Institution: City University London

Unit of Assessment: 19 Business and Management Studies

Title of case study: Preventing insolvency of non-life insurance firms by understanding and quantifying the uncertainty of outstanding insurance claims

1. Summary of the impact

The claims reserve can be the single most important item on the balance sheet of general (non-life) insurance companies and the uncertainty of this item can have serious consequences for assessing solvency, setting capital requirements, company valuation and making sure firms can meet the claims of policyholders. Professors Richard Verrall and Jens Perch Nielsen at City University London developed new methods and insights into claims reserving to enable practitioners to understand how to use powerful statistical methodology in conjunction with their existing *ad hoc* approaches. Their research has been incorporated into the curriculum for professional actuaries in the UK and the US; has informed the debate among practitioners and regulators about the best way to estimate the claims reserve; has influenced the accounting treatment of the claims reserve liability; has changed the way the claims reserve is calculated in a major global non-life insurance company; has been commercially adopted into a new generation of reserving software by a major software company; and has assisted insurance companies striving to meet the regulatory requirements of Solvency II, the new EU Directive that sets the amount of capital insurance companies must hold to reduce the risk of insolvency.

2. Underpinning research

Claims reserving, or loss reserving, refers to the calculation of the required reserves for a general (non-life) insurance business. Typically, the claims reserves represent the funds which should be held by the insurer so it can meet future claims arising from policies in force. The claims reserve is a liability on the balance sheet as it represents an obligation to pay policyholders in the event that they claim for loss. Methods of calculating reserves in general insurance are different from those used in life insurance and health insurance since general insurance contracts are typically of a much shorter duration, often one year, and incur only one premium payment at the start of the contract in exchange for insurance coverage over the insured period.

The need to calculate accurately the outstanding claims reserve liability arises in several different circumstances: (a) assessing the financial condition of an insurer, since movements in reserves over a period are key to assessing the insurer's progress; (b) pricing potential insurance business in the sense of estimating the future cost of claims on risks yet to be insured; (c) assessing the solvency of an insurer, in terms of its ability to meet its liabilities; (d) valuing the net worth of an insurer, particularly for the purposes of sales or acquisitions; and (e) assessing the insurer's obligations under the EU Solvency II Directive on insurance regulation which concerns the amount of capital insurance companies must hold in reserve to reduce the risk of insolvency.

Over a period of fifteen years, Professors Verrall (at City since 1987) and Nielsen (at City since 2007) in the Faculty of Actuarial Science & Insurance at Cass Business School, have made several major advances in claims reserving for general insurance. In essence, their work codified over one hundred years of tacit knowledge in the non-life insurance industry in terms of modern mathematical statistics which led to greater understanding of and better techniques for estimating future insurance claims. Their research presents non-life insurance companies with a coherent and practical approach to understanding and quantifying claims liabilities.

The foundations of this research were published in two papers by England and Verrall (1999, 2002) which have had a significant and widespread influence on the understanding and application of statistical methodology for claims reserving. England was a City PhD graduate in 1993 then became a visiting researcher. The first paper showed how the heuristic method or 'chain-ladder' technique may be used with bootstrapping to derive a distribution for outstanding claims liabilities alongside the familiar central estimate. Bootstrapping is a statistical method which provides an estimate of the distribution of the outstanding liabilities using only the data. The ingenious simplicity by which the authors implemented this technique has made it one of the most popular methods used by insurance companies, consultancies and regulators. The second paper by England and Verrall (2002) set out a coherent framework within which existing claims reserving methods were presented, evaluated and compared with a stochastic approach to claims reserving, enabling

readers easily to compare each method. Stochastic claims reserving produces estimates not only of the expected value of the future payments but also of the variation about that expected value, thereby quantifying the uncertainty of claims.

Verrall collaborated with Nielsen in a research partnership with Royal and Sun Alliance (now RSA Group), the global non-life insurance company, to demonstrate how combining tacit knowledge with mathematical statistics, rather than actuarial science, can improve the calculation of the outstanding claims reserve liability. The collaboration resulted in RSA Group adopting and implementing the techniques. RSA Group actuaries and risk managers identify and report annually to the researchers on any shortcomings of the research. This symbiotic 'knowledge loop' guides continuing academic research and provides RSA Group with tools to understand their liabilities better. This industry-academia partnership has enabled the researchers to produce one academic paper each year since 2008 on specific aspects of the methods and their implementation. The papers were published in leading actuarial science and statistics journals. Several of them were co-authored with academics at the University of Oxford, see for example Kuang *et al* 2011.

The Cass team continues its work to find better ways to estimate the claims reserve. In 2012, the group was the first to develop and publish the 'double chain ladder' method which takes the old chain ladder technique and formalises it with mathematical statistics (Martinez-Miranda *et al.* (2012)). This research took four years and developed expert input to translate actuarial knowledge into modern statistics. The same year, Verrall and Wüthrich (2012) applied the reversible jump Markov chain Monte Carlo (RJMCMC) method to the problem of setting the claims reserve. The RJMCMC method represents an improvement over the manual processes often employed in practice. In particular, the RJMCMC method describes parameter reduction and tail factor estimation in the claims reserving process and provides the full predictive distribution of the outstanding loss liabilities.

3. References to the research

England P. & Verrall R. (1999). Analytic and bootstrap estimates of prediction errors in claims reserving. *Insurance: Mathematics and Economics*, 25(3), 281–293. [141 Google Scholar citations]
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Kuang D., Nielsen B., & Nielsen J.P. (2011). Forecasting in an extended chain-ladder-type model. *Journal of Risk and Insurance*, 78(2), 345–359.
Martinez-Miranda M.D., Nielsen J.P.,& Verrall R. (2012). Double Chain Ladder**.** *ASTIN Bulletin*, 42(1), 59-76.
Verrall R. & Wüthrich M.V. (2012). Reversible jump Markov chain Monte Carlo method for parameter reduction in claims reserving. *North American Actuarial Journal*, 16(2), 240-259.

The research was published in journals that apply a stringent peer-review process prior to accepting articles for publication and supported by a Marie Curie Fellowship [FP7-PEOPLE-2011-IEF- 302600] Stochastic reserving based upon mathematical statistics, Dr María Martinez-Miranda.

4. Details of the impact

Verrall's research on stochastic claims reserving has had a profound and lasting influence on the teaching and conduct of professional actuaries in the UK and overseas. Over a 15 year period, he has completed eight research projects for the Institute of Actuaries, providing its members with cutting-edge knowledge attuned to the realities of their working lives [1]. Verrall also advises the Institute's curriculum team, has written course handbooks and provides research-led CPD courses while his seminal research with England is core reading for the General Insurance examination and essential reading for anyone involved with claims reserving [1b]. The influence of his research is far-reaching as the Institute of Actuaries is one of only two professional bodies representing actuaries in the UK and has a membership of 15,700.

Verrall's work has also influenced the body of knowledge taught to actuaries in the USA where his name receives over 400 'hits' on the website of the Casualty Actuarial Society (CAS) and his seminal papers are core reading for professional examination 7 on Insurance Company Valuation [2]. In 2009 the CAS, the professional body of actuaries in the USA involved in general insurance,

awarded him the Variance Prize for showing how expert opinion can be inserted into a stochastic framework for loss reserving [2b]. The CAS has over 5,600 full members making it the country's second largest actuarial body. The CAS former President Roger M Hayne said: "*To say that the work of Professor Verrall's and others at the Cass Business School in the area of assessing and understanding the uncertainty or volatility in one of the most common loss estimation techniques is seminal might just be an understatement. More than mere citations in academic papers, that work has formed the basis of techniques used by a fairly large number of insurers and consultants to approach this very critical issue…A very large majority of consultants and a substantial proportion of insurers use bootstrap techniques stemming from the work of Professor Verrall in their practical work in understanding and quantifying uncertainty in liability estimates*" [3].

Verrall's research has influenced thinking on how claims liabilities are treated on the balance sheets of general insurance companies, benefiting issuers, auditors and users of financial information. In particular, his work has influenced how the existing accounting treatment of the reserving risk account has deficiencies because of the common use of deterministic approaches to claims liability and how this might be improved through new (stochastic) methods of estimation [4]. Given that non-life insurance accounts for 5% of UK gross national product and the claims reserve is, perhaps, the single most important number on the balance sheet, it is not surprising that this research has caught the attention of the financial regulators. Paul Sharma of the former Financial Services Authority (FSA) said of Verrall and England's research: "*The FSA would like to see the latest techniques available to, and applied by, all general insurance actuaries. The FSA regards stochastic models as fundamental to the accounting reforms that the International Accounting Standards Board is currently developing. The FSA would also like to see stochastic models become fundamental in regulations both in the UK and in Europe… and would like to see the models introduced in the paper as a first stage in producing standard stochastic techniques for regulatory purposes*" [5].

In 2008, a major collaboration began between Verrall and Nielsen and RSA Group. Research and its application for practical purposes gave the global non-life insurance giant a better understanding of, and improvements in, their claims reserving model [6]. Cass researchers immersed themselves among RSA Group's personnel and systems in order to use expert industry knowledge within the framework of sound statistical approaches. The impact of this collaboration was enhanced by long-term knowledge sharing between RSA Group and Cass researchers, a process which continues. Following the success of the research collaboration, the RSA team responsible for claims reserving seized the opportunity to embed the research into the training offered to its graduate trainees. Malcolm Cleugh, Reserving Actuary at RSA Group, commented that RSA had been working with Professor Nielsen for nine years, applying his reserving research in a summer internship programme with final year students from the University of Oxford. The interns apply the research to real life RSA reserving data and assess the validity of the methodologies developed [7]. Reserve model validation is a requirement under Pillar One of Solvency II, the EU Directive which sets the amount of capital an insurer should hold, due to come into effect in 2014.

The strategy of the RSA Group is to ensure it creates leading positions in its chosen markets. This has required RSA to explore the latest developments in actuarial science and statistics that could improve the management of its business. The close collaborative work with Nielsen and Verrall has convinced RSA Group of the advantages of the double chain ladder method and RSA implements it in its daily operations. This has provided RSA Group with a scientific understanding and a means to validate its work through well-established principles of mathematical statistics [8]. An indication of the scale and reach of the work is evidenced by the fact that RSA is active in 130 countries and in 2011 received £8,138M of net written insurance premiums, £3,701M of which were in the UK and Western Europe [9].

In late 2012, ACTUARIS International, a leading actuarial software company, seeing the potential benefits to their clients of the Reversible Jump Markov Chain Monte Carlo method, proposed by Verrall and Wüthrich in 2012, adopted it into their new generation of reserving software, IBNRS. In a communication to clients and subscribers ACTUARIS said: "*This research underlined the strong added value of RJMCMC to actuaries: and this is the reason why ACTUARIS International's teams then decided to implement this method in its reserving software IBNRS.*" In order to prove how

efficient and useful the method is, ACTUARIS International, in association with BNB (Belgium supervisor), led a real case study on the method, using anonymous data from the Belgian market. The conclusion was that the method gives results quite similar to those provided by classical chain ladder without requiring as many manual inputs and leads to generally lower standard deviation and VaR (Value at Risk), which lead to lower capital cost [10]. Once again, the benefits underpinned by the research are felt far and wide. ACTUARIS International provides software to over 200 insurance companies worldwide, including AXA Insurance Group, which has favourably appraised the IBNRS software [11].

The research insights of Verrall's seminal work on stochastic claims reserving and bootstrapping combined with Nielsen's expertise in applying these methods in real settings have enabled the researchers to influence the general insurance industry on an international scale by producing numerical estimates to show that their theory works and through their ability to interpret real world phenomenon as examples of a general class of events that the core theory might be used to examine. Dix Roberts, Chief Actuary at RSA Group, said: "*The work of Verrall was of fundamental influence and is used by us on a daily basis in a number of different applications. We have since then worked with Nielsen on business-driven issues that have led to further academic research papers by Nielsen and Verrall and their co-authors. This whole body of work that is accessible and easy to use through their free software is now of growing importance for our business as well as for other non-life insurance companies around the globe*" [12].

5. Sources to corroborate the impact

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3. President of the Casualty Actuarial Society, 2009-2010, and currently Chair of the Scientific Committee for the 2014 International Congress of Actuaries, testimony given 26th April 2013 is available on request
4. Bell, Rowen B (2008). Margins in Medical Claim Liabilities under Future Accounting Models, *Actuarial Practice Forum*, Society of Actuaries (US), August issue
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8. Nielsen, Jens Perch and Roberts, Dix (2011). 'Double Chain Ladder with a touch of Bornhutter-Ferguson', Presentation at the General Insurance Convention and Exhibition (GIRO), 11th–14th October 2011. Around 600 British non-life actuaries were in attendance
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10. ACTUARIS International (2013) RJMCMC method - ACTU-Software, Email to subscribers and clients (4th January) available on request
11. Dumas, Stéphane (2013) Appraisal of ACTUARIS International IBNRS software, Head of Group P&C Reserving, Group Risk Management, GIE AXA (1st July)
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