A Summary of "IFRS Convergence: The Role of Stochastic Mortality Models in the Disclosure of Longevity Risk for Defined Benefit Plans"

Yosuke Fujisawa and Johnny S.H. Li

1 Background

Traditional pension mathematics assumes that mortality rates are fixed at a valuation date. If mortality rates reduce after a valuation date, the liabilities of defined benefit plans (DB plans) increase, leading to deficits, which are then recognized in arrears (the next valuation date). Such deficits are somewhat unpredictable, because the evolution of mortality rates is a random process. This problem, which is often called longevity risk, makes the maintenance of DB plans difficult. In recent years, there has been a growing awareness of the threat of longevity risk to DB plans. In particular, the International Accounting Standards Board (IASB) has plans to tackle the arduous problem of how to disclose longevity risk on financial statements.

The IASB was established in 2001 to create universal accounting standards, called International Accounting Reporting Standards (IFRSs). The objective of the IASB is to provide comprehensive accounting standards to the standardizing capital markets. The use of IFRSs has been accepted by more than 100 countries. Most countries where DB plans are popular, including Japan and Canada, are either adopting or converging their local Generally Accepted Accounting Principles (GAAP) with IFRSs. The United States (US) and the IASB have been discussing the convergence of accounting standards (IASB, 2009a). Recently, the IASB has been undertaking some projects to create or enhance its accounting standards, including post-employment benefits. In 2008, the IASB published a discussion paper called "Preliminary Views on Amendments to IAS 19 Employee Benefits" (IASB, 2008a). This is the first step for the comprehensive amendment of pension accounting. A large number of actuarial societies, accounting boards and consulting firms submitted comments because the amendment has a significant impact on numerous companies in the world. After carefully deliberating these comments, the IASB determined to create two exposure drafts: part one is about recognition and presentation of changes in DB plans, disclosures and other issues; part two is about contribution-based promises.

One of the important issues under discussion is how to disclose longevity risk for DB plans. According to the comments on the discussion paper (IASB, 2008b), the majority support the additional disclosure of mortality assumptions, although some oppose it because of the costs associated with it. Some believe that standard metrics like life expectancy should be disclosed, but such metrics convey little information about the underlying longevity risk exposure, particularly to users of financial statements who do not have a deep understanding of demographic risk. The deficiency of standard metrics is acknowledged by the IASB. For instance, the IASB staff paper (IASB, 2009b) recommends using the principle-based approach, which provides underlying principles rather than precise step-by-step rules to meet all possible circumstances. If the principle-based approach is adopted, IFRSs are unlikely to stipulate a specific standard metric for longevity risk disclosure, and it is up to pension plan providers to decide a suitable method for disclosing longevity risk. Pension actuaries will therefore need a range of methods that are intuitive and can clearly indicate how longevity risk may affect a plan's financial position. Other than financial reporting purposes, such methods can also help pension actuaries explain the underlying longevity risk exposures to their clients.

2 Our objectives

A primary objective of this paper is to propose a number of methods that can help actuaries and plan sponsors quantify and disclose longevity risk. The methods we propose can be implemented easily with stochastic mortality models that have been developed in recent years. Another objective of this paper is to explain how our proposed methods may be used for measuring the materiality of longevity risk associated with a pension plan. We illustrate our ideas with a hypothetical DB plan in Japan.

3 Proposed Methods

Longevity risk is highly complex. However, in accounting statements, we prefer using one number, or at least a small set of numbers, to indicate the degree to which the pension plan is subject to particular aspects of risk. What we need therefore are some key longevity risk indicators that are simple but are indicative of the pension plan's ability to withstand adverse changes in mortality rates.

In this paper we propose three risk indicators that are useful for quantifying and disclosing longevity risk exposures: (1) longevity Value-at-Risk (VaR), (2) probability of longevity deficit, and (3) probabilistic corridor rule. In this section we give the definitions and explain the intuitions of the risk indicators. How the risk indicators may be used in practice will be illustrated in Section 4.

All three risk indicators we propose are based on the distribution of the following random variable:

$$Y(t) = PV(t) - PV(t_0), \tag{1}$$

where $PV(t)$ is the value of DB liability. The distribution of $Y(t)$ can be obtained by simulating the values of $Y(t)$. In this paper, we simulate values of $Y(t)$ on the basis of sample paths of future mortality rates generated from the Cairns, Blake and Dowd (2006) model.

3.1 Longevity Value-at-Risk

A commonly used risk indicator in the fields of banking and finance is the quantile of the distribution or the Value-at-Risk. In general terms, the VaR is the size of loss for which there is a small, say $p\%$, probability of exceedance. VaR is very popular because it is easily communicated. For example an event at the 1% per year level is often described as the 'one in a hundred year' event. With the aid of a stochastic mortality model, the concept of VaR can be applied readily to longevity risk. Specifically, we define the longevity VaR at $100p\%$ level as follows:

$$\mathrm{VaR}_p[Y(t)] = \inf\{y \in \mathbb{R};\ \mathbb{P}[Y(t) > y] \leqslant 1 - p\}. \tag{2}$$

Although VaR is used extensively in financial risk management, it suffers from some undesirable properties. First, generally speaking, VaR is not a coherent risk measure as it lacks subadditivity. By subadditivity we mean that the risk measure for two risks combined will not be greater than for the risk treated separately. This reflects the fact that there should be some diversification benefit from combining risks. We refer readers to Artzner et al. (1999) for deeper discussions on coherent risk measures. Second, VaR may be viewed as an 'all or nothing' risk measure. This is because if a plan base its risk capital on VaR, then there will be no capital to cushion against the deficit if the deficit exceeds the VaR threshold.

A more informative and more useful risk indicator is Tail-Value-at-Risk (TVaR). TVaR is also called conditional tail expectation (CTE) in North America and expected shortfall (ES) in Europe. Mathematically, we define the longevity TVaR at the $100p\%$ confidence level as follows:

$$\text{TVaR}_p[Y(t)] = \mathbb{E}[Y(t) \mid Y(t) > \text{VaR}_p[Y(t)]]. \tag{3}$$

That is, $\text{TVaR}_p[Y(t)]$ is the expected value of $Y(t)$ given that $Y(t)$ exceeds the $100p$th percentile of the distribution of $Y(t)$. In layman's terms, VaR gives us a definition of 'bad times' – situations when the deficit exceeds the VaR threshold are called 'bad times.' TVaR, on the other hand, tells is the average deficit during 'bad times.' It is clear that TVaR gives us more information about the tail of the distribution than VaR alone. Another advantage of TVaR is that it is a coherent risk measure.

VaR and TVaR are useful for measuring longevity risk with a large magnitude but a small probability. However, when deciding materiality of mortality assumptions, we may want to understand not only the extreme outcomes but also the central tendency of the longevity deficit. In this case, on top of VaR and TVaR, the median of $Y(t)$ will be useful.

3.2 Probability of Longevity Deficit

Another indicator of longevity risk is the probability of longevity deficit, which is defined by $\Pr[Y(t) > 0]$. From the simulated distribution of $Y(t)$ we can easily calculate the probability of longevity deficit.

With the probability of longevity deficit, we can calculate $\mathbb{E}[Y(t) \mid Y(t) > 0]$, the conditional expectation of longevity deficit given that longevity deficit exists. This expectation is quite similar to TVaR in that they both measure the average deficit beyond a certain threshold. However, the threshold on which TVaR is based is higher. Therefore, we may view $\text{TVaR}_p[Y(t)]$ as an indicator of the exposure to extreme longevity risk and $\mathbb{E}[Y(t) \mid Y(t) > 0]$ as an indicator of the overall longevity risk exposure.

3.3 Probabilistic Corridor Rule

The current IAS 19 has the corridor rule so that actuarial gains and losses can be smoothed over several fiscal years. Under the corridor rule, companies do not have to recognize actuarial gains and losses within a 'corridor' (the greater of 10 percent of plan assets and 10 percent of plan liabilities) (IASB, 2008a). A pension plan may use the corridor rule to smooth its gains/losses, or it may choose to disclose its gains/losses when they occur without using the corridor rule.

In the discussion paper (IASB, 2008a), the IASB proposes to abolish the corridor rule, because deferred recognition makes it difficult for users to compare financial statements. According to the IASB staff paper (IASB, 2009b), most comments on the discussion paper support the idea of recognizing all changes in DB liabilities and assets when they occur. Nevertheless, it is important to note that 60% of the comments are submitted from Europe, where the pension regulations have been moving to mark-to-market, and that 20% percent of the comments are submitted from the UK, where the pension accounting has already been mark-to-market.

As a matter of fact, many Japanese companies are concerned about the abolishment of the corridor rule. In its comments on the discussion paper, the Pension Fund Association mentions that they do not agree with the approach to adopt immediate recognition of changes in the defined benefit promises as in the preliminary views. The voice for keeping the corridor rule is very strong.

We propose an idea called "probabilistic corridor rule," which may be seen as an adapted version of the traditional corridor rule. The probabilistic corridor rule is more informative than the traditional corridor rule in that it can help users to determine materiality by not only the magnitude but also the likelihood of the potential deficits.

The probabilistic corridor rule is based on a random variable $Z(t) = Y(t)/PV(t_0)$, which may be viewed as the longevity deficit relative to the DB liabilities in the base year. As in the traditional corridor rule, we need to define a threshold, say τ%. On the basis of the probabilistic corridor rule, we regard mortality assumptions as material if $\Pr[Z(t) > \tau]$ is greater than a certain probability, say p%.

4 An Example

Let us consider a Japanese company, which has a pension plan that pays an amount of \$1 each year to each pensioner until he/she dies. We assume that the plan has 3,000 pensioners. The demographic structure of this plan is the same as that of the general population of Japan in 2005. We assume further that the pensioners' demographic structure is stationary and that an interest rate of 3% is used to discount the pension liabilities.

Since we assume the plan pays each pensioner \$1 per year, the present value of

Year t	2006	2007	2008	2009	2010
$\text{VaR}_{95\%}[Y(t)]$	1420(4.1%)	2015(5.8%)	2673(7.7%)	3321(9.6%)	3949(11.4%)
$\text{TVaR}_{95\%}[Y(t)]$	1753(5.1%)	2573(7.4%)	3295(9.5%)	4022(11.6%)	4673(13.5%)
Median of $Y(t)$	183(0.5%)	353(1.0%)	613(1.8%)	866(2.5%)	1032(3.0%)
$\mathbb{P}[Y(t) > 0]$	61.3%	65.2%	68.2%	72.0%	74.8%
$\mathbb{E}[Y(t) \mid Y(t) > 0]$	635(1.8%)	950(2.7%)	1275(3.7%)	1532(4.4%)	1740(5.0%)
$\mathbb{P}[Z(t) > 0.03]$	11.2%	25.7%	37.2%	44.2%	49.9%

Table 1: Key longevity risk indicators for the hypothetical plan. The numbers in parentheses are the risk indicators divided by the DB liabilities. For this plan, the DB liabilities in 2005, that is, $PV(2005)$, is 34677.

the pension payable to the ith pensioner who is aged x_i in year t is simply $\ddot{a}_{x_i}(t)$, where $\ddot{a}_x(t)$ is the actuarial present value of a life annuity issued to a person aged x at inception. Let $PV(t)$ be the value of the DB liabilities. Then, we have

$$PV(t) = \sum_{i=1}^{n} \ddot{a}_{x_i}(t), \tag{4}$$

where n is the number of pensioners in the plan.

We calculate the longevity risk indicators for $t = 2006, \ldots, 2010$. Values beyond 2010 are not calculated because in 2010 the new Japanese pensioners' mortality table will be released and the longevity deficit will then be recognized. The estimated longevity risk indicators are shown in Table 1.

First, let us focus on the longevity VaR and TVaR. Both values increase rapidly as t increases, this is due in part to the reduction of mortality rates over time, and in part to the increased uncertainty when we make projections farther into the future.

Second, we focus on the probability of longevity deficit. We observe that as mortality improves over time, the probability of longevity deficit increases as t increases.

Finally, we focus on the probabilistic corridor rule. We assume that the threshold is 3% of the DB liabilities in year 2005 (i.e., $\tau = 3\%$), and calculate the values of $\Pr[Z(t) > 0.03]$ for $t = 2006, \ldots, 2010$. We observe that $\Pr[Z(t) > 0.03]$ increases rapidly with time.

References

Artzner, P., Delbaen, F., Eber, J.-M. and Heath, D. (1999). Coherent Measures of Risk. *Mathematical Finance*, *9*, 203-228.

Cairns, A.J.G., Blake, D., and Dowd, K., (2006). A Two-Factor Model for Stochastic Mortality with Parameter Uncertainty: Theory and Calibration. *Journal of Risk and Insurance*, **73**, 687-718.

Human Mortality Database. University of California, Berkeley (USA), and Max Planck Institute for Demographic Research (Germany). Available at www.mortality.org or www.humanmortality.de (data downloaded on 25 Feb 2009).

International Accounting Standards Board (2008a). *Preliminary Views on Amendments to IAS 19 Employee Benefits.* Available at www.iasb.org.

International Accounting Standards Board (2008b). *Comment Letters on Discussion Paper: Preliminary Views on Amendments to IAS 19 Employee Benefits.* Available at www.iasb.org.

International Accounting Standards Board (2009a). *Who We Are and What We Do.* Available at www.iasb.org.

International Accounting Standards Board (2009b). *Agenda Paper 20A for May 2009 meeting: Post-employment Benefits (Disclosures-Defined Benefit Plans).* Available at www.iasb.org.