LIFE INSURANCE AND WEALTH MANAGEMENT PRACTICE COMMITTEE

Information Note : Variable Annuities Taskforce Reading List

October 2012

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1 Status of Information Note

This Information Note was prepared by the Life Insurance and Wealth Management Practice Committee ("LIWMPC") of the Actuaries Institute. It may also have relevance to areas of actuarial practice other than wealth management. It does not represent a Professional Standard or Practice Guideline of the Institute.

It has been prepared for the purpose of informing members of issues in developing and managing variable annuities, and to provide members with a reference to reading material on variable annuity products and their underlying mathematical theory.

Feedback from Institute members is encouraged and should be forwarded to the Product Development Sub-Committee of the LIWMPC as follows:

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This is the second version of this Information Note, replacing that issued in December 2009.

2 Background

2.1 What are variable annuities?

Variable annuities ("VA"'s) are unit linked savings contracts with attaching guarantees. Features of these contracts have been seen before in various guises, such as products including:

- guaranteed minimum annuity rates;
- death benefit protection including return of contributions; and
- ratcheted returns and/or capital protection.

The guarantees on VA products are collectively referred to as "GMxB's" and the most common of these are:

- GMDB: Guaranteed Minimum Death Benefit
- GMAB: Guaranteed Minimum Accumulation Benefit
- GMWB: Guaranteed Minimum Withdrawal Benefit (with a lifetime variation)
- GMIB: Guaranteed Minimum Income Benefit.

2.2 The development of this Information Note

VAs are a relatively new product internationally and particularly in Australia. The LIWMPC established the Variable Annuities Taskforce ("Taskforce") in 2009 to consider the knowledge available in overseas variable annuity markets and identify how that style of guarantees could be applied in Australia. At that point, only two life companies offered investment guarantees in Australia, but they are playing a growing role in the market. VA sales in the US and the UK have been also been stronger in the last three years than might have been expected following the GFC. There is evidence of a change in approach in hedging and the guarantees being offered.

The Taskforce has subsequently been disbanded, but its responsibilities have partly been assumed by the Product Development Sub-Committee. This version of the Information Note updates the earlier version issued in December 2009. In keeping with the original purpose, papers have been sourced that have the widest interest to members although the search has not been exhaustive. Papers have been included that support the change in approach and others that challenge the accuracy of the models.

A small number of textbooks have been listed. There are many books covering mathematical finance; those listed cover topics of interest and at different levels of expertise. These textbooks do not all explicitly discuss variable annuities but provide the framework to enable the reader to understand the complexity of the embedded optionality within variable annuities.

3 Readings

3.1 General description and market

- **SIAS paper "Variable Annuities" by Tamsin Abbey and Catherine Henshall**
  http://www.sias.org.uk/data/papers/VariableAnnuities/DownloadPDF

  This paper is recommended as a good overall introduction to the topic.

- **Variable Annuities (2010) by Ledlie, Corry, Finkelstein, Ritchie, Su & Wilson, *British Actuarial Journal Volume 14. 2***

  The paper provides a UK market context for VA products, including a sample product design and features. The need to provide adequate advice and services to customers, marketing and distribution, pricing methodology, sensitivity testing of economic and insurance assumptions, dynamic policy holder behaviour and various product features are discussed. Institute and Faculty of Actuaries' discussions of papers are included in the journal and are always interesting.

3.2 Mathematical background

An important part of understanding derivative pricing is the implementation of numerical methods, which may assist actuaries in developing their understanding of the various models of stochastic processes applicable to financial contracts. Books on programming or on numerical methods have not been included as there are extensive references contained within the textbooks.

- **The Concepts and Practice of Mathematical Finance by Mark S. Joshi**

  The book provides an excellent introduction; the mathematics is light enough not to be distracting but sufficient to comprehend the papers provided in the reading list. Further, the author was an experienced practitioner before moving to academia and the text blends theory and practice. The final four chapters introduce alternative pricing models and discuss market incompleteness – important concepts when dealing with the exotic options embedded into variable annuities. The text provides advice on further reading.

  Recommended as "even better" is: Mathematical Methods for Financial Markets (Springer Finance) Monique Jeanblanc, Marc Yor and Marc Chesney

- **Volatility and Correlation: The Perfect Hedger and the Fox (2nd edition) by Riccardo Rebonato**

  This provides an extensive discussion on payoff replication under various models covering equities and interest rates in a post-Black Scholes world. Whilst the detail (at over 800 pages) may be off-putting, the book focuses on the usefulness of models, given that all of them are wrong; an important consideration when hedging VA and for setting reserves.

- **Investment guarantees: The new science of modelling and risk management for equity-linked life insurance by Mary Hardy**

  Mary Hardy is a well-known academic actuary and has applied the "new science" to the pricing of investment guarantees in general and those in variable annuities in particular.

The following books provide a graded introduction into the mathematics underlying stochastic calculus.

- **Probability and Random Processes by G R Grimmett and D R Stirzaker**

  Chapters seven and nine will provide a useful bridge between the probability studied for the actuarial exams and that required to appreciate the continuous-time processes discussed in the following textbooks. Chapter seven discusses modes of convergence

of random variables and discrete-time martingales. Chapter nine introduces continuous time processes with a useful discussion on Brownian motion.

- **Stochastic Differential Equations: An introduction with Applications by Bernt Oksendal**

  A relatively straightforward introduction to stochastic calculus.

- **Financial Calculus: An introduction to Derivative Pricing by M Baxter and A Rennie**

  An introduction focused on martingale methods, it is on the Institute and Faculty of Actuaries' reading list for CT8.

- **Stochastic Calculus and Financial Applications by J Michael Steel**

  A more advanced mathematical book with a focus on finance. This is a challenging book that develops stochastic calculus from first principles, but it does focus on applications to finance (albeit in a technical manner).

- **Stochastic Calculus for Finance II: Continuous-Time Models by S Shreve**

  Another more advanced book that also deals with exotic options and jump processes that may provide the basis for more realistic hedging strategies.

- **Brownian Motion and Stochastic Calculus by I Karatzas and S Shreve**

  This is a rigorous examination of continuous-path martingales and continuous path Markov processes. It requires a significant amount of effort but should satisfy those who felt the mathematical justification was lacking in some of the books listed above.

3.3 Product, pricing and opportunity

- **Sustainable Manufacturing of Variable Annuities by Milliman**
  http://insight.milliman.com/article.php?cntid=6387

  This paper, printed in March 2010, suggests a new model is required to manage and price VA contracts. The paper discusses alterations that may be required to fix the issue of offering contracts with fixed (in percentage terms) fees whilst hedging costs may fluctuate more than anticipated. The paper concludes contract design is likely to change in the next couple of years. The following link suggests that this has occurred.

- **Sustainable Manufacturing Model Winning over Variable Annuity Writers by Milliman**
  http://www.valmarksecurities.com/Data/Sites/59/sustainablemanufacturingwinningovervariableannuitywriters-ambest-october2011.pdf

  This press release in 2011 claims that 50% of new business sales in VA use the Milliman Sustainable Manufacturing Model.

- **Variable Annuity Dynamic Lapse Study: A data mining approach by Milliman**
  http://publications.milliman.com/research/life-rr/pdfs/variable-annuity-dynamic-lapse.pdf

  A model of how lapses affect the guarantees is presented. Since sales have been successful in North America, there is now a wealth of data and the paper discusses how to use data mining techniques to analyse historical lapses.

- **Practical Considerations In Variable Annuity Pricing by Milliman**
  http://insight.milliman.com/article.php?cntid=7541

  The paper separates the pricing process into four, inter-relating, components: profitability, hedging, charges and reserve/capital. Identical products in different organisations have different risk-adjusted profits. The author discusses each element of the pricing process and how to present the results using risk adjusted statistics.

- **Allocation to Variable Annuities with Guaranteed Minimum Withdrawal Benefit – the Australian Perspective by Ibbotson Associates**
  http://www.ibbotson.com.au/Assets/Files/IBB-5-004%20Annuities-5.pdf

  This is a summary of a longer paper examining how variable annuities may be combined with traditional investment products in order to manage post retirement income. The paper provides an example of how the wider financial community in Australia view VAs and explains their usefulness in personal portfolios.

- **Pricing Variable Annuity: Guaranteed Minimum Withdrawal Benefits in a Challenging Market by Towers Watson**
  http://www.towerswatson.com/assets/pdf/1470/VA_GMWB%20Insights_Final.pdf

  This paper examines the US market pre-2010 and concludes product features will need de-risking. It provides independent support to the Milliman predictions.

- **A Universal Pricing Framework for Guaranteed Minimum Benefits in Variable Annuity Contracts by Daniel Bauer, Alexander Kling, Jochen Russ**
  http://www.fbv.kit.edu/symposium/11th/Paper/20LifeInsurance/Bauer.pdf

  A monte carlo numeric pricing algorithm is presented, as well as a method for pricing under the assumption of dynamic rational policyholder behaviour. Cost of options on money back, ratchet and annual roll-ups are calculated and contrasted under

deterministic and dynamic policyholder behaviour. Guarantee price sensitivities are calculated for risk free and volatility assumptions. Finally, guarantee costs are compared to typical market prices.

- **Rethinking Variable Annuity Guarantees**
  http://www.towersperrin.com/tp/getwebcachedoc?webc=TILL/USA/2004/200412/LeitzLeBelModi.pdf

  The paper suggests various methods of limiting benefits, explaining how applying benefit limitations to VA guarantees can be beneficial to both policyholders and insurance companies.

- **Policyholder Behaviour in the Tail (SOA): 2011 Survey**
  http://www.soa.org/WorkArea/DownloadAsset.aspx?id=30098

  This paper updates earlier surveys. It studies the nature of the policyholder behavioural assumptions employed by US insurers. The survey continues to offer valuable insight into the actual lapse assumptions employed, discussing common lapse rate features including:

  - relationship between lapse rates and surrender charges;
  - source of lapse assumptions; and
  - dynamic lapse modelling features.

There are a number of academic papers that may also be of interest:

- **Kwok, Y K and Leung, K S and Peng, J, Pricing Guaranteed Minimum Withdrawal Benefits under Stochastic Interest Rates, Quantitative Finance (2010), 1-9**;
- **Chen, Z and Forsyth, P A, A Numerical Scheme for the Impulse Control Formulation for Pricing Variable Annuities with a Guaranteed Minimum Withdrawal Benefit (GMWB), Numer. Math., 2008, 109, 535–569**;
- **Kijima, M and Wong, T, Pricing of Ratchet Equity-Indexed Annuities under Stochastic Interest Rates, Insurance: Mathematics and Economic., 2007, 41(3), 317–338**;
- **Holz, D, Kling, A and Rub, J, An Analysis of Lifelong Withdrawal Guarantees, Working paper, Ulm University, 2007**;
- **Schrager, D, Affine Stochastic Mortality, Insurance: Mathematics and Economics 38 (2006), 81-97**;

- **Sun, Feng, Pricing and Risk Management of Variable Annuities with Multiple Guarantees** http://www.soa.org/library/journals/actuarial-practice-forum/2006/october/APF0610_4.pdf ; and

- **Bauer, Daniel, Kling, Alexander and Jochhen Russ, A Universal Pricing Framework for Guaranteed Minimum Benefits in Variable Annuities, Astin Bulletin 38(2), 621-651**.

3.4 Risk management and operations

Books that may help the actuary involved in VA expand their thinking around modelling market behaviour and statistical descriptions are:

- **Theory of Financial Risk and Derivative Pricing: From Statistical Physics to Risk Management by J Bouchard and M Potters**

  The topics concentrate on short time scales, which are often ignored by actuaries as not relevant to our issues. The authors come from a theoretical physics background and it is instructive to view how their original discipline introduces ways of looking at data and models that may not be familiar to all actuaries. The consequence of non-normality of tails is frequently discussed.

- **Quantitative Risk Management: Concepts, Techniques, and Tools by Alexander J McNeil, Rüdiger Frey and Paul Embrechts**

  A "comprehensive treatment of the theoretical concepts and modelling techniques of quantitative risk management" that includes a famous actuary amongst its authors.

- **An Executive's Handbook for Understanding and Risk Managing Unit Linked Guarantees (2010) by James Maher, Joshua Corrigan, Anthony Bentley, William Diffey** https://web.actuaries.ie/sites/default/files/event/2010/07/Executive%20Handbook%20for%20UL%20Guarantees.pdf

  Prepared by the Variable Annuity Member Interest Group of the UK Actuarial Profession for "senior management and executives of life insurance companies", this is a comprehensive review of risk management issues.

There are a few short notes and presentations that may be helpful:

- **VA VA Voom by Oliver Wyman** http://www.mmc.com/knowledgecenter/OliverWymanVariableAnnuities.pdf

- **Beyond the Greeks : Managing Unhedgeable Risks by Gebler, Matterson & Tindall** http://www.actuaries.asn.au/Library/Events/FSF/2008/FSF08_8b_PPT_Matterson-Gebler-Tindall.pdf

3.5 Hedging, investments and valuation

- **Results of Survey on Variable Annuity Hedging programs for Life Insurance Companies by Charles Gilbert, K Ravindran, Robert Reitano, Society of Actuaries 2007**
  http://www.soa.org/research/research-projects/finance-investment/research-results-of-the-survey-on-variable-annuity-hedging-programs-for-life-insurance-companies.aspx

- **Understanding the True Cost of Hedging in Volatile Markets by Craig Turnbull, Barrie + Hibbert Insights November 2008**
  http://barrhibb.com/documents/downloads/Understanding_the_true_cost_of_VA_hedging.pdf

A case study to explain the risks left by a dynamic delta hedging strategy:

- **New Approaches to Variable Annuity Hedging by Stephan Reulein, Stefan Jaschke, 4th Chief Risk Officer Assembly 2009**
  http://www.genevaassociation.org/PDF/Working_paper_series/GA_E&D_353.06_REULEIN_&_JASCHKE_Annuities,Risk_management,Theory.pdf

A presentation with some colourful slides showing some practical results:

- **Impact of Recent Market Turbulence on Hedging Programs for Equity-Linked Guarantees, Milliman Research Report - May 2008**
  http://au.milliman.com/perspective/pdfs/impact-of-recent-market-05-01-08.pdf

A survey of US, Asian and European VA hedging programs that had incurred few unanticipated losses at the time of writing:

- **The Effect of Modelling Parameters on the Value of GMWB Guarantees by Z Chen, K Vetzal and P A Forsyth**
  http://www.cs.uwaterloo.ca/~paforsyt/gmwb_model.pdf

  This paper studies the no-arbitrage fee for GMWB VA riders. They model the value of the GMWB guarantee in the presence of jumps and allow for the separation between hedging fee and fee for managing the underlying investment fund. The effects of withdrawal strategies are considered. The authors conclude typical fees are insufficient to cover the cost of hedging the guarantees.

- **Variable Annuities - Issues relating to Dynamic Hedging Strategies by Christophe Bonnefoy, Alexandre Guchet, Lars Pralle, presented at AFIR / LIFE Colloquium, Munich 2009**
  http://www.actuaries.org/Munich2009/papers/LIFE/Wed_11.40_LIFE_Pralle_Financial_marktes_Paper.pdf

Academic papers include:

- **Milevsky, M A and Salisbury, T S, Financial Valuation of Guaranteed Minimum Withdrawal Benefits, Insurance: Mathematics and Economics, 2006, 38(1), 21–38**;
- **Lin, X S and Tan, K S, Valuation of Equity-Indexed Annuities under Stochastic Interest Rates, North American Actuarial Journal, 2003, 6, 72–91**;
- **Piscopo, G and and Haberman, S, The Valuation of Guaranteed Lifelong Withdrawal Benefit Options in Variable Annuity Contracts and the Impact of Mortality Risk, North American Actuarial Journal 15 (2011), no. 1, 59-76**;
- **Schrager, D, Affine Stochastic Mortality, Insurance: Mathematics and Economics 38 (2006), 81-97**;
- **Coleman, Thomas, F, Yuying Li and Maria-Cristina Patron, Hedging Interest and Equity Risk**
  http://www.cs.uwaterloo.ca/~yuying/papers/interestRisk.pdf ;
- **Dahl, M and Moller, T, Valuation and Hedging of Life Insurance Liabilities with Systematic Mortality Risk, Insurance: Mathematics and Economics 39 (2006), 193-217**;
- **Hardy, M, Hedging and Reserving for Single-Premium Segregated Fund Contracts, North American Actuarial Journal 4 (2000), no. 2, 1-9**; and
- **Wilkie, A, Waters, H and Yang, S, Reserving, Pricing and Hedging for Policies with Guaranteed Annuity Options, British Actuarial Journal 9 (2003), no. 2, 263-391**.

3.6 Accounting issues

The information provided below refers to the accounting standards and regulatory requirements of the United States only. They will need adaptation for Australia or other countries.

- **American Academy of Actuaries, Practice Note on Common Practices Relating to FASB Statement 133, Accounting for Derivative Instruments and Hedging Activities, As It Relates to Variable Annuities with Guaranteed Benefits**
  http://www.actuary.org/pdf/practnotes/life_fas07.pdf
- **Recommended Approach for Setting Regulatory Risk-Based Capital Requirements for Variable Annuities and Similar Products from the American Academy of Actuaries**
  http://www.naic.org/documents/committees_e_capad_lrbc_2_LCASDocFinal.pdf

- **Milliman Research Report - A Discussion of Actuarial Guideline 43 for Variable Annuities, Junus and Motiwalla, April 2009**
  http://www.milliman.com/expertise/life-financial/publications/rr/pdfs/discussion-actuarial-guideline-43-RR04-01-09.pdf

3.7 Capital requirements

The Australian regulatory capital standards now cater specifically for variable annuity products. APRA's LPS 110 Attachment A specifies the basis and permits up to 70% of the benefits of dynamic hedging to be available to reduce capital requirements.

Two presentations have been made to the Actuaries Institute:

- **Investment Guarantee Product Risk Management by John Nichols**
  http://www.actuaries.asn.au/Library/Events/FSF/2008/FSF08_2b_PPT_Nicholls.pdf

- **Approaches to Setting Capital for Investment Guarantees by John Nicholls and Isma Tuzovic**
  http://www.actuaries.asn.au/Library/events/Conventions/2011/ApproachesToSettingCapital-Presentation.pdf

4 Recent developments

- **Press release on UK VA sales by Towers Watson**
  http://www.towerswatson.com/press/6882

  Sales in the UK have now topped GBP1 billion in 2011 although they are slightly below peak sales in 2008. The press release shows that sales jumped by more than 100% in 2007 and have ranged between GBP1.15b and GBP0.95b over the last four years.

- **Bloomberg Press Release on US Q1 Sales in 2012**
  http://www.bloomberg.com/news/2012-05-18/variable-annuity-sales-slide-7-as-metlife-cuts-back.html

  Sales in the US have declined in Q4 2011 and Q1 2012. The level of sales is still significant: USD36b of sales in Q1 2012. The decline is attributed to MetLife who have reduced their guarantees.

- **Performance of insurance company hedging programs during the recent capital market crisis - Milliman Research Report - November 2008**
  http://www.milliman.com/expertise/life-financial/publications/rr/pdfs/performance-insurance-company-hedging-rr12-01-08.pdf

- **Responding to the Variable Annuity Crisis by McKinsey**
  http://www.mckinsey.com/clientservice/financialservices/pdf/Responding_to_the_Variable_Annuity_Crisis.pdf

This analyses the losses in the GFC arising from unhedged guarantees and hedges that did not function appropriately. It estimated that hedges prevented losses of some $40bn, but that the industry lost a further $15bn that had not been hedged.

5 Market capacity

One of the major concerns facing variable annuity providers is whether there will be sufficient market capacity to provide for a dynamic hedging program over the lifetime of the existing book. There appears to be limited published research on this although Aonbenfield recently noted: "Hedging strategies have become even more sophisticated and will prove interesting to see how they hold up during the current turmoil in the financial markets. The reinsurance market continues to be relatively limited with traditional reinsurers wary of market risk and policyholder behavior risk. Several banks are providing packaged hedging/reinsurance solutions but also on a limited basis at terms some companies find out of line with their own pricing."

http://thoughtleadership.aonbenfield.com/Documents/201109_ab_reinsurance_market_outlook.pdf

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