Joint Life Functional Disability and Mortality Modelling and Insurance Pricing

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Overview

Introduction

Background

- **Increasing life expectancy and population aging:** Global aging is driving economic challenges and increasing demand for long-term care (LTC) (Bloom et al., 2010).
- **Marital status and health interdependence:** Most U.S. retirees are married, with health states influenced by their spouse's disability and mortality (Lawrence et al., 2019; Brown et al., 2009; Dammeyer et al., 2024; Dufresne et al., 2018; Sanders and Melenberg, 2016).
- **Pressure on long-term care:** Even among the healthiest older adults, there is a 75% chance that one partner will require a significant level of long-term care as they age.

Background

- **Health transition models:** Research mainly focuses on individual health transition models (Fleischmann et al., 2021; Sherris and Wei, 2021; Biessy, 2016), with fewer joint models for couples.
- **LTCI Products:** LTCI pricing, risk reduction through combining LTCI with other insurance, and demand sensitivity to factors like home equity and bequest motives are investigated in Shao et al. (2017), Pitacco (2016) and Xu et al. (2023).
- **The LTCI Puzzle:** Despite high LTC needs, LTCI uptake remains low, a discrepancy known as the "LTCI puzzle". (Ameriks et al., 2017; Tumicki, 2019; Boyer et al., 2017)

Motivation

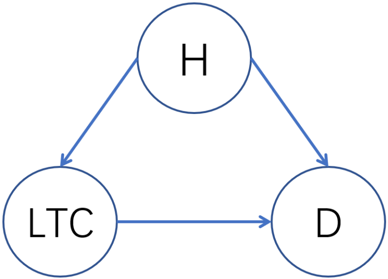
Aims:

- Develop a joint health transition model, capturing the mortality and disability rates of retired couples.
- Study whether health dependence exists and how the effect of dependence changes with time.
- Classify couples into groups on their health states, and price a variety of LTC-related products for each group.
- Compare the premiums and risks of single-person contracts and joint contracts of different products.

Methodology

Introduction of Joint Health Transition Model

We consider a 3-state health transition model comprising states H (Healthy), LTC (Long-Term Care), and D (Dead), where recovery is not incorporated. The model accounts for gender, time trend, mortality dependence, disability dependence, and a latent factor.



Model Setting

Inspired by Jagger and Sutton (1991) and Fu et al. (2022), we define the transition rates of transition Type s for k^{th} individual as

$$\begin{aligned}\ln\{\lambda_{k,s}(t)\} =& \beta_s + \gamma_s^{age} x_k(t) + \gamma_s^{female} f_k + \gamma_s t \\ &+ \theta_k^1 Y_{k,1} g_1(t - T_{k,1}) + \theta_k^2 Y_{k,2} g_2(t - T_{k,2}) + \alpha_s \cdot \psi(t),\end{aligned} \tag{1}$$

where γ_s^{age}, γ_s^{female} and γ_s represent how sensitive $\ln\{\lambda_{k,s}(t)\}$ is to age, gender and time, $g_1(t - T_{k,1})$ and $g_2(t - T_{k,2})$ measure the impact of mortality and disability dependence, α_s describes the sensitivity of the log transition rates to the common latent factor $\psi(t)$, which is a simple random walk process

$$\psi_n = \psi_{n-1} + \epsilon_n, \quad \epsilon_n \overset{i.i.d.}{\sim} \mathcal{U}(0, t_n - t_{n-1}). \tag{2}$$

Significance

The result of likelihood ratio test of each model:

Pair of models	LR test statistics
trend model vs. mortality model	291.68***
$g_1(t) = a * \exp(-38t) + b$	
mortality model vs. disability model	76.3***
$g_2(t) = c * t^2 + d * t + g$	
disability model vs. frailty model	124.58***

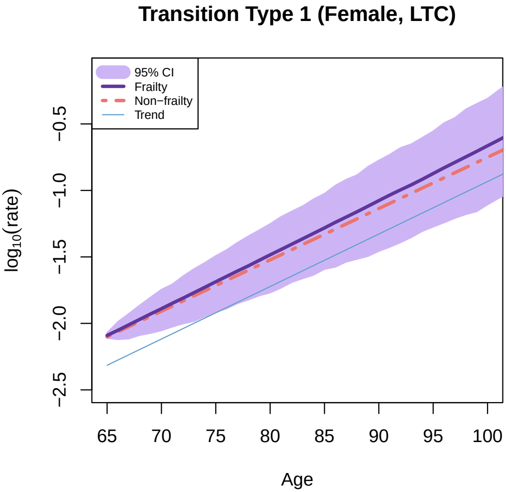
Note: $***p < 0.01$, $p > 0.1$ otherwise.

LTCI Products

- **Traditional LTCI with or without Limited Benefits and Policy Terms**: Fixed annual benefit of 5,000 USD until death or reach the limit.
- **Shared LTCI**: Couples have individual accounts (20,000 USD each) and a shared account (10,000 USD) accessible by either one.
- **LTCI with Residual Benefit**: Couples share a 40,000 USD benefit account, with access to at least half even if one reaches the limit. Combined claims can reach up to 60,000 USD in extreme cases.
- **LTCI Combined with Life Insurance**: Provides a 5,000 USD annual benefit in LTC; death benefit depends on remaining coverage, up to 25,000 USD.
- **LTCI Combined with Life Annuity**: Offers an annual benefit of 3,000 USD if healthy; 5,000 USD if in LTC.

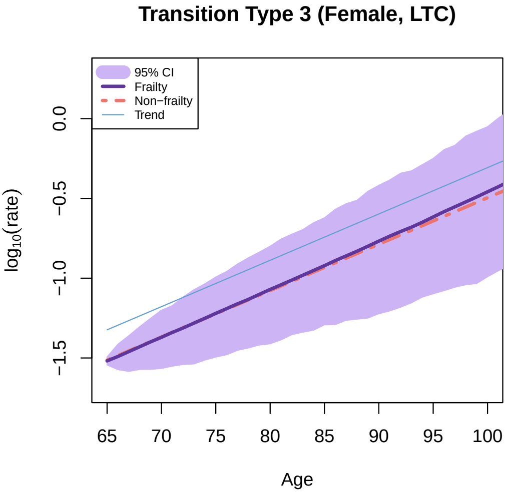
Numerical Analysis

Transition Rates



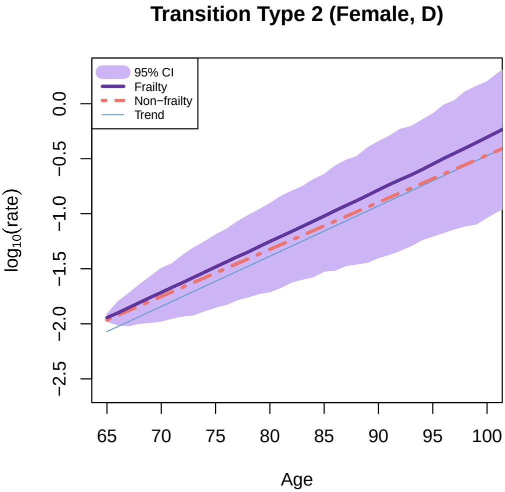
- The figure shows the difference of transition rates from state H to state LTC for females between three models assuming $t - T_2 = 0.2$.
- Spouse's disability has negative effect on health.

Transition Rates



- The figure shows the difference of transition rates from state LTC to state D for females between three models assuming $t - T_2 = 0.2$.
- Disability dependence exists on both transition Type 1 and transition Type 3.

Transition Rates



- The figure shows the difference of transition rates from state H to state D for females between three models assuming $t - T_1 = 0.1$.
- Spouse's death increases the mortality rate.

Disability Rate

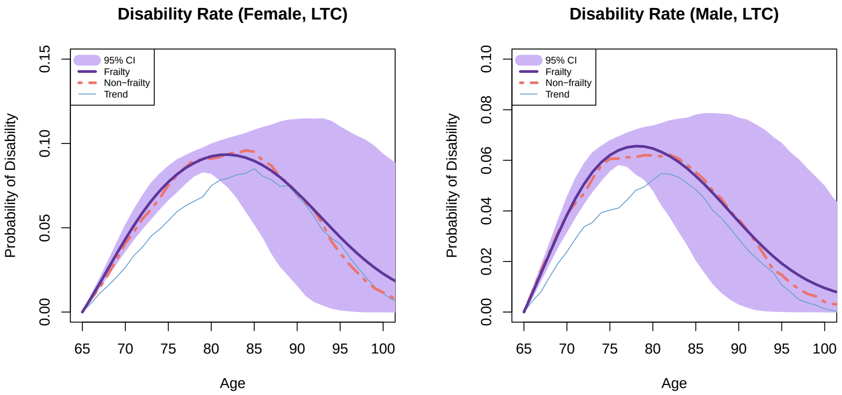


Figure: Comparison of Disability Rates

Premiums

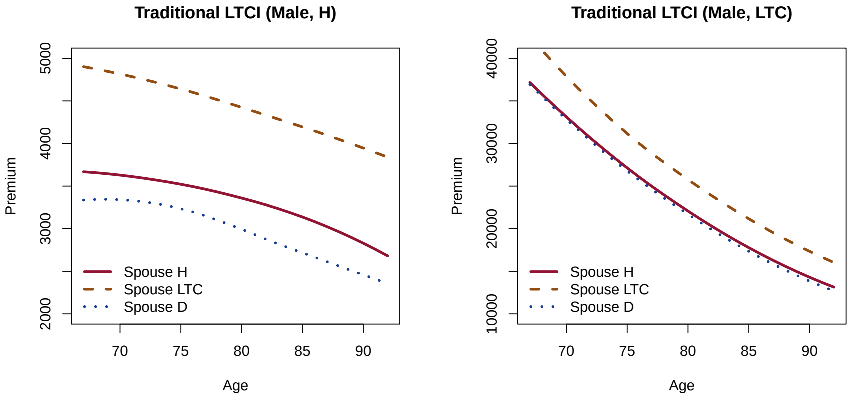


Figure: Premium of Traditional LTCI (Male)

Premiums

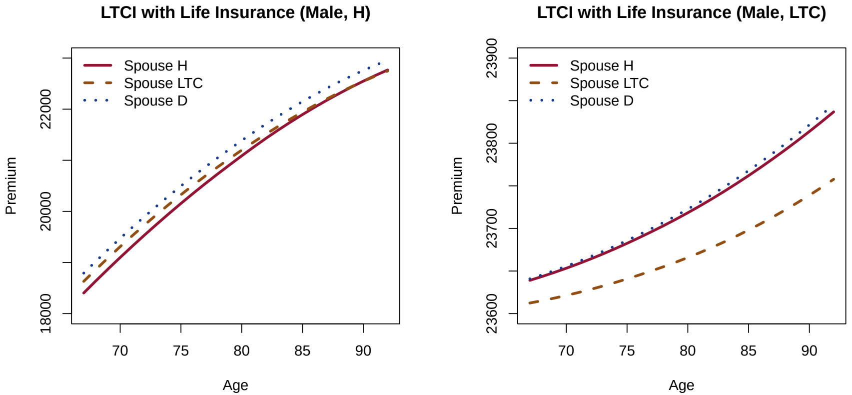


Figure: Premium of LTCI with Life Insurance (Male)

Effect of Mortality and Disability Shocks

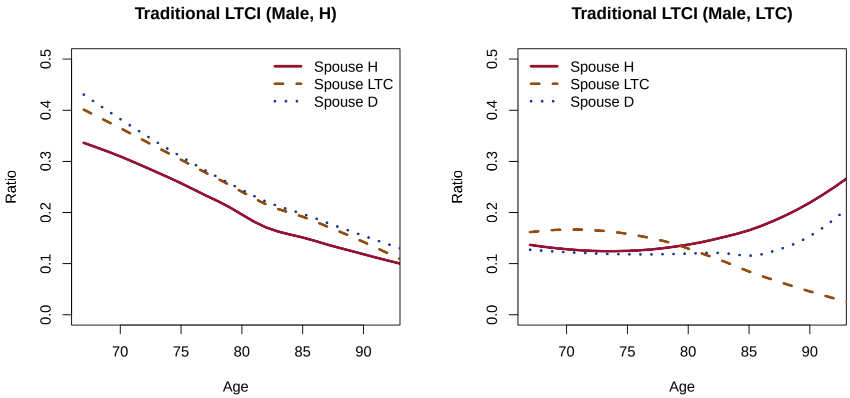


Figure: Increase of PV of Future Benefits

Conclusion

Conclusion

- **Key Findings:**
  - Health transition rates differ by gender: overall, males have higher mortality rates, while females have higher disability rates. Males are also more sensitive to the health states of their spouses.
  - We observe a positive correlation in health states between spouses. Individuals with a disabled spouse face higher disability rates, and those with a deceased spouse experience higher mortality rates.
  - Health state groupings lead to different health evolution paths, resulting in varying LTC demand, which is important for insurance pricing.
  - Compared to traditional LTCI, products such as LTCI with limited policy terms, limited benefits, and combined products are more affordable and have less disparities across groups.

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