International Conference on
Mathematics of Finance and Related Applications

THE UNIVERSITY OF HONG KONG

January 3-4, 2008

The University of Hong Kong
T6, Meng Wah Complex

List of speakers:

1. Andrew Carverhill (HKU)
2. G.Y. Han (HKU)
3. Ching-kang Ing (Academia Sinica, Taipei)
4. Y.K. Kwok (HKUST)
5. T.L. Lai (Stanford)
6. W.K. Li (HKU)
7. Tiong-Wee Lim (NUS)
8. Shanjian Tang (Fudan)
9. Zhen Wei (Stanford)
10. Alan Wong (Baptist U and NUS)
11. Sam Wong (CUHK)
12. Jonathan Wylie (CitiU)
13. Hailiang Yang (HKU)
14. Philip L.H. Yu (HKU)
15. Shu-Hui Yu (National U of Kaohsiung)
16. K.C. Yuen (HKU)
17. S.P. Yung (HKU)
18. X.Y. Zhou (Oxford and CUHK)

Organisers:

T.L.Lai (Stanford)
W.K.Li (HKU)
H.L.Yang (HKU)
G.Y.Han (HKU)
S.P.Yung (HKU)

International Conference on Mathematics of Finance and Related Applications

Department of Statistics & Actuarial Science

Department of Mathematics

and

Institute of Mathematical Research

The University of Hong Kong

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Organizing Committee:

T.L. Lai (Stanford), W.K. Li (HKU), H.L. Yang (HKU), G.Y. Han (HKU), S.P. Yung (HKU).

09:00 – 09:15   *Welcoming Address and Introductory Remarks*
N.M. Mok, Chair Professor and Director of the Institute of Mathematical Research, University of Hong Kong

Chair: **T.L. Lai,** Stanford University

09:15 – 09:55   **Shanjian Tang**, Fudan University
New Results on Unbounded SDEs and BSDEs and Hedging of Contingent Claims

09:55 – 10:35   **W.K. Li**, University of Hong Kong
Testing for Threshold Moving Average with Conditional Heteroscedasticity

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10:35 – 10:55   *Coffee Break*

Chair: **W.K. Li**, University of Hong Kong

10:55 – 11:35   **X.Y. Zhou,** Oxford
Thou Shalt Buy and Hold

11:35 – 12:15   **Andrew Carverhill**, University of Hong Kong
Modeling Long Maturity Interest Rates

12:15 – 14:15   *Lunch Break*

Chair: **S.P. Yung**, University of Hong Kong

14:15 – 14:55   **Jonathan Wylie,** City-University of Hong Kong
Change-Point Estimation for Sequences with Dependence

14:55 – 15:35   **G.Y. Han**, University of Hong Kong
Analyticity and Derivatives of Entropy Rate for Hidden Markov Chains

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15:35 – 15:55   *Coffee Break*

Chair: **K.C. Yuen**, University of Hong Kong

15:55 – 16:35   **Samuel Wong**, Chinese University of Hong Kong
Statistical Methods for Basel II ---Approach to Measuring Credit Risk of Retail Product

16:35 – 17:15   **Philip L.H. Yu**, University of Hong Kong
On a Dynamic Mixture GARCH Model

Chair:	**Hailiang Yang**, University of Hong Kong
09:00 – 09:40	**Ching-kang Ing**, Academia Sinica Taipei, and **Shu-Hui Yu**, National University of Kaohsiung, Taiwan.
	Estimating Credit Transition Matrices Using Matrix Autoregressive Models
09:40 – 10:20	**Tiong-Wee Lim**, National University of Singapore
	Optimal Early Withdrawal and Valuation of Fund Protection Options

10:20 – 10:40	*Coffee Break*

Chair:	**G.Y. Han**, University of Hong Kong
10:40 – 11:20	**Hailiang Yang**, University of Hong Kong
	Pricing Participating Products under a Generalized Jump-Diffusion with a Markov-Switching Compensator
11:20 – 12:00	**S.P. Yung**, University of Hong Kong
	On Mean-Variance Portfolio Selection with a VaR Constraint

12:00 – 14:00	*Lunch Break*

Chair:	**Philip L.H. Yu**, University of Hong Kong
14:00 – 14:40	**T.L. Lai and Zhen Wei,** Stanford University
	Basis Selection for Valuation of American and Path-Dependent Options
14:40 – 15:20	**Y.K. Kwok**, Hong Kong University of Science & Technology
	Guaranteed Minimum Withdrawal Benefit in Variable Annuities

15:20 – 15:40	*Coffee Break*

Chair:	**Tiong-Wee Lim**, National University of Singapore
15:40 – 16:20	**Alan Wong**, Baptist University of Hong Kong
	Asset Performance Evaluation with the Mean-Variance Ratio
16:20 – 17:00	**K.C. Yuen**, University of Hong Kong
	Modeling Dependence Based on the Compound Binomial Risk Model

17:00 – 17:20	*Closing*

Abstracts

Andrew Carverhill (HKU)

Modelling Long Maturity Interest Rates

It is natural to assume that interest rates mean-revert, and natural consequence of this is that long forward rates are asymptotically constant. However, from US Treasury STRIPs data, forward rates slope increasingly downwards, and do not attenuate in volatility, as maturity increases beyond about 15 years.

We fit an equilibrium model which reconciles this behavior with mean reversion. The key is to extract a latent factor, which the forward rate follows, but overshoots, causing mean reversion on a time scale in terms of weeks. This allows the forward rates to mean revert over the long term in the objective measure but not in the risk neutral measure. We show that this mean reversion can in principle be exploited for profit.

Our model falls into the Essentially Affine class. We finally set our analysis in the context of similar models for shorter maturities, and discuss applications to managing positions in long maturity bonds and associated derivatives.

G.Y. Han (HKU)

Analyticity and Derivatives of Entropy Rate for Hidden Markov Chains

We prove that under mild positivity assumptions the entropy rate of a hidden Markov chain varies analytically as a function of the underlying Markov chain parameters. A general principle to determine the domain of analyticity is stated. We also show that under the positivity assumptions the hidden Markov chain itself varies analytically, in a strong sense, as a function of the underlying Markov chain param- eters. For a natural class of hidden Markov chains called "Black Hole", we show that one can exactly compute any derivatives of entropy rate.

Ching-kang Ing (Academia Sinica, Taipei) and Shu-Hui Yu (National U of Kaohsiung)

Estimating Credit Transition Matrices Using Matrix Autoregressive Models

One of the major approaches in analyzing credit risk is to estimate the credit transition matrix (Credit TM), for example, CreditMetrics TM and Credit Portfolio ViewTM. Because the Credit TM contains lots of credit risk information, a better estimator of it can help achieve a more precise credit risk analysis. However, traditional Credit TM estimators usually ignore some important characters embedded in the data. For example, the well-known cohort approach is a static estimation method which does not consider the data evolution over time. While a hazard rate approach, proposed by Lando and Skeodeberg (2002), provides a dynamic estimator which can take care of some time-varying features, it neglects stochastic dependence among the data. To overcome the difficulties

encountered by traditional approaches, in this talk, we propose a new Credit TM estimator using a matrix autoregressive (MAR) model. Empirical evidence shows that the newly proposed estimator performs favorably compared to many existing estimators from a prediction point of view.

Y.K. Kwok (HKUST)

Guaranteed Minimum Withdrawal Benefit in Variable Annuities

We develop a singular stochastic control model for pricing variable annuities with the guaranteed minimum withdrawal benefit. This benefit promises to return the entire initial investment, with withdrawals spread over the term of the contract, irrespective of the market performance of the underlying asset portfolio. A contractual withdrawal rate is set and no penalty is imposed when the policyholder chooses to withdraw at or below this rate. Subject to a penalty fee, the policyholder is allowed to withdraw at a rate higher than the contractual withdrawal rate or surrender the policy instantaneously. We explore the optimal withdrawal strategy adopted by the rational policyholder that maximizes the expected discounted value of the cash flows generated from holding this variable annuity policy. An efficient finite difference algorithm using the penalty approximation approach is proposed for solving the singular stochastic control model. Optimal withdrawal policies of the holders of the variable annuities with the guaranteed minimum withdrawal benefit are explored. We also construct the discrete pricing formulation that models withdrawals on discrete dates. Our numerical tests show that the solution values from the discrete model converge to those of the continuous model. Joint work with Min DAI and Jianping ZONG.

T.L. Lai and Zhen Wei (Stanford)

Basis Selection for Valuation of American and Path-Dependent Options

An important development in the valuation of American style interest rate derivatives such as callable bonds and Bermudan swaptions during the past decade is the approximate dynamic programming approach that consists of least squares regression and Monte Carlo simulation. However, how to choose the basis functions suitably for the regression component of this approach has been relatively unexplored in the literature. Moreover, the methods developed have not been able to handle options with complex payoffs and high dimensionality.

We describe how these difficulties can be resolved by making use of recent advances in high-dimensional functional learning algorithms for variable and basis selection. We also use the methodology to evaluate not only the prices, but also the pricing profiles for hedging, of complex high-dimensional European path-dependent options such as Rainbow options and Basket Average Options.

W.K. Li (HKU)

Testing for Threshold Moving Average with Conditional Heteroscedasticity

The recent paper by Ling and Tong (2005) considered a quasi-likelihood ratio test for the threshold in moving average models with i.i.d. errors. This article generalizes their results to the case with GARCH errors and a new quasi-likelihood ratio test is derived. The generalization is not direct since the techniques developed for TMA models heavily depend on the property of p-dependence which is no longer satisfied by the time series models with conditional heteroscedasticity. The new test statistic in this article is shown to converge weakly to a functional of a centered Gaussian process under the null hypothesis of no threshold and it is also proved that the test has nontrivial asymptotic power under local alternatives. Monte Carlo experiments demonstrate the necessity of our test when a moving average time series has a time varying conditional variance. As a further support, two real data examples are also reported. This is a joint work with Guodong Li.

Tiong-Wee Lim (NUS)

Optimal Early Withdrawal and Valuation of Fund Protection Options

When embedded in equity-linked annuities, the dynamic fund protection option automatically increases the number of primary fund units so that their total value does not fall below the guaranteed level. As the payoff is determined by the running maximum of a price ratio, the "standard" fund protection option can be excessively expensive. We modify the design of the embedded option by relaxing the guarantee to take effect only when the upgraded fund value has fallen a certain level (the "spread") below the reference fund level. Our numerical results show that the introduction of a spread in the option payoff is effective in making fund protection options more economically attractive. We also study the effect of proportional fees and random maturity on the value and optimal withdrawal of these fund protection options with spread.

Shanjian Tang (Fudan)

New Results on Unbounded SDEs and BSDEs and Hedging of Contingent Claims

In this talk, I shall expose some new results on stochastic differential equations (SDEs) and backward stochastic differential equations (BSDEs) with unbounded coefficients. These new results will be used to solve the problem of hedging contingent claims in an unbounded financial market. The talk is based on my recent work jointed with Freddy Delbaen, ETH.

Alan Wong (Baptist U and NUS)

Asset Performance Evaluation with the Mean-Variance Ratio

Asset performance evaluation is one of the most important areas in investment analysis. In order to compare the performance among assets, several statistics have been developed; and among them, the

Sharpe-ratio statistic is the most prevalent. However, the major limitation of the Sharpe-ratio statistic is that its distribution is only valid asymptotically, but not valid for small samples. Nevertheless, it is important in finance to test the performance among assets for small samples. To further serve this purpose, we develop both one-sided and two-sided mean-variance-ratio statistics to evaluate the performance among the assets for small samples. In this paper we further prove that our proposed statistics provide uniformly most powerful unbiased tests. We illustrate the superiority of our proposed test over the traditional Sharpe-ratio test by applying both tests to analyze the performance of funds from Commodity Trading Advisors. Our findings show that while the traditional Sharperatio test concludes most of the CTA funds being analyzed as being indistinguishable in their performance, our proposed statistics show that some funds outperform the others. On the other hand, when we apply the Sharpe-ratio statistic on some other funds, we find that the statistic indicates that one fund is significantly outperforming another fund even though the difference between the two funds is insignificantly different from zero and/or even changes directions. However, when our proposed meanvariance-ratio statistic is applied, we could detect the change in the difference. This shows the superiority of our proposed statistic in revealing short term performance and in return, enables investors to make better decisions about their investments.

Sam Wong (CUHK)

Statistical Methods for Basel II — Approach to Measuring Credit Risk of Retail Product

Basel II Accord is a financial risk management standard that recently adopted by many national regulators and financial institutes around the globe. The spirit of the Accord is recommending a statistical approach in evaluating and controlling risks with practical banking wisdom. The interface between the financial practitioners and the statisticians is of pivotal importance in attaining a synergic implementation of Basel II Accord. This article aims at building such a bridge by providing an integrated approach in credit risk analysis of retail exposures.

Jonathan Wylie (CitiU)

Change-Point Estimation for Sequences with Dependence

We consider a family of cumulative-sum change-point estimators for detecting a change in some moment of a correlated sequence. We show that the $1/n$ convergence rate typical of the independent case is also achieved for short-memory and long-memory sequences. Moreover, since cumulative-sum estimators compare differences between empirical means, it seems natural that ergodicity is a minimal assumption for consistent change-point estimation. Surprisingly, we show that change-point estimation can be consistently performed for nonergodic sequences. We determine the rate of convergence for sequences under very general conditions including nonergodic cases. In particular, we determine the rate of convergence for sequences in which the correlations decay to zero arbitrarily slowly or even do not decay to zero at all.

Hailiang Yang (HKU)

Pricing Participating Products under a Generalized Jump-Diffusion with a Markov-Switching Compensator

We consider the problem of valuing participating life insurance products under a generalized jump-diffusion model with a Markov-switching compensator. We suppose that the jump component is specified by the class of kernel-biased completely random measures, which can provides a great deal of flexibility in modeling different types of finite and infinite jump activities. We also provide additional flexibility to incorporate the impact of structural changes in macro-economic conditions and business cycles on the valuation of participating policies by introducing a continuous-time, finite-state Markov chain. In particular, we assume that the market interest rates, the drift, the volatility and the compensator of the reference asset switch over time according to the state of the Markov chain. We employ the Esscher transform to determine an equivalent martingale measure under the incomplete market setting. We conduct simulation experiments to compare the fair values of participating products implied by our model with those obtained from other existing models in the literature and highlight some features that can be obtained from our model.
(This is a join paper with Ken Siu and John Lau).

Philip L.H. Yu (HKU)

On a Dynamic Mixture GARCH Model

This talk introduces a new mixture GARCH model with a dynamic mixture proportion. The mixture Gaussian distribution of the error can vary from time to time. Bayesian Information Criterion and the EM algorithm are used to estimate the number of parameters as well the model parameters and their standard errors. The new model is applied to the S&P 500 Index and Hang Seng Index and compared with GARCH models with Gaussian error and Student's t error. The result shows that the IGARCH effect in these index returns could be the result of the mixture of one stationary volatility component with another non-stationary volatility component. The VaR based on the new model performs better than traditional GARCH based VaRs, especially in unstable stock markets.
(The paper is coauthored with Xixin Cheng and W.K. Li from Department of Statistics and Actuarial Science, The University of Hong Kong).

K.C. Yuen (HKU)

Modeling Dependence Based on the Compound Binomial Risk Model

In the discrete-time setting, we consider two variants of the well-known compound binomial risk model, namely the compound binomial risk model with time-correlated claims and the compound Markov binomial risk model, which possess certain dependence structure. For the compound binomial risk model with time-correlated claims, we investigate the finite-time ruin probabilities and the infinite-time (ultimate) ruin probabilities. For the compound Markov binomial risk model, we examine some ruin problems through the expected discounted penalty function.

S.P. Yung (HKU)

On Mean-Variance Portfolio Selection with a VaR Constraint

In this talk, we shall study the selection of optimal allocation in a mean-variance portfolio problem, in which a Value-at-Risk constraint is present. A verification function type of approach is used to find the optimal portfolio through solving a Hamilton-Jacobi-Bellman equation.

X.Y. Zhou (Oxford and CUHK)

Thou Shalt Buy and Hold

An investor holding a stock needs to decide when to sell the stock. It is tempting to think that he should sell at the maximum price over a given investment horizon – which is what investors always dream of. Unfortunately this is a "mission impossible". A close yet realistic goal is to sell the stock at the time when the expected relative error between the sold price and the maximum price is minimized. This problem is thoroughly investigated for a geometric Brownian motion model, and it is shown that when the stock is good enough – which we specify explicitly – the optimal strategy is to sell at the end of the horizon. Moreover, the resulting expected relative error never exceeds 25% - a universal number that is independent of the investment opportunities. This result justifies the conventional wisdom that one should buy and hold a stock – if it is good, that is.