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De-risking defined benefit plans

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ABSTRACT

To identify an appropriate pension de-risking method, this paper proposes an optimization model that minimizes the expected total pension cost subject to a conditional value at risk (CVaR) constraint on pension funding level. Using this model, we examine three pension hedging strategies, *i.e.*, longevity hedge, buy-in and buy-out; each strategy is examined with hedging costs that include a risk premium, search and information cost, underfunding cost, and counter-party risk cost. The numerical examples demonstrate that these hedging costs have a significant impact on the hedging decision. The hedge ratio (total pension cost) decreases (increases) with the transaction cost, the counter-party default probability and the underfunding ratio. In addition, the buy-out underperforms the longevity hedge and the buy-in for underfunded plans and the longevity hedge is less sensitive to the default risk than the buy-in.

1. Introduction

Sponsoring a defined benefit (DB) pension plan has become an increasingly significant business issue because of unprecedented market swings, sustained declines in interest rates, volatile funding levels, increased longevity and new regulatory requirements. Twice in the past 10 years, sponsors of US corporate pension plans lost over 35% of their funded status in market downturns (Prudential, 2012). This has caused sponsors of DB pension plans to consider strategies to better manage pension risk.

In the past few years, there has been increased interest in and development of the "longevity hedge", "pension buy-in" and "pension buy-out" strategies (Coughlan et al., 2013). Longevity hedges such as longevity swaps and longevity insurance allow a pension plan to transfer the risk of retirees living longer than expected to a third party. A pension buy-in also allows a risk transfer and in this case the pension plan pays a premium to an insurer in exchange for a bulk annuity policy as an investment that matches its future obligations to retirees. Similarly, a pension buy-out transfers all or part of the pension obligations and assets to an insurer using a bulk annuity contract; unlike the other strategies, the transferred liabilities are no longer the plan's obligations. A full buy-out of a plan's pension liabilities to retirees and non-retirees winds up the plan. The risk transfer is different in each strategy. The longevity hedge only transfers longevity risk while buy-ins and buy-outs transfer not only longevity risk but also other risks including interest rate risk, inflation risk and asset risk.

Despite difficult economic conditions, 2011 was a record year that saw the transaction volumes of buy-ins, buy-outs and longevity swaps hit £12.3 billion. This was a 50% increase from the approximate £8 billion in each year from 2008 to 2010 (LCP, 2012). British Airways transferred its longevity risk with a longevity swap of £1.3 billion to Rothesay Life in December 2011. The two buy-out "mega-deals" in 2011 were Turner & Newall at £1.1 billion in October 2011 and Uniq at £830 million in December 2011. In 2011, there was also a £280 million buy-in transaction between Prudential and the pension scheme of Home Retail Group, a UK home and general merchandize retailer.

The UK is leading the way in pension de-risking, but both UK techniques and attitudes toward risk are also manifest in other countries. For example, Hickory Springs Manufacturing Company and Prudential completed the first US pension buy-in of $75 million in 2011 (Vasan, 2011). In 2012, General Motor purchased a group annuity from Prudential Insurance Company of America to complete a pension buy-out that transferred its pension obligations to eligible US salaried retirees. This GM buy-out transaction reduced its pension liabilities by $26 billion (Vlasic and Walsh, 2012).

While headlines in 2011 and 2012 were all about the pension de-risking conducted by several top pension plans, de-risking

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Table 1
Cost and risk comparisons among three pension de-risking strategies.

	Longevity hedge	Buy-in	Buy-out
Simplicity	Less complex	More complex	More complex
Counter-party risk	Yes	Yes	No
Affordability[a]	More affordable	More affordable	Less affordable

[a] For underfunded plans.

strategies often lead to an increase in pension costs. Generally, we observe larger plan asset reductions than the corresponding plan liability reductions (Ehrhardt et al., 2013). Hence, companies should gain a clear understanding of the costs and benefits of each de-risking strategy and implement the one with the highest longer-term savings to cover the near-term costs. Longevity hedges such as index-based longevity swaps have much simpler structures than buy-ins and buy-outs. The sophisticated structures with collateral and surrender terms increase the transaction costs of buy-ins and buy-outs. While buy-outs are the most direct way to take liabilities off balance sheets, the cost of buy-outs can be very high for underfunded plans because buy-outs require cash infusions to satisfy a certain minimum funded status. Longevity hedges and buy-ins reduce future volatilities but trustees still maintain the plans and have the responsibility to pay benefits to retirees when a chosen insurer becomes insolvent or defaults on its obligations at some point in the future; this counter-party risk exists in longevity hedges and buy-ins.[1] According to Jerry Gandhi, the Group Pensions Director at RSA Insurance Group, "Our largest concern was the risk of the counter-party defaulting and this of course was a concern for the trustees and the company. The trustees in their own right would be able to get rid of the risk but in the event of default, it would come back to the scheme, which would then sit back with the company" (Deutsche Bank, 2011). Table 1 summarizes the main differences of the three de-risking strategies in terms of cost and risk.

Having an understanding of capital market performance, general mortality trends, regulatory requirements and the interest rate environment can provide a plan trustee with the right perspective for evaluating and selecting a de-risking strategy. Deciding what is right for the plan, however, requires an in-depth evaluation of costs, counter-party risk, and the overall financial implications of each de-risking strategy. While there exists a rich literature that explores optimal pension financing and investment policies, little is known about whether and the extent to which the near-term costs of de-risking can be offset by longer-term savings. The lack of a promising model in which to quantify these de-risking costs and benefits severely limits previous studies in this area. Indeed, much of the prior research ignores the costs of longevity hedges, pension buy-ins and buy-outs (Black, 1989; Bodie, 1991; Haberman et al., 2000; Bogentoft et al., 2001; Kouwenberg, 2001; Chang et al., 2003; Josa-Fombellida and Rincón-Zapatero, 2004; Colombo and Haberman, 2005; Lin and Cox, 2005; Cox et al., 2006; Cox and Lin, 2007; Delong et al., 2008; Lin and Cox, 2008; Lucas and Zeldes, 2009; Maurer et al., 2009; Milidonis et al., 2011; Lin et al., 2013). As a result, the motives for and value of pension de-risking are still not clear. To fill the gap, this paper brings a hedging component to the study of pension funding risk and cost, motivated by the proliferation of recent pension de-risking activities. Most of the earlier research on pension asset–liability optimization does not numerically analyze asset and liability risk transfer. Our model does and has important implications for pension plans as it describes how a de-risking strategy affects the magnitude of a plan's risk and cost, which in turn determines an appropriate hedge.

Managing both pension funding status and total pension cost is important for pension risk management (Cox et al., 2013a). In this analysis, we consider a constrained minimization problem; the expected total pension cost is minimized subject to constraints that control for tail risk and more. Total pension cost includes all costs and/or penalties associated with hedging, contributions and withdrawals (Cox et al., 2013a). The analysis links various costs and counter-party risks to total pension cost while controlling pension funding tail risk. The numerical examples developed from the model show how a pension plan's funding status, transaction costs and credit risks determine the expected total pension cost and so are determinants of any de-risking decision.

Our work contributes to a growing body of research on pension de-risking. Pension hedging policy has been found to be determined by the risk premium necessary for the risk transfer and by the transaction costs such as search and information costs as well as the costs of monitoring and enforcing contractual performance (Cox et al., 2013a; Lin et al., 2014). Cox et al. (2013a), for example, provide analysis to show that a higher transaction cost decreases the optimal pension hedging level. In this paper, we extend the existing DB pension de-risking literature by comparing not only the transactions costs but also the default probability and underfunding ratio on the choice of a hedging strategy. Our results complement the previous studies by showing that credit risk (pension funding status) is a significant determinant of the optimal longevity hedge and pension buy-in hedge levels (buy-out hedge levels). A higher credit risk (initial underfunding ratio) decreases the hedge ratio of a longevity hedge and buy-in (buy-out).

The paper is organized as follows: Section 2 presents the basic framework for a DB pension plan. Section 3 describes the setup for longevity hedges, buy-ins and buy-outs. We also introduce a stochastic financial market model and a stochastic mortality model. In Section 4, we describe the pension fund optimization model. We provide a numerical example to illustrate how to implement our model for each hedging strategy. Section 5 compares different de-risking options subject to different hedge costs. The last section concludes the paper.

2. Basic framework

Consider a retired cohort at the age of x_0 at time 0. Denote ${}_s\tilde{p}_{x,t}$ the probability that a plan member age x at time t survives to age $x+s$ at the beginning of year $t+s$ and gets a benefit payment given the mortality table at time t. It is random for $s = 1, 2, \ldots$. The conditional expected value of a life annuity is defined as

$$a(x(t)) = \mathrm{E}\left[a_{\overline{K(x)}}|\tilde{p}_{x,t}, {}_2\tilde{p}_{x,t}, \ldots\right] = \sum_{s=1}^{\infty} v^s \, {}_s\hat{p}_{x,t}, \tag{1}$$

where $v = 1/(1+r)$ is the discount factor with the discount rate r and ${}_s\hat{p}_{x,t}$ is the conditional expected s-year survival rate for age x at time t:

$${}_s\hat{p}_{x,t} = \mathrm{E}\left[{}_s\tilde{p}_{x,t}|\tilde{p}_{x,t}, \tilde{p}_{x+1,t+1}, \ldots, \tilde{p}_{x+s-1,t+s-1}\right].$$

That is, the life annuity factor for age x at t, $a(x(t))$, is the discounted conditional expected value of payments of \$1 per year as long as the retiree survives.

Let PL_0, PA_0 and UL_0 denote the pension liability, asset and underfunding with no hedge at time 0 respectively. In our model, PA_0 is given, $PL_0 = \mathrm{E}[Ba(x_0(0))]$ and $UL_0 = PL_0 - PA_0$. The constant B is the promised annual survival payment. Without de-risking, the

[1] In this paper, we compare a buy-in (or longevity hedge) and a buy-out without a credit derivative added for the buy-in (or longevity hedge). In practice, it may be appropriate to add a credit derivative to the buy-in (or longevity hedge) to control credit risk if such a credit derivative is available and at a low cost.

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