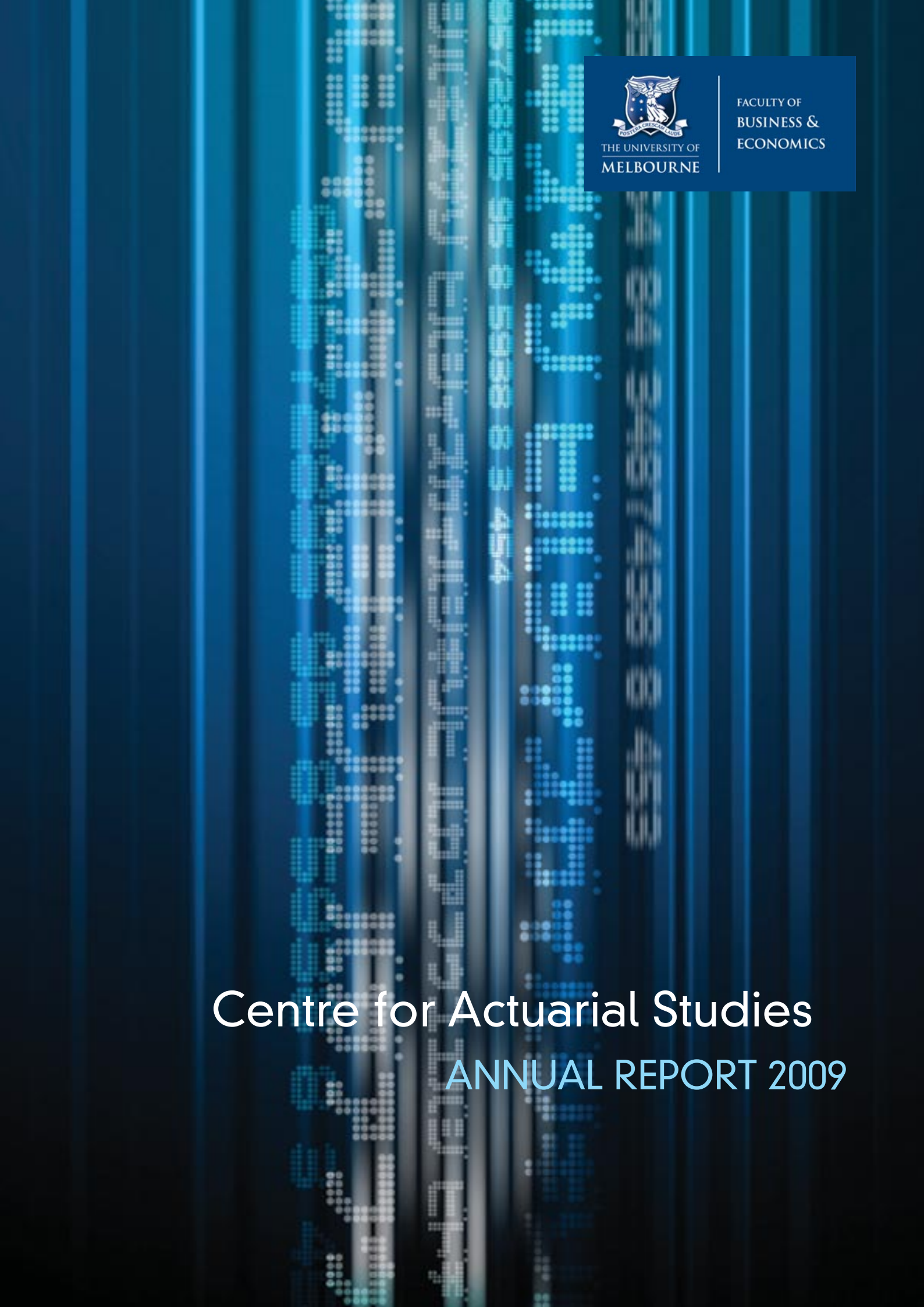

Centre for Actuarial Studies

ANNUAL REPORT 2009

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The Year in Review

The main activities of the Centre for Actuarial Studies are teaching future actuaries, research and knowledge transfer. The Centre is proud of the high achieving students it attracts and strives to give them the best preparation for actuarial and other quantitative work. Because it is fully accredited by the Institute of Actuaries of Australia, the Centre for Actuarial Studies allows its students to obtain exemptions from the whole of Parts I and II of the actuarial examinations. With regard to research, the members of the Centre are experts in their fields and are internationally recognised for their work in actuarial science, financial mathematics and related disciplines. The Centre has seven full-time academic staff and a number of part-time lecturers from the actuarial profession (the complete list is at the end of this report).

The new degree of Master of Actuarial Science was created in 2009, and will come into existence in 2011. In 2009 the Centre saw an increase in the number of students, while research output remained at a good level.

Staff News

Daniel Dufresne became Director of the Centre in 2009, after David Dickson stepped down at the end of 2008.

Ping Chen joined the Centre for Actuarial Studies as Lecturer in September, having just completed her PhD in Actuarial Science at the University of Hong Kong.

Shuanming Li was promoted from Senior Lecturer to Associate Professor, effective at the beginning of 2010.

David Dickson was appointed as an editor of the ASTIN Bulletin, having previously served on its Editorial Board. David was on long service leave for nine weeks in the middle of the year.

David Pitt was appointed as an associate editor of the Australian Actuarial Journal.

Student Recruitment

Overall enrolments were up slightly from their 2008 level. Enrolments at the 3rd year level were very good, and 37 students completed the Honours year. Details of enrolments are shown on page 5.

David Pitt and Richard Fitzherbert ran three classes in the Melbourne Schools Partnership International Program for high achieving Year 11 students. These were very well attended with over 100 students learning about the Actuarial Studies Program at Melbourne.

The Centre's promotional activities included other school visits by David Dickson and David Pitt.

Teaching

David Dickson and Mr Mike Pottenger, Department of Economics, were awarded a Faculty Teaching Innovation, Application and Staff Development Grant of just over $25,000 for a project entitled "E-learning and collaborative learning in business statistics". David is teaching the subject Quantitative Methods for Business, which is a core subject in the Faculty's Master of Management degree.

David Pitt and Xueyuan Wu were awarded a teaching grant of $10,000 for a project entitled "Development of a capstone subject in Actuarial Studies".

Teaching was supported by a number of external lecturers including Mr Richard Fitzherbert (for Financial Mathematics I and II), Mr Donald Campbell, Dr Jules Gribble, Mr David Heath, Mr Cary Helenius and Dr Allen Truslove (for Actuarial Practice and Control I and II).

New Master in Actuarial Science

The Master of Actuarial Science degree will commence in 2011. This two-year program will consist of 16 subjects (8 core plus 8 elective subjects) and will provide actuarial education for graduates who have mathematical or statistical specialisations (e.g. in commerce, mathematics, physics or engineering). The course enables students who obtain a sufficiently high pass to receive exemptions from the professional actuarial examinations conducted by the Institute of Actuaries of Australia and the Institute of Actuaries (UK), as is already the case for our undergraduate program. The program director is Professor David Dickson. Further information about this new degree is available online at http://www.melbournegsm.unimelb.edu.au/programs/actuarial-studies/master-of-actuarial-science.html.

University of Melbourne Actuarial Alumni

David Dickson hosted an actuarial alumni evening in Singapore in May that was attended by 15 graduates from 1999 to 2008.

Research Areas and Publications

Research continued in a variety of areas including applied probability, disability income insurance, financial mathematics, investments, market models and risk theory. Staff continue to publish in top journals and to present their work at seminars and conferences around the world. The Centre holds the Joint Seminar Series on Stochastic Processes and Financial Mathematics, in collaboration with the Department of Mathematics and Statistics.

Details of publications and additions to the Centre's Research Paper Series can be found at the end this report.

The Year in Review

Research Grants

Several members of the Centre have ongoing grants from the Australian Research Council. Staff who obtained new grants in 2009 are: David Pitt and Yan Wang (RMIT), Australian Actuarial Research Grant of $13,588 for their project "Claim termination for income protection insurance and data mining"; Xueyuan Wu and Shuanming Li, Australian Actuarial Research Grant of $7,000 for their project "On the recursive evaluation of aggregate claims for a large family of claim number distributions". Both grants are funded by the Institute of Actuaries of Australia.

Visitors

Professor David Stanford, from the Department of Statistics and Actuarial Science at the University of Western Ontario, visited the Centre in February. David gave a talk entitled "Perturbed Risk Processes Analysed as Fluid Flows".

Professor Peter Cerone from Victoria University visited the Centre from February to July.

A group of academics from the Central University of Finance and Economics, China, visited the Centre in August, including Professor Cunwen Tao, Associate Professors Lijun Guo and Jingfeng Xu, and Dr. Sujin Zheng, all from the Department of Actuarial Science, School of Insurance.

Professor Jiadong Tong and Professor Junyi Guo from Nankai University, China, visited the Faculty and the Centre for Actuarial Studies in December for discussions about a joint Masters degree in Actuarial Science, to be taught in Tianjin and in Melbourne.

Student exchange again took place with the Department of Actuarial Mathematics and Statistics at Heriot-Watt University, with two Melbourne students returning in July and two departing in September to spend a year in Edinburgh.

Knowledge Transfer

David Dickson co-authored a textbook with Mary Hardy (University of Waterloo, Canada) and Howard Waters (Heriot-Watt University, Edinburgh) entitled "Actuarial Mathematics for Life Contingent Risks", published by Cambridge University Press.

Mark Joshi is an administrator of the xlw open-source project, which released version 4.0 in 2009. This project provides a mechanism for the automatic integration of new functions into EXCEL, and is widely used in the banking industry to provide a user-friendly front-end for pricing models. The 4.0 release achieves new levels of user-friendliness by providing template projects that make it even faster for a new user to get started. Its functionality is also extended to encompass C# and VB.net as well as C++.

Mark Joshi continued to contribute to the QuantLib open source derivatives pricing library and gave a training course on it and the LIBOR market model with MoneyScience at the Institute of Physics in London in February.

During the year the members of the Centre acted as referees for a wide variety of academic and professional journals (listed later in this report).

Professional Activities

David Dickson is an external examiner for the actuarial program at Nanyang Business School, Singapore, and also independent examiner for the UK actuarial profession.

Awards

Ping Chen was awarded the Best Demonstrator Award by the Department of Statistics and Actuarial Science, The University of Hong Kong.

David Dickson and Shuanming Li were each awarded a Dean's Certificate for Research Excellence for 2009.

Shuanming Li was awarded a Dean's Certificate for Teaching Excellence for 2009.

David Pitt was awarded an ALTC Citation by the Australian Learning and Teaching Council. This is an outstanding achievement at the national level. He was also awarded a Dean's Certificate for Teaching Excellence for 2009.

Teaching

Subject Name	2007	2008	2009
300-101 Introduction to Actuarial Studies	124	164	161
300-203 Financial Mathematics I	125	146	119
300-204 Financial Mathematics II	100	130	99
300-205 Introduction to Actuarial Practice	52	—	—
300-312 Actuarial Modelling I	76	86	119
300-313 Actuarial Modelling II	70	87	118
300-314 Contingencies	68	82	97
300-315 Actuarial Statistics	60	84	89
300-316 Models for Insurance and Finance	63	80	89
300-334 Financial Mathematics III	65	80	109
300-400 Actuarial Studies Research Essay	7	5	6
300-406 Risk Theory I	40	48	39
300-407 Risk Theory II	10	23	15
300-408 Advanced Financial Mathematics I	37	42	37
300-409 Actuarial Studies Projects	34	41	33
300-410 Actuarial Practice and Control I	42	45	37
300-411 Actuarial Practice and Control II	37	31	27
300-412 Advanced Financial Mathematics II	27	9	17
Total Enrolments	**1037**	**1183**	**1211**

The following students successfully completed a Bachelor of Commerce (Honours) with a specialisation in Actuarial Studies:

Jason Aront
Vitaly Beliavski
Luv Bhatnagar
Vanessa Box
Chen Siang Cheong
Ting Chen
Yoong Xiong Chong
Lai Keong Chuah
Richard Cooney
Nguyen Dat Diep
Kimberly Fraser
Alastair Hawkins
Li Jiang
Yew Kwang Khoo
Cecilia Yee-Man Li
Lu Li
Yan Liu
Benjamin Locke
James McDonald
Y'ng Yiing Phoon
Arjun Sathasivam
Jin Min Tricia Seow
Kok Keng Siaw
Yi Ping Tan
Yue Wang
Lifei Wang
Shona Wills
Kah Wai Wong
Shook Yeng Wong
Wei Raun Wong
Piotr Wydymus
Yang Xu
Nicholas Andrew Yap
Chong Yang
Yimeng Yang
Ling Mien Yeo
Yan Zhong

Honours Results and Essay Topics

The following are topics of essays submitted by Honours students. An Honours research essay is about 10,000 words and represents 25% of the final assessment for a student's Honours grade.

- Bivariate modelling techniques for the CTE risk measure
- Dividends in the threshold risk model
- Further results on matrix-form recursions for aggregate claims distribution
- Moments of the present value of aggregate claims in dependent risk models
- Truncation and acceleration of the Tian tree for the pricing of American put options
- A statistical analysis and application of a stochastic investment model

The table below shows the number of students awarded an Honours degree over the last three years and their overall grades.

	H1	H2A	H2B	H3	Total
2007	11	18	8	4	41
2008	13	16	11	6	46
2009	15	7	13	2	37

Student Prize Winners

Centre Awards

Honours Medal in Actuarial Studies
Shona Wills

ANZ Prize
For Financial Mathematics
Shona Wills

Aviva Prize
For Contingencies
Alexander Wiguna

Comminsure Prize
For Introduction to Actuarial Studies
Jeremiah Cheung and William Zheng

Deloitte Actuaries and Consultants Prize
For Actuarial Practice and Control I and II
Alastair John Hawkins

Institute of Actuaries of Australia Prize
For Research Essays and Projects (Honours year)
Ting Chen

Taylor Fry Prize
For Actuarial Statistics
Navin Ranasinghe

Towers Perrin Prize
For Risk Theory I and II
Shona Wills and Lai Keong Chuah

Faculty of Business and Economics Awards

J.F. Major Memorial Prize
For the best student in the third year of the Bachelor of Commerce degree
Alexander Wiguna

Kinsman Studentship Award and Kinsman Honours Research Essay Prize
For the best publishable article, and for the best Honours essay in the Department of Economics
Wang Chun Wei

PhD Students and Research Topics

Christopher Beveridge
Pricing long-dated exotic interest rate contracts in the displaced diffusion LIBOR market model

Jiun Hong Chan
Methodologies for computation in the stochastic volatility LMM

Stephen Chin
Option pricing under stochastic volatility

Nicholas Denson
Variance reduction using a Markov LIBOR market model

Evan Hariyanto
Pricing and risk management of reverse mortgages in the Australian market

Jingchao Li
Finite time ruin problems

Qing Liu
Bivariate claim modelling for general insurance

Ciyu Nie
A lower barrier alerting system for risk processes

Robert Tang
The accurate estimation of Greeks in multi-factor credit interest-rate hybrid models

Chao Yang
Pricing and hedging models

Publications and Other Research Activities in 2009

Book

Dickson D, Hardy M and Waters H. Actuarial Mathematics for Life Contingent Risks. Cambridge University Press, xvii+493 pages.

Refereed Journal Articles

Beveridge C, Denson N and Joshi M. Comparing discretisations of the LIBOR market model in the spot measure. *Australian Actuarial Journal.* **15** (2): 231-253.

Chan J, Joshi M, Tang R and Yang C. Trinomial or binomial: Accelerating American put option price on trees. *Journal of Futures Markets.* **29** (9): 826-839.

Dufresne D, Garrido J and Morales M. Fourier inversion formulas in option pricing and insurance. *Methodology and Computing in Applied Probability.* **3** (11): 359-383.

Denson NA and Joshi M. Flaming logs. *Wilmott Journal.* **1** (5-6): 259-262.

Joshi M. Achieving smooth asymptotics for the prices of European options in binomial trees. *Quantitative Finance.* **9** (2): 171-176.

Joshi M. The convergence of binomial trees for pricing the American put. *Journal of Risk*. **11** (4): 87-108.

Li S and Lu Y. The distribution of total dividend payments in a Sparre Andersen model. *Statistics and Probability Letters.* **79** (9): 1246-1251.

Li S, Lu Y and Garrido J. A review of discrete-time risk models. *Real Academia de Ciencias Exactas, Fisicas y Naturales. Revista. Serie A, Matematicas.* **103** (2): 321-337.

Lu Y and Li S. The Markovian regime-switching risk model with a threshold dividend strategy. Insurance: *Mathematics and Economics.* **44** (2): 296-303.

Tanthanongsakkun S, Pitt D and Treepongkaruna S. A comparison of corporate bankruptcy models in Australia: The Merton vs accounting based models. *Asia-Pacific Journal of Risk and Insurance*, **3** (2): 93-112.

Taylor G. The chain ladder and Tweedie distributed claims data. *Variance.* **3**: 96-104.

Taylor G and McGuire G. Adaptive reserving using Bayesian revision for the exponential dispersion family. *Variance*. **3**:105-130.

Wu X and Li S. On the discounted penalty function in a discrete time renewal risk model with general interclaim times. *Scandinavian Actuarial Journal*. **4** (109): 281-294.

Zhang Z, Li S and Yang H. The Gerber-Shiu discounted penalty functions for a risk model with two classes of claims. *Journal of Computational and Applied Mathematics.* **230** (2): 643-655.

Other Publications

Dickson D. Discussion of "On the joint distributions of the time to ruin, the surplus prior to ruin, and the deficit at ruin in the classical risk model" by D. Landriault and G. Willmot. *North American Actuarial Journal*. 13 (2): 271-272.

McKenzie G, Gribble J, Pilger J. Developing the framework – industry efficiencies. *Superfunds*, No. 335.

Conference and Seminar Presentations

Beveridge, Chris

Generic methods for obtaining rapid and tight bounds for Bermudan derivatives using Monte Carlo simulations, Stochastic Processes and Financial Mathematics Seminar, The University of Melbourne, April.

Generic methods for obtaining rapid and tight bounds for Bermudan derivatives using Monte Carlo simulations, Actuarial Science Seminar, The University of Amsterdam, September.

Generic methods for obtaining rapid and tight bounds for Bermudan derivatives using Monte Carlo simulations, Quantitative Methods in Finance conference, The University of Technology Sydney, December.

Chen, Ping

Explicit solutions of optimal investment-consumption strategies under uncontrollable liabilities in a regime-switch market. Istanbul, Turkey, May.

Dickson, David

On the ruin time distributions for a Sparre Andersen process with exponential claim sizes. Poster at Institute of Actuaries of Australia Biennial Convention, Sydney, April.

The probability and severity of ruin in finite time, Nanyang Business School, Singapore, May.

Finite time ruin problems in Erlang risk models, Australasian Actuarial Education and Research Symposium, University of New South Wales, December.

Dufresne, Daniel

Beta-gamma algebra and Barnes' integrals, Australian Mathematical Society Conference, University of South Australia, January.

Beta-gamma algebra, discounted cash-flows and Barnes' Lemmas, Concordia University, Montreal, July.

Formule de Parseval pour options dans un modèle avec volatilité stochastique, Université du Québec à Montréal, August.

Option pricing with stochastic volatility: Applying Parseval's Theorem, Australasian Actuarial Education and Research Symposium, University of New South Wales, December.

Publications and Other Research Activities in 2009

Education in Australian universities: Fooled by Measurement, Australasian Actuarial Education and Research Symposium, University of New South Wales, December.

Gribble, Jules

Quantifying and Managing a Risk Culture, Institute of Actuaries of Australia Biennial Convention, Sydney, April.

Joshi, Mark

Market model vegas in the displaced diffusion LMM, Sydney, December.

Li, Shuanming

Some results for a Sparre Andersen model with phase-type inter-claim times. Poster at Institute of Australia Biennial Convention, Sydney, April.

Pitt, David

Model selection and claim frequency for workers' compensation insurance, Melbourne, May.

Model selection and claim frequency for workers' compensation insurance, London, U.K., December.

Model selection and claim frequency for workers' compensation insurance, Barcelona, Spain, December.

Taylor, Greg

The chain ladder and Tweedie distributed claims data, Casualty Actuarial Society Spring Meeting, New Orleans, May.

Treatment of large claims in pricing and reserving. Institute of Actuaries GIRO Seminar, Edinburgh, October.

A few reflections of a research-aware practitioner, Institute of Actuaries of Australia Biennial Convention, Sydney, April.

Valuation assumptions, Institute of Actuaries of Australia seminar on "GI in a GFC world", Sydney, June.

Wu, Xueyuan

Matrix-form recursions for a family of compound distributions, Australasian Actuarial Education and Research Symposium, UNSW, December.

Involvement as Editors and Reviewers

David Dickson is an editor of ASTIN Bulletin, an associate editor of Insurance: Mathematics and Economics, the British Actuarial Journal, and Annals of Actuarial Science. David is also a member of the editorial board of North American Actuarial Journal.

Shuanming Li is a reviewer for American Mathematical Reviews.

David Pitt is an associate editor of Australian Actuarial Journal.

Greg Taylor is an associate editor of Insurance: Mathematics and Economics.

Members of the Centre acted as reviewers for the following journals and publishers:

Acta Mathematica Applicatae Sinica

Annals of Actuarial Science

Annals of Applied Probability

ANZIAM

Applied Mathematics—A Journal of Chinese Universities

Applied Mathematics and Computation

Applied Stochastic Models in Business and Industry

Asian Journal of Control

ASTIN Bulletin

Australian Actuarial Journal

Blätter der DGVFM

Cambridge University Press

IMA Journal of Management Mathematics

Insurance: Mathematics and Economics

International Journal of Theoretical and Applied Finance

Journal of Computational and Applied Mathematics

Journal of Optimization Theory and Applications

Journal of Inequalities and Applications

Journal of Quantitative Finance

Journal of Systems Science and Complexity

Methodology and Computing in Applied Probability

North American Actuarial Journal

Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales

Scandinavian Actuarial Journal

Statistics and Probability Letters

Research Paper Series

Abstracts of the papers added in 2009 to the Centre's Research Paper Series are given below. All these papers may be found at http://www.economics.unimelb.edu.au/actwww/wps2009.shtml

No 180: A hierarchical Kalman filter

By Greg Taylor

Sundt's hierarchical credibility model is generalised to a dynamic form, i.e. a form in which parameters are assumed to evolve over time. This is done by superimposing a Kalman filter on Sundt's model. In the process it is shown that both Sundt's model and the Kalman filter may be derived as direct consequences of Hachemeister's credibility regression model. A numerical example in Section 7 illustrates the application of the hierarchical Kalman filter to a hierarchy of occupational groups. The example shows how parameter estimates produced by the filter track the true values of parameters better than the estimates from a static model when those parameters evolve over time.

No 181: G distributions and the beta-gamma algebra

By Daniel Dufresne

This paper has four interrelated themes: (1) express Laplace and Mellin transforms of sums of positive random variables in terms of the Mellin transform of the summands; (2) show the equivalence of the two Barnes' lemmas with known properties of gamma distributions; (3) establish properties of the sum of two reciprocal gamma variables, and related results; (4) study the G distributions (whose Mellin transforms are ratios of products of gamma functions).

No 182: A general formula for option prices in a stochastic volatility model

By Stephen Chin and Daniel Dufresne

We consider the pricing of European derivatives in a Black-Scholes model with stochastic volatility. We show how Parseval's theorem may be used to express those prices as Fourier integrals. This is a significant improvement over Monte Carlo simulation in many cases. The main ingredient in our method is the Laplace transform of the ordinary (constant volatility) price of a put or call in the Black-Scholes model, where the transform is taken with respect to maturity (T); this does not appear to have been used before in pricing options under stochastic volatility. We derive these formulas and then apply them to the case where volatility is modelled as a continuous-time Markov chain, the so-called "Markov regime switching model". This model has been used previously in stochastic volatility modelling, but mostly with only N = 2 states. We show how to use N = 3 states without difficulty, and how larger number of states can be handled. Numerical illustrations are given, including the implied volatility curve in two and three-state models. The curves have the "smile" shape observed in practice.

No 183: Chain ladder forecast efficiency

By Greg Taylor

The paper considers two models of a claim triangle, for both of which the chain ladder algorithm for loss reserving is maximum likelihood. Section 4 examines the relation between them in terms of fitted values and forecasts. Later sections consider the prediction efficiency of the CL algorithm. For one model, the algorithm is found to be minimum variance unbiased; for the other, it is biased but, if corrected for bias, is also minimum variance unbiased (Section 5). The minimum variance unbiased estimators are also minimum prediction error unbiased forecasts (Section 6).

No 184: A review of the methodology of forecasting long-term equity returns

By Richard Fitzherbert

There are two main approaches to forecasting the long-term return from equities as an asset class. The first is to assume a premium over interest rates or bond returns, justified by the risk-averse behaviour of portfolio investors. The second approach is to project dividend income assuming a link with inflation and/or parity with gross domestic profit. Except for GDP parity, these methods are all supported, superficially, by historical data. However the causal justifications for either the risk premium or the inflation link are dubious – which reduces the status of these assumptions from laws of nature to historical regularities upon whose future we can only speculate. In a business environment in which historical cost accounting prevails, return-on-shareholders' equity is the key variable which determines the underlying long-term return from equity portfolio investment which is monetary and not real in nature. Adjustments are required when historical cost accounting is not strictly applied.

No 185: Stochastic volatility and option pricing

By Daniel Dufresne

Stochastic volatility models are now routinely used in investments and option pricing. A brief introduction to those models is first given, and then a method for pricing options is described. The stochastic process that later became known as "Brownian motion" first appeared in Bachelier (1900), as a model for security prices. Bachelier imagined the security price as an arithmetic Brownian motion; this has the shortcoming of allowing negative security prices. Osborne (1959), apparently unaware of Bachelier's work, proposed geometric Brownian motion (GBM) as a model for stock prices, in part because GBM cannot be negative. That model was used in economics from the 1960s, notably to value options. Black and Scholes (1973) also used GBM for their risky asset, and since then Osborne's GBM model for stock prices has often been called the "Black-Scholes model".

Research Paper Series

No 186: Matrix-form recursions for a family of compound distributions

By Xueyuan Wu and Shuanming Li

In this paper, we aim to evaluate the distribution of the aggregate claims in the collective risk model. The number of claims is firstly assumed to belong to a generalised (a, b, 0) family. A matrix form recursive formula is then derived to evaluate the related compound distribution when individual claim amounts follow a discrete distribution on the non-negative integers. The corresponding formula is also given for continuous individual claim amounts. Secondly, we pay particular attention to the recursive formula for compound phase-type distributions, since only certain types of discrete phase-type distributions belong to the generalised (a; b; 0) family. Similar recursive formulae are obtained for discrete and continuous individual claim amount distributions. Finally, numerical examples are presented for three counting distributions in this family.

No 187: The analysis of perturbed risk processes with markovian arrivals

By Jiandong Ren and Shuanming Li

In this paper, we study the perturbed risk processes with Markovian arrivals. We present explicit formulas for the Laplace transform of the time to cross a certain level before ruin, the Laplace transform of the time of recovery and the distribution of the maximum severity of ruin, as well as the expected discounted dividends and the distribution of the total dividends prior to ruin for the risk model in the presence of a constant dividend barrier.

No 188: The perturbed compound Poisson risk model with two-sided jumps

By Zhimin Zhang, Hu Yang, and Shuanming Li

In this paper, we consider a perturbed compound Poisson risk model with two-sided jumps. The downward jumps represent the claims following an arbitrary distribution, while the upward jumps are also allowed to represent the random gains. Assuming that the density function of the upward jumps has a rational Laplace transform, the Laplace transforms and defective renewal equations for the discounted penalty functions are derived, and the asymptotic estimate for the probability of ruin is also studied for heavy-tailed downward jumps. Finally, some explicit expressions for the discounted penalty functions, as well as numerical examples, are given.

No 189: Fast sensitivity computations for Monte Carlo valuation of pension funds

By Mark Joshi and David Pitt

Sensitivity analysis, or so-called 'stress-testing', has long been part of the actuarial contribution to pricing, reserving and management of capital levels in both life and non-life assurance. Recent developments in the area of derivatives pricing have seen the application of adjoint methods to the calculation of option price sensitivities including the well-known 'Greeks' or partial derivatives of option prices with respect to model parameters. These methods have been the foundation for efficient and simple calculations of a vast number of sensitivities to model parameters in financial mathematics. This methodology has yet to be applied to actuarial problems in insurance or in pensions. In this paper we consider a model for a defined benefit pension scheme and use adjoint methods to illustrate the sensitivity of fund valuation results to key inputs such as mortality rates, interest rates and levels of salary rate inflation. The method of adjoints is illustrated in the paper and numerical results are presented. Efficient calculation of the sensitivity of key valuation results to model inputs is useful information for practising actuaries as it provides guidance as to the relative ultimate importance of various judgments made in the formation of a liability valuation basis.

No 190: Fast and accurate pricing and hedging of long-dated CMS spread options

By Mark Joshi and Chao Yang

We present a fast method to price and hedge CMS spread options in the displaced-diffusion co-initial swap market model. Numerical tests demonstrate that we are able to obtain sufficiently accurate prices and Greeks with computational times measured in milliseconds. Further, we find that CMS spread options are eakly dependent on the at-the-money Black implied volatility skews.

No 191: Efficient greek estimation in generic market models

By Mark Joshi and Chao Yang

Abstract: We first develop an efficient algorithm to compute Deltas of interest rate derivatives for a number of standard market models. The computational complexity of the algorithms is shown to be proportional to the number of rates times the number of factors per step. We then show how to extend the method to efficiently compute Vegas in those market models.

No 192: Fast delta computations in the swap market model

By Mark Joshi and Chao Yang

We develop an efficient algorithm to implement the adjoint method that computes sensitivities of an interest rate derivative (IRD) with respect to different underlying rates in the co-terminal swap market model. The order of computation per step of the new method is shown to be proportional to the number of rates times the number of factors, which is the same as the order in the LIBOR market model.

Research Paper Series

No 193: Model selection and claim frequency for workers' compensation insurance

By Jisheng Cui, David Pitt and Guoqi Qian

We consider a set of workers' compensation insurance claim data where the aggregate number of losses (claims) reported to insurers are classified by year of occurrence of the event causing loss, the US state in which the loss event occurred and the occupation class of the insured workers to which the loss count relates. An exposure measure, equal to the total payroll of observed workers in each three-way classification, is also included in the dataset. Data are analysed across ten different states, 24 different occupation classes and seven separate observation years. A multiple linear regression model, with only predictors for main effects, could be estimated in 223+9+1+1 = 234 ways, theoretically more than 17 billion different possible models! In addition, one might expect that the number of claims recorded in each year in the same state and relating to the same occupation class, are positively correlated. Different modelling assumptions as to the nature of this correlation should also be considered. On the other hand it may reasonably be assumed that the number of losses reported from different states and from different occupation classes are independent. Our data can therefore be modelled using the statistical techniques applicable to panel data and we work with generalised estimating equations (GEE) in the paper. For model selection, Pan (2001) suggested the use of an alternative to the AIC, namely the quasi-likelihood under independence model criterion (QIC), for model comparison. This paper develops and applies a Gibbs sampling algorithm for efficiently locating, out of the more than 17 billion possible models that could be considered for the analysis, that model with the optimal (least) QIC value. The technique is illustrated using both a simulation study and using workers' compensation insurance claim data.

No 194: Assessing the impact of suicide exclusion periods on life insurance

By Paul Yip, David Pitt, Yan Wang, Xueyuan Wu and Tina Xu

We study the impact of suicide exclusion periods, which are common in life insurance, on the rates of suicide and of accidental death among life-insured individuals. The suicide exclusion period implies that if the life-insured individual were to die, where the cause of death is reported as suicide, during the exclusion period immediately after entering the policy of insurance, then the life insurance company would not be required to pay the sum insured to the deceased life's estate. Suicide exclusion periods are commonly thirteen months. Our first research hypothesis is that the imposition of a suicide exclusion period affects the timing of suicides of life-insured individuals. Our second research hypothesis relates to the rates of accidental deaths reported to insurers. Given that insurers will not pay sum insured benefits during the suicide exclusion period to individuals that die by suicide, it may be that there exists an increased desire to report deaths as accidental rather than as suicide during the suicide exclusion period. A third research hypothesis is that life insured individuals with higher sums insured have higher rates of suicide than other life-insured individuals. Crude and age-standardized rates of suicide, accidental death and overall death, split by duration since the insured first bought their insurance policy, were computed. There were significantly fewer suicides and no significant spike in the number of accidental deaths in the exclusion period for Australian life insurance data. An increased number of suicides were detected for the first two years after the exclusion period. Also, life-insured individuals with higher sums insured have higher rates of suicide than other life-insured individuals. These provide evidence suggesting the existence of adverse selection as a result of the exclusion period adopted in the life insurance industry in Australia. We suggest that by extending the exclusion period to three years, we might prevent some "insurance induced" suicides. The rationale for preventing suicide deaths by lengthening the suicide exclusion period is given.

No 195: Interpolation schemes in the displaced-diffusion LIBOR market model and the efficient computation of prices and greeks for callable range accruals

By Christopher Beveridge and Mark Joshi

We introduce a new arbitrage-free interpolation scheme for the displaced-diffusion LIBOR market model. Using this new extension, and the Piterbarg interpolation scheme, we study the simulation of range accrual coupons when valuing callable range accruals in the displaced diffusion LIBOR market model. We introduce a number of new improvements that lead to significant efficiency improvements, and explain how to apply the adjoint-improved pathwise method to calculate deltas and vegas under the new improvements, which was not previously possible for callable range accruals. One new improvement is based on using a Brownian-bridge-type approach to simulating the range accrual coupons. We consider a variety of examples, including when the reference rate is a LIBOR rate, when it is a spread between swap rates, and when the multiplier for the range accrual coupon is stochastic.

No 196: Graphical Asian options

By Mark Joshi

We discuss the problem of pricing Asian options in Black–Scholes model using CUDA on a graphics processing unit. We survey some of the issues with GPU programming and discuss code design and memory usage. We show that by using a Quasi Monte Carlo simulation with a geometric Asian option as a control variate, it is possible to get prices that are accurate to 2E-4 within a fiftieth of a second.

Research Paper Series

No 197: Pricing and deltas of discretely-monitored barrier options using stratified sampling on the hitting-times to the barrier

By Mark Joshi and Robert Tang

We develop new Monte Carlo techniques based on stratifying the stock's hitting-times to the barrier for the pricing and Delta calculations of discretely-monitored barrier options using the Black-Scholes model. We include a new algorithm for sampling an Inverse Gaussian random variable such that the sampling is restricted to a subset of the sample space. We compare our new methods to existing Monte Carlo methods and find that they can substantially improve convergence speeds.

No 198: Fast Monte-Carlo greeks for financial products with discontinuous pay-offs

By Jiun Hong Chan and Mark Joshi

We introduce a new class of numerical schemes for discretizing processes driven by Brownian motions. These allow the rapid computation of sensitivities of discontinuous integrals using pathwise methods even when the underlying densities post-discretization are singular. The two new methods presented in this paper allow Greeks for financial products with trigger features to be computed in the LIBOR market model with similar speed to that obtained by using the adjoint method for continuous pay-offs. The methods are generic with the main constraint being that the discontinuities at each step must be determined by a one-dimensional function: the proxy constraint. They are also generic with the sole interaction between the integrand and the scheme being the specification of this constraint.

No 199: Minimal partial proxy simulation schemes for generic and robust Monte Carlo greeks

By Jiun Hong Chan and Mark Joshi

In this paper, we present a generic framework known as the minimal partial proxy simulation scheme. This framework allows stable computation of the Monte-Carlo Greeks for financial products with trigger features via finite difference approximation. The minimal partial proxy simulation scheme can be considered as a special case of the partial proxy simulation scheme (Fries and Joshi, 2008b) as a measure change (weighted Monte Carlo) is performed to prevent path-wise discontinuities. However, our approach differs in term of how the measure change is performed. Specifically, we select the measure change optimally such that it minimises the variance of the Monte-Carlo weight. Our method can be applied to popular classes of trigger products including digital caplets, autocaps and target redemption notes. While the Monte-Carlo Greeks obtained using the partial proxy simulation scheme can blow up in certain cases, these Monte-Carlo Greeks remain stable under the minimal partial proxy simulation scheme. Standard errors for Vega are also significantly lower under the minimal partial proxy simulation scheme.

No 200: Practical policy iteration: generic methods for obtaining rapid and tight bounds for Bermudan exotic derivatives using Monte Carlo simulation

By Christopher Beveridge and Mark Joshi

We introduce a set of improvements which allow the calculation of very tight lower bounds for Bermudan derivatives using Monte Carlo simulation. These tight lower bounds can be computed quickly, and with minimal hand-crafting. Our focus is on accelerating policy iteration to the point where it can be used in similar computation times to the basic least-squares approach, but in doing so introduce a number of improvements which can be applied to both the least-squares approach and the calculation of upper bounds using the Andersen Broadie method. The enhancements to the least-squares method improve both accuracy and efficiency. Results are provided for the displaced-diffusion LIBOR market model, demonstrating that our practical policy iteration algorithm can be used to obtain tight lower bounds for cancellable CMS steepener, snowball and vanilla swaps in similar times to the basic least-squares method.

No 201: Vega control

By Nick Denson and Mark Joshi

The calculation of prices and sensitivities of exotic interest rate derivatives in the LIBOR market model is often very time consuming. One approach that has been previously suggested is to use a Markov-functional model as a control variate for prices and deltas but not vegas. We present a new approach that is effective for prices, deltas and vegas. It achieves a standard error reduction by a factor of 10 for the price of five-factor, twenty-year Bermudan swaption, and of 5 for its vega.

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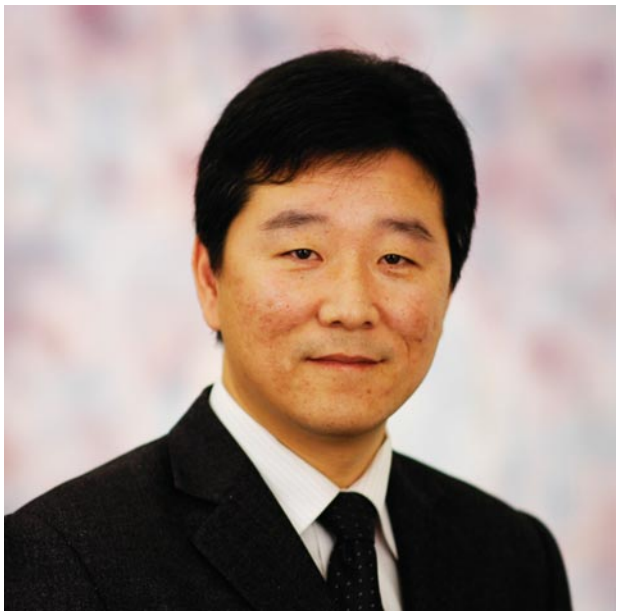

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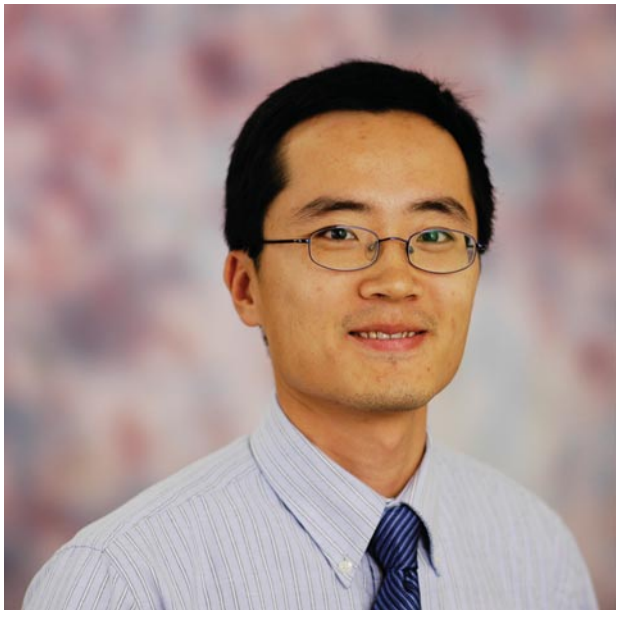

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