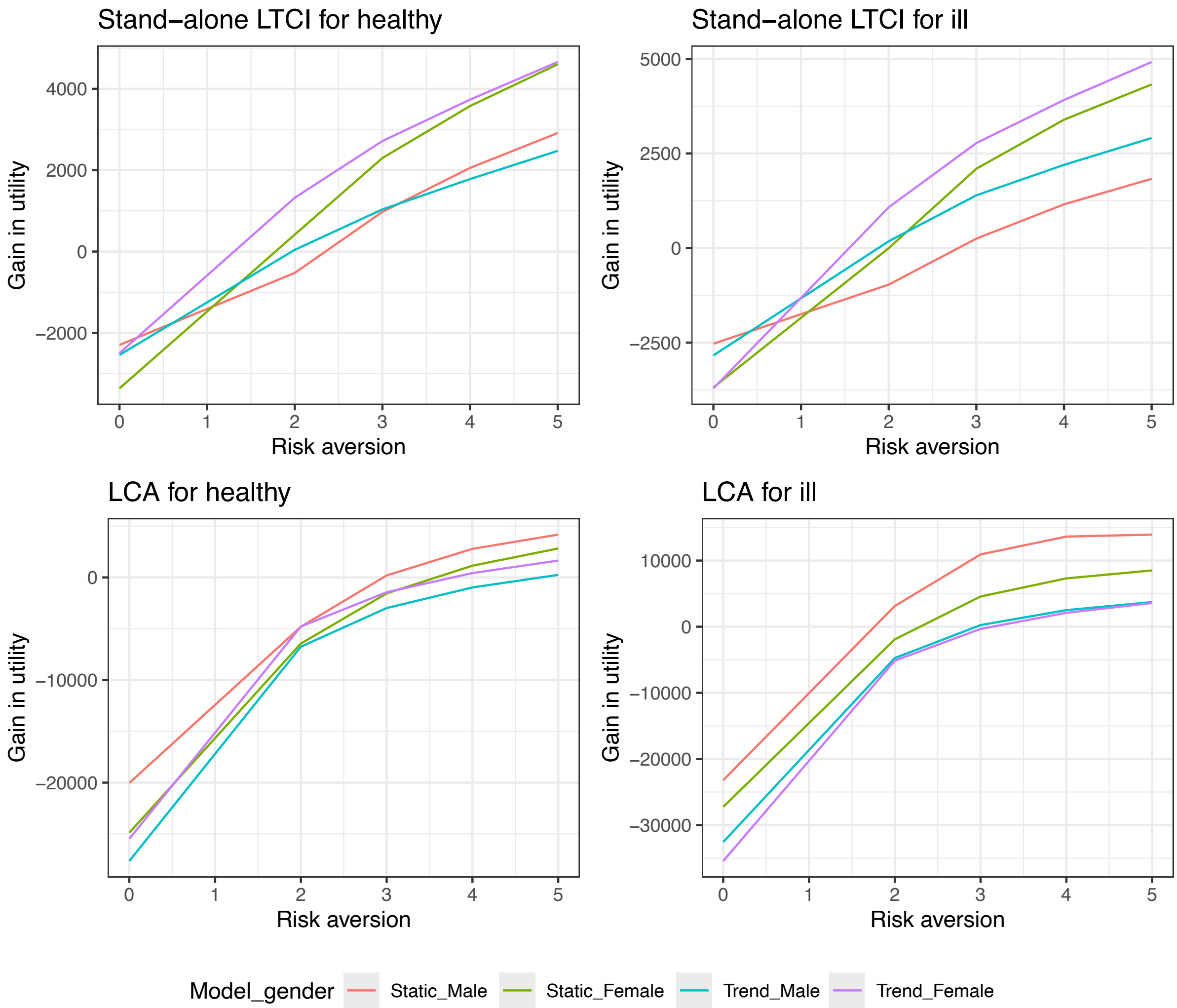

Figure 8: Gain in utility by risk aversion

Note 1: The gain in utility is measured as the utility when the respective product is purchased minus the utility when it is not purchased.
Note 2: As the utility function does not permit the risk aversion level of 1, the plots show the gain in utility for that level of risk aversion by linearly connecting observations for neighbour risk aversion levels.

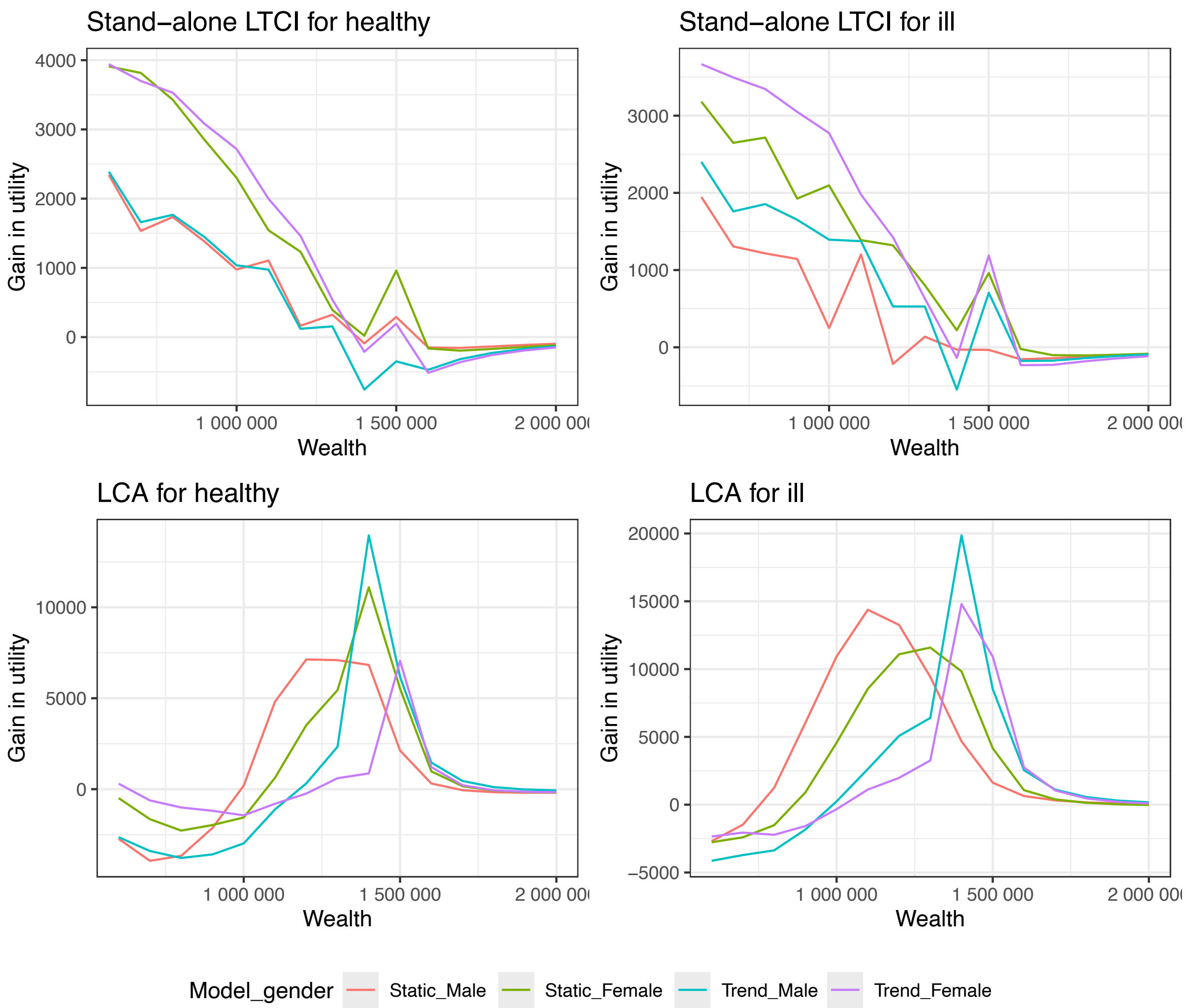

Figure 9: Gain in utility by initial wealth

Note: The gain in utility is measured as the utility when the respective product is purchased minus the utility when it is not purchased.

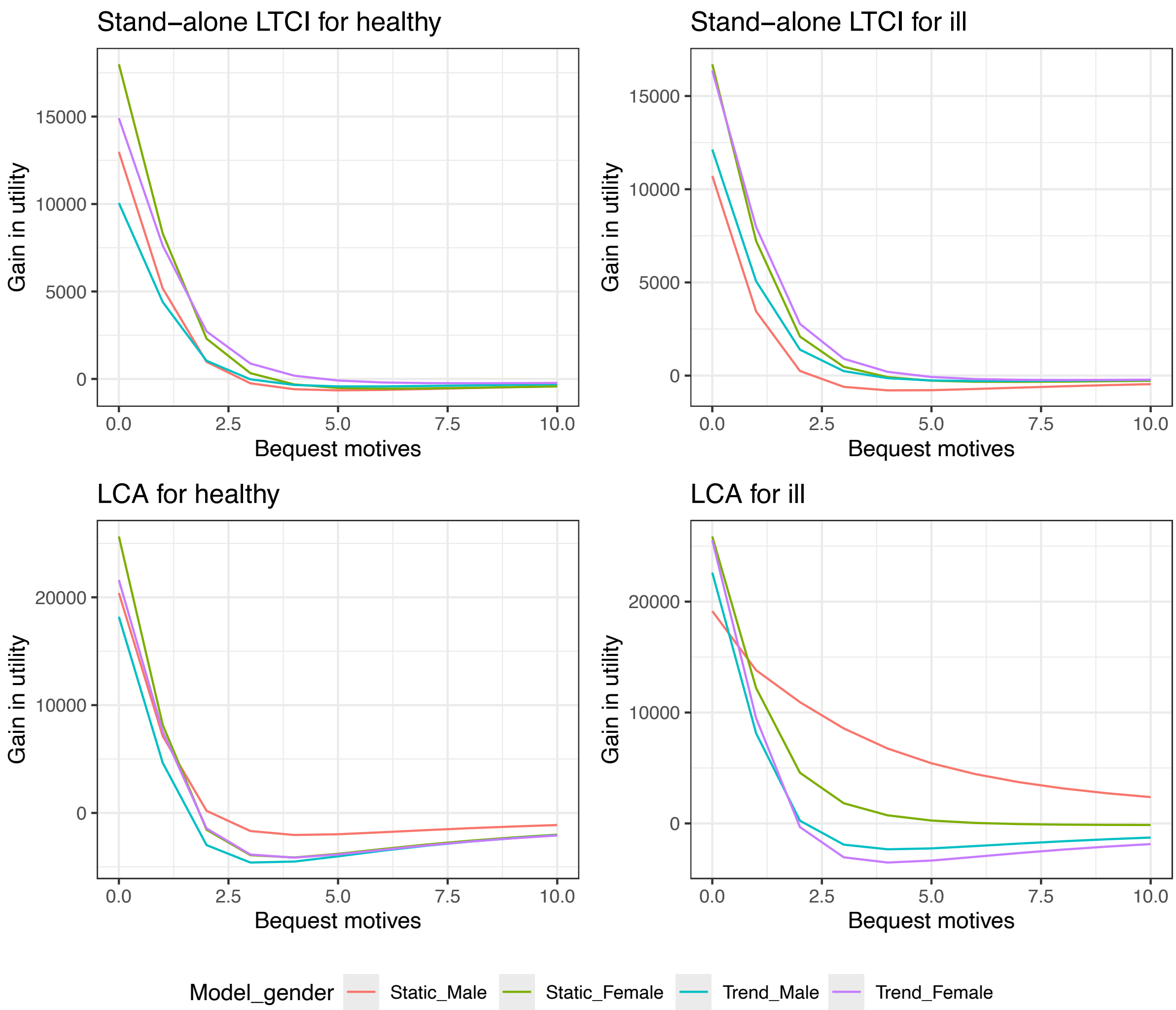

Figure 10: Gain in utility by bequest motives

Note: The gain in utility is measured as the utility when the respective product is purchased minus the utility when it is not purchased.

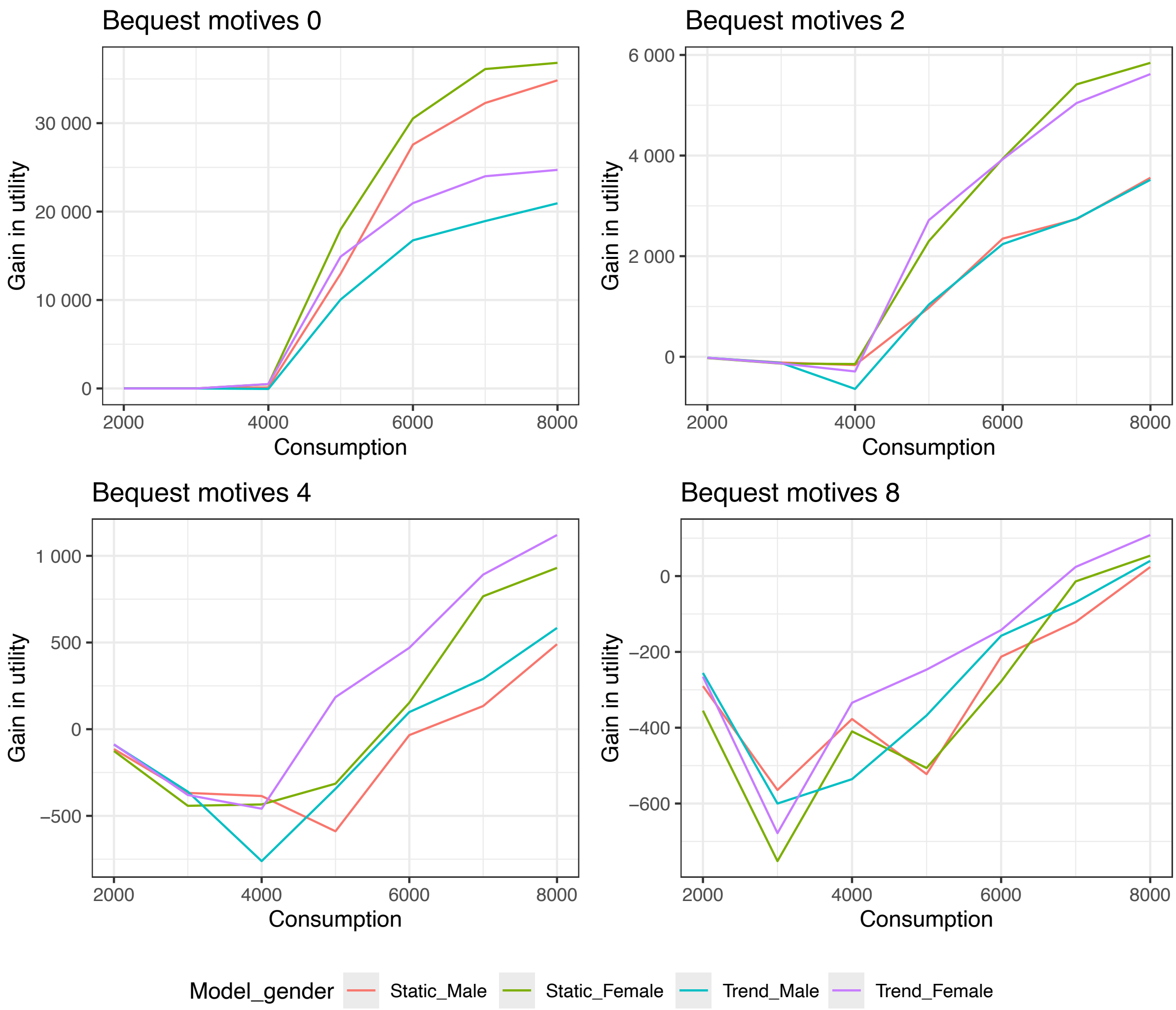

Figure 11: Utility by consumption and bequest motives for healthy retirees when stand-alone LTCI is purchased

Note: The gain in utility is measured as the utility when the respective product is purchased minus the utility when it is not purchased.

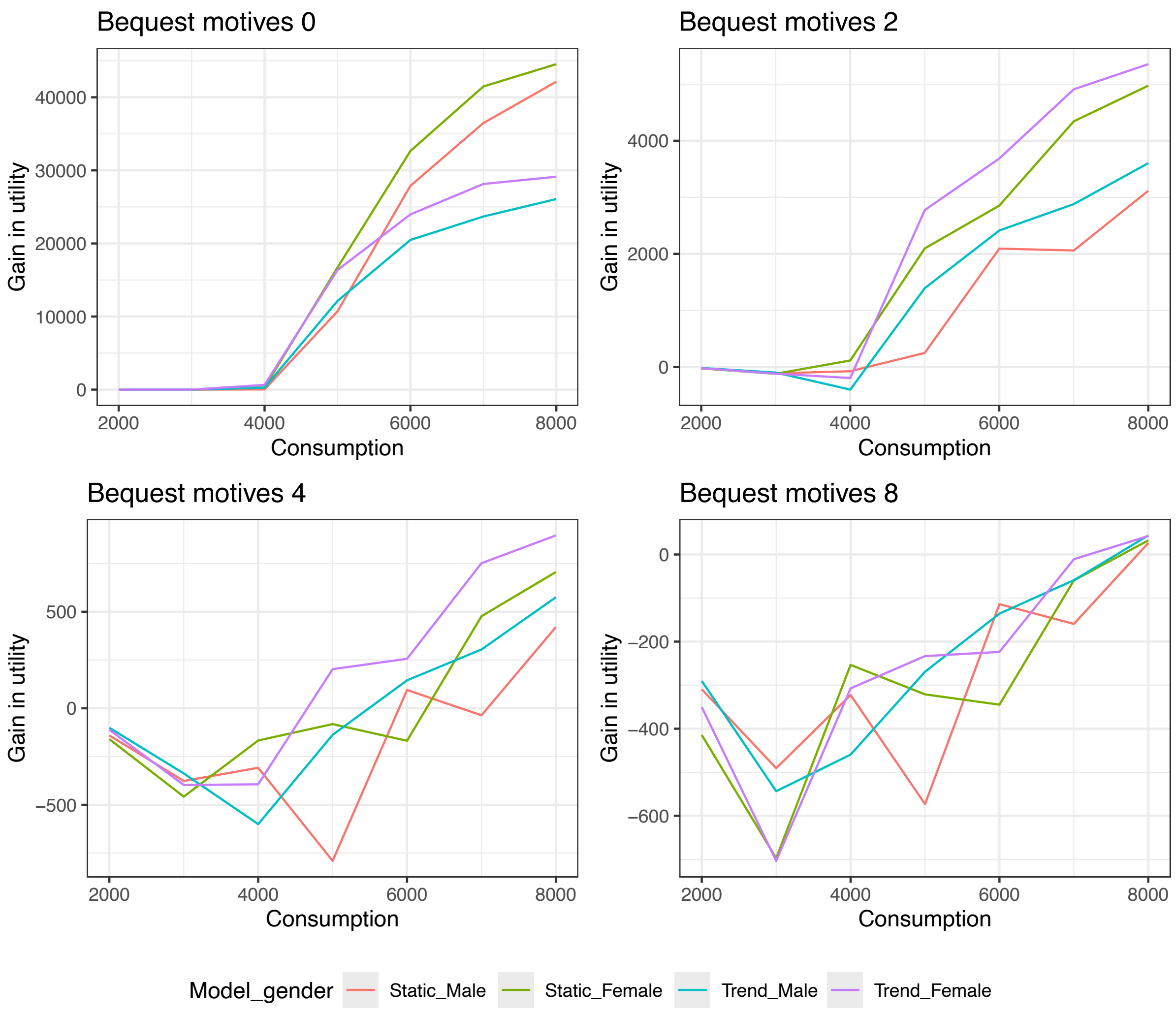

Figure 12: Utility by consumption and bequest motives for ill retirees when stand-alone LTCI is purchased

Note: The gain in utility is measured as the utility when the respective product is purchased minus the utility when it is not purchased.

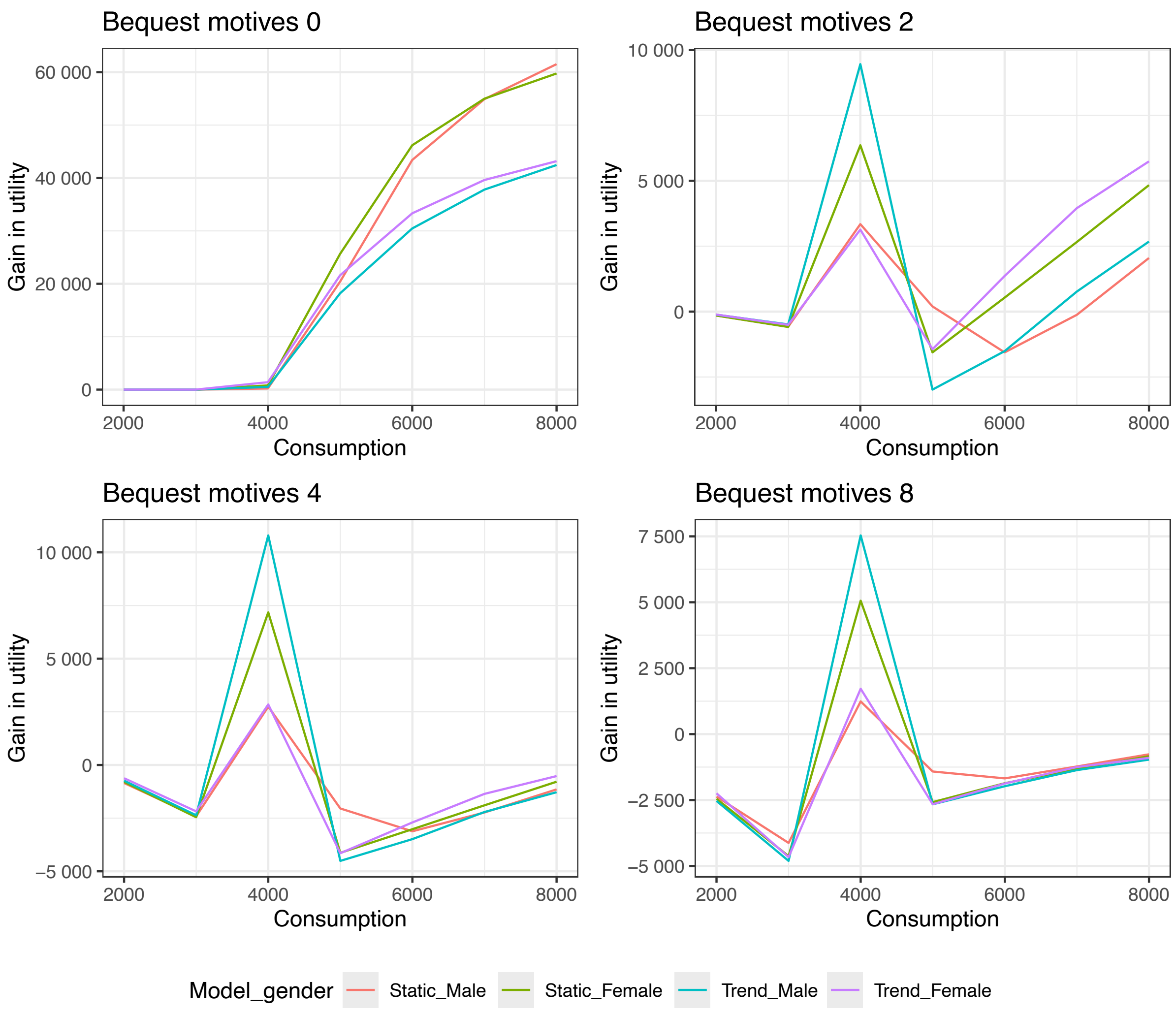

Figure 13: Utility by consumption and bequest motives for healthy retirees when LCA is purchased

Note: The gain in utility is measured as the utility when the respective product is purchased minus the utility when it is not purchased.

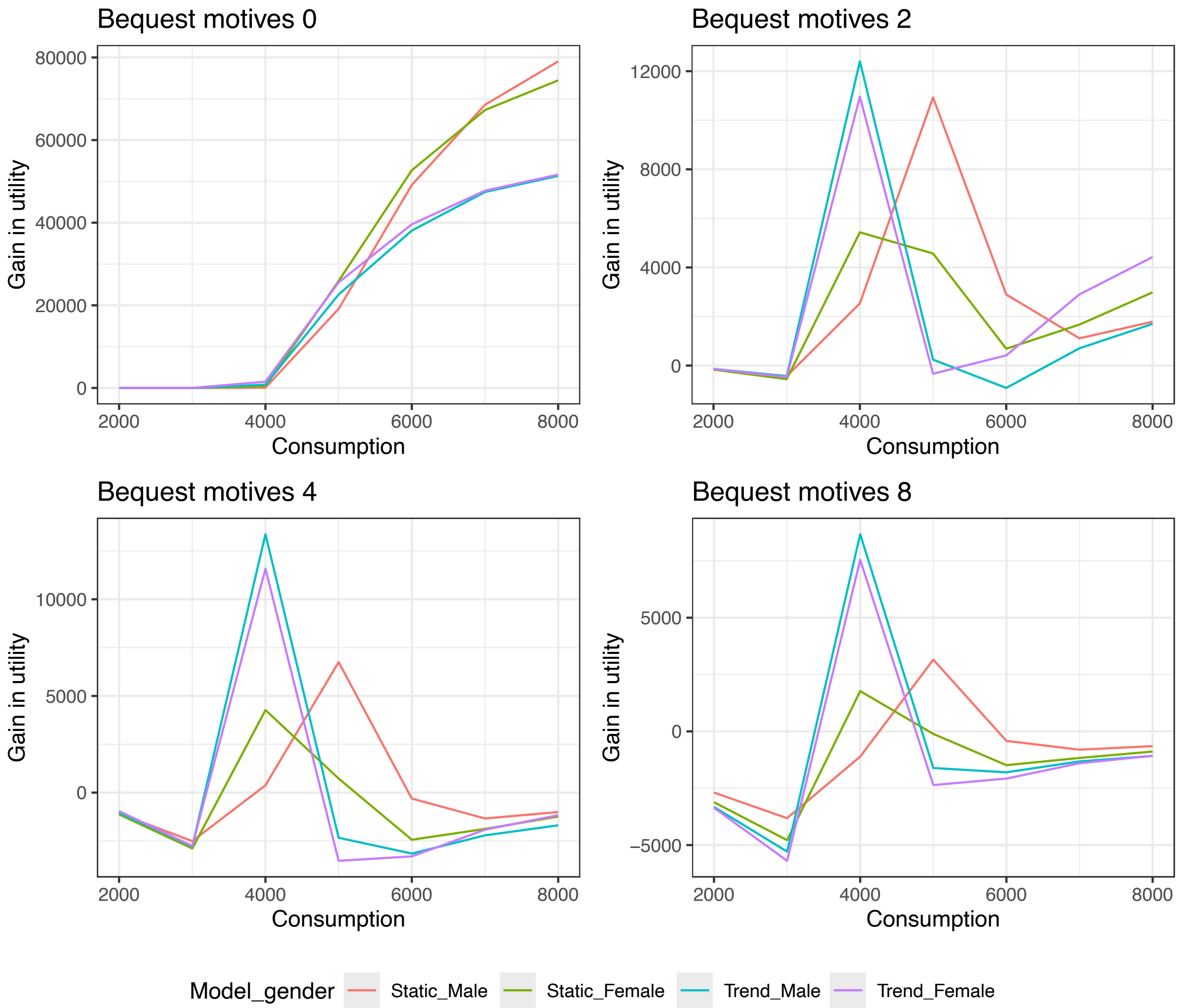

Figure 14: Utility by consumption and bequest motives for ill retirees when LCA is purchased

Note: The gain in utility is measured as the utility when the respective product is purchased minus the utility when it is not purchased.

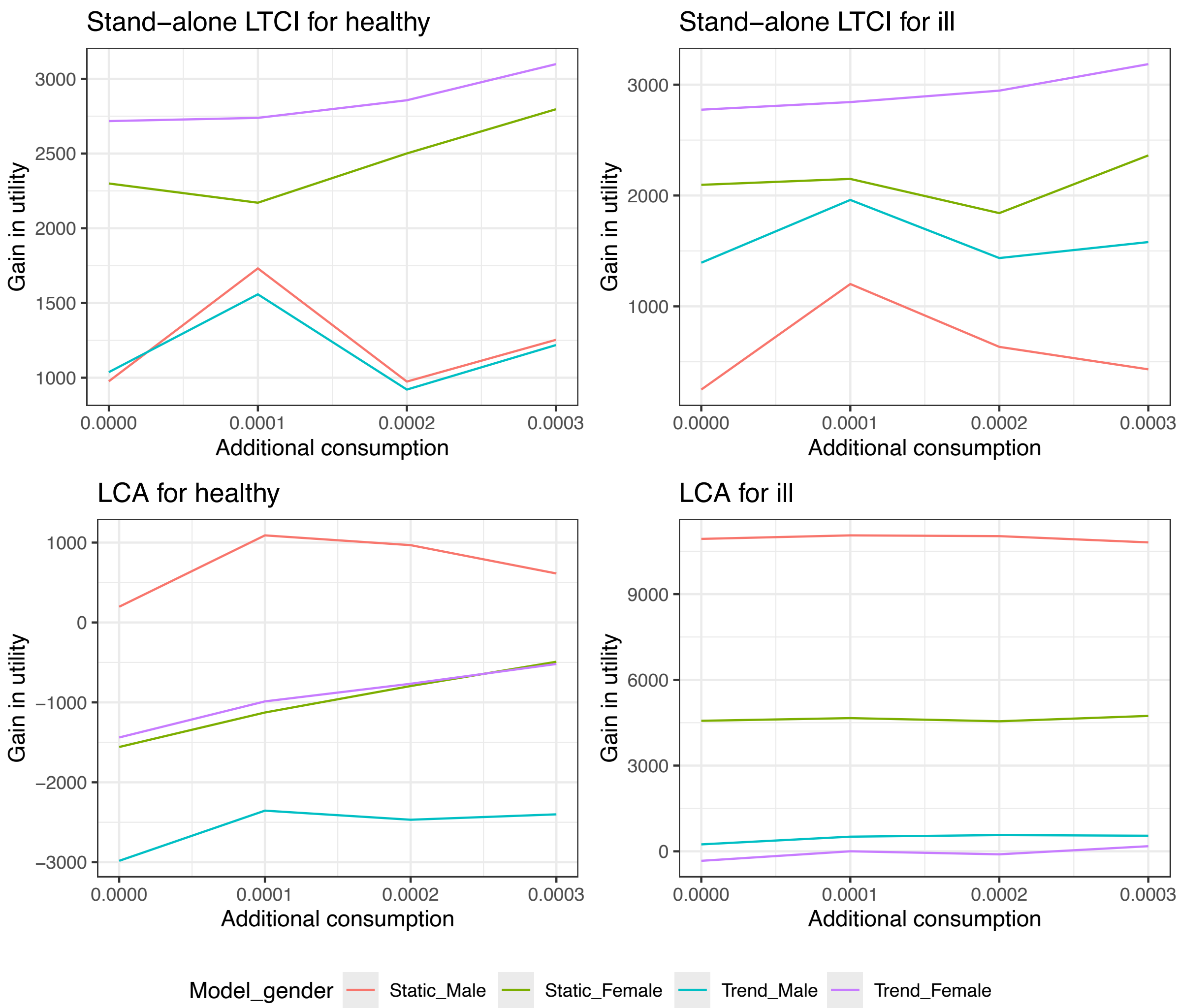

Figure 15: Gain in utility by additional consumption

Note: The gain in utility is measured as the utility when the respective product is purchased minus the utility when it is not purchased.

6 Discussion

We use mortality and disability assumptions based on Australian data from 1998 to 2018. We do not include data covering the COVID-19 pandemic period which could lower the estimates for the LTCI premiums and their cost components including the risk margin, especially in the trend model. In 2022, there were 12% more deaths in Australia than the number of deaths predicted based on the pre-pandemic mortality trends [COVID-19 Mortality Working Group, 2023]. The excess deaths include deaths from COVID-19 (51%), COVID-19 related deaths (15%), and other deaths without any mention of COVID-19 on the death certificate (34%). While it does not report the figures for disabled population, from their analysis on COVID-19 related death, we can see that COVID-19 has differential impacts on different causes of death and hence would affect individuals in different states in our model differently. For instance, dementia patients (with a greater likelihood of ADL inabilities) were found particularly vulnerable during COVID-19 waves, given that dementia represented 19% of the COVID-19 related deaths but only 9% of the other deaths. Although these effects are of interest, the main conclusions of our study remain unchanged.

Our analysis includes a trend factor which provides valuable insights and an important contribution to the understanding of LTCI pricing, especially given the limited number of previous studies examining trends as covered in Section 2. Trends in mortality, disease, and disability rates will have a fundamental impact on the future demand for LTC services [Christensen et al., 2009]. We have aimed to incorporate the potential impact and compare it with results from models without the trends incorporated.

Results from both the static model (ignoring the trend effect) and the trend model should be considered to understand the potential impacts of future uncertainty. We should emphasise that the multi-state model we used was numerically estimated to best replicate the observed prevalence of populations by state from cross-sectional data. For Australia, we do not have actual transitions data, so the accuracy of the numerical model estimation cannot be statistically assessed with respect to the transitions between states. Also, the trend model has 12 more parameters to estimate compared to the static model, which means there is potentially more error in the model estimation.

This issue is more likely to impact the disability parameters since the disabled population is relatively small at many ages. For instance, from the simulations, we observe the shorter retirement time spent with disability in the trend model compared to the static model. This is because of the higher transition intensity from *Disabled* to *Dead* for older individuals due to the higher age coefficient for that transition type estimated in the trend model, than in the static model. This indicates a risk that the cost of stand-alone LTCI is less reliable in the trend model than in the static model.

Our utility analysis shows the potential demand for the LTCI, based on model simplifications and assumptions. In practice there are many issues to consider in assessing the demand for these products that are not captured in our modelling. First, individuals may not be able to make an informed decision about the purchase of LTCI by understanding the heterogeneity of health status in their later lives relative to their personal circumstances and preferences. Second, individuals could substitute for private LTCI with informal care or family support, or some means to receive extra public support (e.g., by concentrating wealth in their principal home to reduce the total asset value for a better entitlement). Third, individuals may possess private information regarding their LTC and longevity risks that the insurance premiums fail to account for. As a result, the most unfavorable risks tend to selectively opt for the LTCI, leading to an increase in premiums and a decrease in demand among lower-risk individuals [Lambregts and Schut, 2020, Sloan and Norton, 1997, Ameriks et al., 2016]. Fourth, behaviours driven by a form of limited rationality, not accounted for in expected utility assessments, could influence participation [Brown, 2007]. For instance, when individuals deviate from perfect rationality, factors like financial literacy may impact the demand. Most of these arguments also explain the finding that the uptake of LTCI remains unexpectedly low in the developed international LTCI markets [Lambregts and Schut, 2020, Pestieau and Ponthière, 2012].

Our demand analysis has provided an assessment of relationships between the gains in utility for risk-averse individuals from LTCI and factors including premiums (expense and risk loading), the extent of risk aversion, wealth level, the extent of bequest motives, and potential tendency to consume more at higher levels of wealth. We demonstrate that these relationships differ by gender, type of LTCI, initial health status and presence of a trend factor. Potential demand for Australian LTCI products should consider market observations including population mix by gender and health status, financial literacy, relative preference for different types of LTCI products, risk perception, preferences for consumption and wealth accumulation, and an insurer's financial policy and efficiency.

Our focus has been to evaluate Long-Term Care Insurance (LTCI) products specifically designed to alleviate the financial strain on individuals associated with the co-payment requirements. These co-payments have the potential to compromise an individual's ability to maintain a comfortable lifestyle. In addition, our focus has been on assessing the impact on individuals rather than the burden on the broader public LTC system. However, it is worth noting that our developed model and methodology can be extended to areas related to the public LTC system. For example, we can project the future cost of LTC by considering the Australian population structure by health state. We can evaluate the cost impact of policy reform such as replacing existing co-payment requirements with a universal aged care levy. Furthermore, we have the capability to gauge public well-being using utility measures within the existing system or within any potential alternative systems under consideration.

7 Conclusion

Our aim was to contribute to the international literature on the development of a private long-term care insurance (LTCI) market by providing an analysis based on Australian data. Using a five-state Markov model of functional disability and chronic illness for Australians, we assessed premiums for a range of LTCI products, including stand-alone LTCI and life care annuity (LCA), for both healthy and chronically ill retirees. The estimated premiums reflected the greater mortality of ill versus healthy retirees, the longer life expectancy of females compared to males, and the trend of increasing life expectancy but decreasing time spent with disability observed over the 20-year period to 2018. Based on measured utilities, potential insured individuals would be willing to purchase the LTCI products in most cases, with several exceptions due to high solvency capital requirements and the low projected risk of disability in the future. Results varied with assumptions, including expense loading, risk aversion, wealth levels and the extent of bequest motives. Our findings suggest that an Australian private LTCI market could potentially provide additional funding to the aged care system, thereby improving the financial sustainability of the public aged care financing system.

Declarations

The authors received support and funding from the Australian Research Council Centre of Excellence in Population Ageing Research (Project Number CE170100005). The authors have no competing interests to declare that are relevant to the content of this article.

Acknowledgement

We acknowledge the support of the Australian Research Council Centre of Excellence in Population Ageing Research (CEPAR) with the project number CE110001029 and the contribution of Owen Jin, Summer Scholarship Student at CEPAR in 2023, for his research assistance with the systematic literature review.

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