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Individual post-retirement longevity risk management under systematic mortality risk

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ABSTRACT

This paper analyzes an individual's post-retirement longevity risk management strategy allowing for systematic longevity risk, recent product innovations, and product loadings. A complete-markets discrete state model and multi-period simulations of portfolio strategies are used to assess individual longevity insurance product portfolios with different levels of systematic and idiosyncratic longevity risk. Portfolios include: fixed life annuities, deferred annuities, inflation-indexed annuities, phased withdrawals and recently proposed group self-annuitization (GSA) plans. GSA plans are found to replace even inflation-indexed annuity products when there are loadings on guaranteed life annuity products. With a bequest motive and loadings, coinsurance portfolio strategies with phased withdrawals and GSA's dominate portfolios with life annuities or deferred annuities.

1. Introduction

Most developed countries use subsidies and tax incentives to increase mandatory and voluntary retirement savings so individuals are less reliant on public pay-as-you-go pension systems. Payout phases of pension systems are organized very differently across countries with individuals increasingly responsible for post-retirement financial decisions (Rocha et al., 2010; Rocha and Vittas, 2010). Although most private retirement savings are in defined contribution plans, limited attention has been paid to the decumulation of these funds. Individuals face a complex problem of post-retirement financial planning. They have to take into account investment risk, inflation risk, product loadings and guarantees and both systematic and unsystematic (idiosyncratic) longevity risk.[1] Recent product innovations in the form of group self-annuitization (GSA) plans provide new opportunities to manage longevity risk.

The importance and complexity of the post-retirement financial planning problem has been well recognized in the literature. There is a longstanding literature on optimal annuitization dating back to Yaari (1965). Recent studies consider individuals' retirement portfolio choice with longevity insurance products such as life annuities and deferred annuities (e.g., Horneff et al., 2010b; Post, 2012; Purcal and Piggott, 2008; Schulze and Post, 2010; Stevens, 2010), variable annuities (e.g., Doyle and Piggott, 2003; Milevsky and Kyrychenko, 2008; Horneff et al., 2010a), variable deferred annuities (Kartashov et al., 2011), or group self-annuitization plans (e.g., Piggott et al., 2005; Valdez et al., 2006; Stamos, 2008). Only a few of these papers distinguish between idiosyncratic and systematic longevity risk, model inflation risk or assess new product innovations including group self-annuitization.

This paper makes two contributions. First, we develop a complete markets framework to study the optimal management of systematic and idiosyncratic longevity risk, in a structure which distinguishes between idiosyncratic and systematic risk. This affirms the Yaari result in the special case of zero loadings and no bequest motive, but shows how products other than a standard annuity come into play when these assumptions are relaxed. Second, we adapt this framework to allow numerical simulation analysis, to show how portfolios of retirement products can improve welfare in this environment when product loadings and a bequest motive are introduced.

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[1] Systematic longevity risk arises from uncertain changes in population survival probabilities that apply to all individuals to a greater or lesser extent.

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New insights into the impact of systematic longevity risk, loadings for guarantee products and the potential impact of insurer insolvency risk on an individual's optimal product portfolio are provided. Multi-period simulation allows us to assess a broader range of realistic individual portfolio strategies. The multi-period model incorporates stochastic mortality and inflation risk. Investment risk is not included in order to focus on products that manage longevity risk rather than investment risk.[2]

Individual welfare is compared for different product portfolios motivated by the optimal insurance literature (see,e.g., Borch, 1960; Arrow, 1971, 1973; Raviv, 1979). Coinsurance for longevity risk is represented in the portfolio by self-insurance, referred to as phased withdrawals, and deductibles by deferred annuities. Applying concepts from the optimal insurance literature is complicated by the effect of a bequest motive in the longevity case. We address this by including cases with and without bequests to highlight the impact on individual longevity risk management.

The paper consists of two main parts. Section 2 presents a two-period discrete state model to derive the optimal longevity insurance strategy for an individual facing both idiosyncratic and systematic longevity risk subject to a budget constraint. The individual has access to a complete market of financial and insurance products that allows the individual to attain optimal consumption in current and future states. The products required to complete the market are a risk-free bond, a life annuity, a longevity bond, and a GSA plan. Products are priced using a contingent claims approach. Frictional costs and insolvency risk are introduced. An example is used to highlight the main insights of the model.

In Section 3 the two-period model is extended into a more comprehensive multi-period expected utility framework. Simulation analysis is used to compare a range of longevity insurance strategies developed from the insights of the two-period model and optimal insurance concepts. The longevity insurance strategies include portfolios of life annuities, deferred annuities, inflation-indexed annuities, GSA's, and phased withdrawals. Expected utilities and certainty equivalent consumption are used for welfare comparisons. The market price for insurer annuity products is determined as the actuarially fair insurance premium plus loadings typically observed in annuity markets. In practice loadings cover costs of guarantees, adverse selection and costs of capital from regulatory capital requirements. The stochastic evolution of mortality rates is based on a multivariate mortality model in Wills and Sherris (2010) designed to study the pricing and risk management of longevity risk. The market model developed by Ngai and Sherris (2011) is used to generate future stochastic inflation and economic scenarios. This model simulates gross domestic product, interest rates, stock prices, and inflation.

The results of the study show that for individuals with no bequest motive and with no product loadings, annuitization strategies including small GSA holdings are optimal under systematic longevity risk. Inflation indexed annuities dominate, and because life annuities insure both systematic and idiosyncratic longevity risk, GSA's have a limited role. With loadings on guaranteed life annuity products, GSA plans, which are mutual and non-guaranteed, become significantly more attractive for individuals in managing their post-retirement longevity risk, replacing even annuitization products with inflation guarantees. For individuals with a bequest motive, coinsurance strategies in the form of self annuitization (phased withdrawals) dominate. Holdings of GSA plans increase significantly where there are loadings on guarantee products typical of these products.

[2] Although only risk free investments are included, allowing for investment risk changes the relative weighting of phased withdrawals in the individual portfolios but not the main conclusions of the study.

2. Optimal longevity insurance: a two-period model

We study the optimal transfer of idiosyncratic and systematic longevity risk and demonstrate the impact of loadings and insolvency risk for longevity products on optimal longevity insurance using a two-period expected utility model.[3] At the start of the period, an individual is endowed with an initial wealth of W_0 (his retirement savings). He chooses consumption C_0 and a portfolio of financial and insurance products to obtain optimal second period consumption C_1 in future states. Uncertainty at the end of the period arises from both idiosyncratic and systematic longevity risk, introduced in Section 2.1.

The individual has access to a risk-free investment, a life annuity, a longevity bond, and a GSA fund. These products complete the market and are introduced in Section 2.3. Their prices are derived using the state-contingent claims approach outlined in Section 2.2. These products allow the individual to achieve the optimal consumption pattern based on his preferences.

Section 2.4 studies the optimal consumption problem when there are no frictional costs and products are priced at fair market prices. In Section 2.5 the market is no longer complete as frictional costs are introduced. Products issued by intermediaries (i.e., the life annuity) include loadings for guarantees and adverse selection. To allow for solvency and costs of capital, the life annuity is then assumed to have a (small) probability of not paying off fully when the population survival rate is high.

Section 2.6 uses a numerical example to demonstrate the insights of the model for optimal individual longevity risk management as well as the practical implications. The results are used as a basis for the product portfolios assessed in the multi-period simulations.

2.1. Idiosyncratic versus systematic longevity risk

Systematic longevity risk is the risk that arises from shocks to population-level mortality rates that apply to all individuals to a greater or lesser extent, whereas idiosyncratic longevity risk is uncertainty in individual survival given the population mortality rates. The model includes systematic and idiosyncratic longevity risk using four different states at the end of the period determined by the random population survival rate and the survival status of the individual given the mortality rate. The states are denoted by (h, a) for a high population survival rate with the individual alive, (l, a) for a low population survival rate with the individual alive, (h, d) for a high population survival rate with the individual dead, and (l, d) for a low population survival rate with the individual dead.

The probability that the population survival rate at the end of the period is high is denoted by $\pi(h)$; a low population survival outcome occurs with probability $\pi(l) = 1 - \pi(h)$. The individual's survival outcome depends on the population survival rate. For example, the probability that the population survival rate is high and the individual is alive is given by $\pi(h)\pi(a|h)$. Table 1 summarizes the possible survival outcomes and the corresponding probabilities.

2.2. Contingent claims

A state-contingent pricing approach is used. We consider a complete market and assume that for each of the four states a contingent claim is available that pays off 1 in the state and 0 in all other states. The prices of these contingent claims are denoted

[3] Two-period models have been employed, for example, by Brown (2003), Valdez et al. (2006), and Schulze and Post (2010) to study the demand for annuities and for group self-annuitization funds.