Insurance: Mathematics and Economics 48 (2011) 1–18

Contents lists available at ScienceDirect

Insurance: Mathematics and Economics

journal homepage: www.elsevier.com/locate/ime

Three retirement decision models for defined contribution pension plan members: A simulation study

Bonnie-Jeanne MacDonald [a,*], Andrew J.G. Cairns [b]

[a] Department of Economics, Dalhousie University, Halifax, Nova Scotia, Canada, B3P 1A9

[b] Maxwell Institute for Mathematical Sciences, Edinburgh, and Department of Actuarial Mathematics and Statistics, School of Mathematical and Computer Sciences, Heriot-Watt University, Edinburgh, EH14 4AS, UK

ARTICLE INFO

Article history:
Received July 2008
Received in revised form
June 2010
Accepted 29 June 2010

JEL classification:
G11
J26
J33

Keywords:
Defined contribution pension plan
Dynamic and stochastic simulation
One-year retirement decision model
Two-thirds model
Option-value of continued work model

ABSTRACT

This paper examines the hypothetical retirement behavior of defined contribution (DC) pension plan participants. Using a Monte Carlo simulation approach, we compare and discuss three retirement decision models: the two-thirds replacement ratio benchmark model, the option-value of continued work model and a newly-developed "one-year" retirement decision model. Unlike defined benefit (DB) pension plans where economic incentives create spikes in retirement at particular ages, all three retirement decision models suggest that the retirement ages of DC participants are much more smoothly distributed over a wide range of ages. We find that the one-year model possesses several advantages over the other two models when representing the theoretical retirement choice of a DC pension plan participant. First, its underlying theory for retirement decision-making is more feasible given the distinct features and pension drivers of a DC plan. Second, its specifications produce a more logical relationship between an individual's decision to retire and his/her age and accumulated retirement wealth. Lastly, although the one-year model is less complex than the option-value model as the DC participants' scope is only one year, the retirement decision is optimal over all future projected years if projections are made using reasonable financial assumptions.

1. Introduction

It is widely known that defined contribution (DC) pension plans are on the rise around the world in the private pension plan domain as well as in state pension systems, in both developed and non-developed countries.[1] As DC pension plans emerge, more consideration should be given to the consequential effect on retirement behavior patterns. Defined benefit (DB) pension plans have historically dominated the pension plan world and past published research has focused almost exclusively on the retirement behavior of DB plan participants while saying very little on the retirement conduct of DC plan participants. For instance, numerous studies have investigated the influence of DB pension plan benefits on retirement behavior using the popular "option-value of continued work" retirement decision model (Stock and Wise, 1990a), including Stock and Wise (1990a,b), Lumsdaine et al. (1990, 1992, 1994), Samwick (1998a), Hakola (1999), Coile and Gruber (2000), Harris (2001), Samwick and Wise (2001), Hurd et al. (2003), Piekkola and Deschryvere (2004), Gruber and Wise (2004), and Asch et al. (2005). A central feature in the development of the option-value model was to capture the influence of pension benefit incentives on the retirement decision. It has been predominantly used to model the retirement behavior of DB participants since important incentives are present in the DB pension accrual pattern. For instance, this decision model takes account of DB plan rules concerning early and sometimes late retirement.

Our goal is to investigate the less familiar retirement decision-making process of a worker with a DC pension plan. Retirement decision models found to be helpful in capturing the retirement behavior of DB plan members may or may not be be suitable in describing a DC member's approach to retirement. Recent empirical studies have suggested that the rules governing retirement behavior under a DB pension plan do not match those under a DC pension plan. Friedberg and Webb (2000) reported that they have found substantial changes in the retirement patterns among US workers, to which they attributed to the spread of DC type plans in the US.

This paper explores three hypothetical approaches taken among DC plan participants in their decision to retire. We first examine the two-thirds retirement decision model, where workers retire once their accumulated pension fund can replace two-thirds of their earnings. This model can be criticized as not being "forward looking" since potential increments in future pension and

* Corresponding author. Tel.: +1 902 471 6660.
E-mail address: BonnieJeanne_MacDonald@hotmail.com (B.-J. MacDonald).

[1] See Broadbent et al. (2006) for a description and discussion of the worldwide shift towards DC pension plans.

0167-6687/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.insmatheco.2010.06.008

employment income do not affect the retirement decision. We next consider the option-value of continued work model (Stock and Wise, 1990a), which takes into consideration all future retirement opportunities in the retirement decision. The option-value model is a well developed and researched model that has been discussed and applied by numerous authors as noted above. Finally, we present the one-year (OY) retirement decision model. The two features that distinguish the OY model from the option-value model are (1) the OY model approaches the retirement decision by regarding only the added value of delaying retirement by one year rather than all future retirement possibilities, and (2) there is a second leisure component in the OY model.

This study builds on the stochastic simulation model developed in MacDonald and Cairns (2007), which is summarized in Section 2. Section 3 follows, describing each retirement decision model.[2] Section 4 explores the theoretical retirement behavior of DC pension plan members. Section 5 presents the simulated results. Section 6 investigates the optimality of the retirement choice generated by the OY model. Section 7 examines the implied relationship between an individual's choice to retire and his/her current pension and age under each retirement decision model. This section also tests the sensitivity of the utility function parameter estimates. Section 8 gives a few suggestions for future work and, finally, Section 9 summarizes the primary findings.

The conclusions reached in this paper are theoretical—they are based on a qualitative examination of the three models (Section 4) and the simulated retirement behavior generated by each (Sections 5–7). In future work, we hope to ascertain which of the models best describes the retirement behavior of DC participants by testing each model against empirical data.

2. Model and assumptions

This study stochastically simulates the retirement decision behavior of DC participants. To do so, we simulate the worker's financial career path, savings accumulation and choice to retire using the approach outlined in MacDonald and Cairns (2007), except we now include two additional retirement decision models. The following is a brief bullet point summary of the assumptions:

- All private and public sources of retirement income are treated as a single DC pension plan.
- The DC pension plan is a pure design in the sense that we do not include any government/employer imposed restrictions. For instance, there exists neither a minimum pension guarantee, a minimum period of enrollment for vesting, nor a mandatory retirement age.
- Five assets are available for investment: equities, fixed-income bonds, index-linked bonds, risk-free one-year bonds (cash) and index-linked cash.
- There are 581 available portfolio strategies, each containing a different combination of the five assets. We test the portfolio's exposure to bonds, index-linked bonds and equities in increments of 10% of the total portfolio. We examine only 20% increments for cash and index-linked cash since they play a minor role in the outcome (Section 5 finds that they are not optimal investment choices).
- The Vasicek interest rate model (Vasicek, 1977) underpins the dynamics of the economic variables.
- The relationship among the annuitization rates, financial market rates of return and earnings growth are modeled from year to year.
- The participant's earnings model is composed of the prevailing level of inflation and real wage growth, which are both stochastic. It also includes a merit scale that is a deterministic function of years of employment.
- A participant begins working at age 20, enters the DC pension plan at age 25, has no dependents, makes an annual 10% of earnings contribution to his/her retirement account and chooses a static asset allocation strategy. A short examination of the effect of varying these assumptions was done in MacDonald and Cairns (2007).
- We assume neither taxes, expenses, nor allowances for profit in the financial assets' pricing, the management of the DC plan, nor the cost of purchasing annuities.
- We rely on fixed income annuities as the funding medium benchmark to calculate the pension benefit income available from the accumulated DC funds.
- The annual mortality rate is a fixed blend of 50% of the male mortality rate and 50% of the female mortality rate in the 2002 United States Life Tables (Arias, 2004).
- We assume that retirement patterns, asset demand and labor force participation rates do not affect the market equilibrium asset returns or the wage earnings, although in reality we would expect some feedback.[3]
- We consider retirement an absorbing state and a retired member cannot reenter the workforce.

MacDonald and Cairns (2007) explained the rationale behind our assumptions.

Our modeling is not country-specific and it does not include any country's labour laws or tax and transfer system. Including the contemporary complexities of regulations and tax incentives for any particular country at this stage would convolute the analysis since the results would be blurred by the country's public policy rather than the effect of using alternative retirement decision models.[4] Unfortunately, owing to its complexity, even existing published research of a more practical nature nearly universally ignores labour laws, taxes and government transfers when analyzing the value of income generated from DC style accounts.[5] Moreover, as far as we can find, previously published work employing the option-value model has neglected the important role played by the country's tax and transfer system by inputting wage earnings and retirement benefits before tax.

3. Retirement decision models

This section outlines the two-thirds, option-value and OY retirement decision models.

3.1. Two-thirds retirement model

The two-thirds model, described in MacDonald and Cairns (2007), states that a DC member retires once his/her DC account can replace two-thirds of his/her current earnings.

[2] The appendices provide further details on the retirement decision models. Appendix A discusses our parameter estimates and Appendix B details the execution of the retirement decision models by explaining how members form expectations of future income.

[3] MacDonald and Cairns (2009) studied the potential impact of feedback among these variables.

[4] For example, if a country promoted retirement at a particular age by giving preferential tax treatment to retirement income over wage income, then this tax wedge would generate results skewed to that age for all of the retirement decision models. Additions of this sort would increasingly create difficulties in distinguishing public policy incentives from the retirement decision behavior implied by the features of the models.

[5] Samples of this line of research include Blake et al. (2003), Dus et al. (2004), Horneff et al. (2007) and Milevsky and Young (2007).