Stochastic Calculus

and its applications to

Quantitative Finance

and

Electrical Engineering

A conference in honor of the contributions of

Robert J. Elliott

24-27 July 2005

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A Better Place to Think About Business

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The University of Calgary

Alberta, Canada

Overview

In recent years the quantitative finance community has used techniques from the Ito calculus and stochastic processes. Further, several mainstream Electrical Engineering conferences, such as the IEEE Conference on Decision and Control, now include sessions dedicated to financial engineering. It is clear from these developments, that the two communities of quantitative finance and modern electrical engineering often use similar mathematical tools and have overlapping interests. This conference will focus on common ground of these two areas. In addition to these objectives, this conference will also honour the contributions of Robert J. Elliott and is timed to coincide with the occasion of his 65th birthday.

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1. Program

Sunday, 24 July, 2005

Registration from 8:00am,

Oak Room, 3rd Floor Scurfield Hall

Tutorial Day - Track # 1 - Sunday, 24 July, 2005		
Morning Session (dual track) Track # 1 (Quantitative Finance Emphasis) Esso Theatre, Room 257		
	Tutorial #1	
9:00 – 10:30	Stochastic Calculus for Fractional Brownian Motion	Dr. John van der Hoek Adelaide University
10:30 – 11:00	***Morning Break***	
11:00 – 12:30	Stochastic Calculus for Fractional Brownian Motion	Dr. John van der Hoek Adelaide University
12:30 – 1:30	***Lunch Break***	
Afternoon Session (dual track) Track # 1 (Quantitative Finance Emphasis) Esso Theatre, Room 257		
	Tutorial #2	
1:30 – 3:00	White Noise Theory and its Applications in Quantitative Finance	Dr. Alexei Filinkov Adelaide University
3:00 – 3:30	***Afternoon Break***	
3:30 – 5:00	White Noise Theory and its Applications in Quantitative Finance	Dr. Alexei Filinkov Adelaide University

Tutorial Day - Track # 2 - Sunday, 24 July, 2005

Morning Session (dual track)
Track # 2 (Electrical Engineering Emphasis)
RGO Room, Room 465

	Tutorial #3	
9:00 – 10:30	Change of Measure Techniques in Filtering Estimation and Control	Prof. Lakhdar Aggoun Sultan Qaboos University Dr. Paul Malcolm National ICT Australia
10:30 – 11:00	***Morning Break***	
11:00 – 12:30	Change of Measure Techniques in Filtering Estimation and Control	Prof. Lakhdar Aggoun Sultan Qaboos University Dr. Paul Malcolm National ICT Australia
12:30 – 1:30	***Lunch Break***	

Afternoon Session (dual track)
Track # 2 (Electrical Engineering Emphasis)
RGO Room, Room 465

	Tutorial #4	
1:30 – 3:00	Information Theory and Stochastic Control of Uncertain System	Prof. Charalambos Charalambous University of Cyprus Prof. Farzad Rezaei
3:00 – 3:30	***Afternoon Break***	
3:30 – 5:00	Information Theory and Stochastic Control of Uncertain System	Prof. Charalambos Charalambous University of Cyprus Prof. Farzad Rezaei

Day 1 – Monday, 25 July, 2005 – Track #1 – AM and PM

Morning Session (single track)
Chairperson: Prof. Robert Elliott
Esso Theatre, Room 257

08:40 – 08:50	Welcome and opening remarks	Ms. Carol Stewart (Vice Dean) U of C
08:50 – 09:00	Conference Overview	Dr. Paul Malcolm ANU, Canberra
Time	Title	Speaker
09:00 – 10:00	Mathematical Finance in the management of Equity Structured Products	Prof. Dilip Madan Robert H. Smith School of Business University of Maryland
10:00 – 10:40	Benchmarking and fair pricing applied to two market models	Prof. Eckhard Platen University of Technology Sydney, Australia
10:40 – 11:10	***Morning Break***	
11:10 – 11:50	Stochastic Calculus for Fractional Brownian motion	Dr. John van der Hoek Adelaide University
11:50 – 12:30	PDE Evaluation in the reduced form Credit risk model	Prof. Monique Jeanblanc Université d'Evry, France
12:30 – 2:00	***Lunch Break***	

Afternoon Session (dual track)
Track # 1 (Quantitative Finance Emphasis)
Chairperson: Mr. Andrew Royal
Esso Theatre, Room 257

Time	Title	Speaker
2:00 – 2:25	Policy iteration for American Options	Dr. Christian Bender Weierstrass Institute Berlin, Germany
2:25 – 2:50	Predictability Analysis of Asset Price Dynamics under the HMM Paradigm	Dr. Rogemar Mamon Brunel University London, U.K.
2:50 – 3:20	***Afternoon Break***	
3:20 – 3:45	Exponential affine futures and forward prices	Dr. Cody Hyndman University of Waterloo Ontario, Canada
3:45 – 4:10	Inflation Uncertainty and Credit Risk	Prof. Alexander David University of Calgary

Day 1 – Monday, 25 July, 2005 – Track #2 – PM.

Afternoon Session (dual track)
Track # 2 (Electrical Engineering Emphasis)
Chairperson: Prof. Vikram Krishnamurthy
RGO Room, Room 465

Time	Title	Speaker
2:00 – 2:25	Two-time-scale and applications to filtering	Prof. George Yin Wayne State University Detroit, Michigan USA
2:25 – 2:50	Discrete-time weak Markov control dynamic programming	Prof. Allanus Tsoi University of Missouri Columbia, Missouri USA
2:50 – 3:20	***Afternoon Break***	
3:20 – 3:45	Some applications of M-ary detection in finance	Dr. Paul Malcolm The Australian National University, Canberra
3:45 – 4:10	Credit rating processes as a hidden Markov chain	Dr. M. Korolkiewicz University of South Australia

Kananaskis Excursion & BBQ Dinner - Boundary Ranch

4:45 – 5:00 PM	Loading the coach at Motel Village, Banff Trail N.W. In front of Hampton Inn & Econolodge. ***** As this is an hour long bus ride, and to a casual outdoor atmosphere, please come dressed for comfort. With our Alberta weather known to be 'unpredictable' I would recommend bringing a jacket.

Day 2 – Tuesday, 26 July, 2005 – Track #1 – AM and PM.

Morning Session (single track)
Chairperson: TBA
Esso Theatre, Room 257

Time	Title	Speaker
9:00 – 10:00	On some partially observable control problems arising in Operations Research	Prof. Alain Bensoussan University of Dallas, USA
10:00 – 10:40	Adaptive Brownian Dynamics for Structural Estimation of Bio-Nanotubes	Prof. Vikram Krishnamurthy University of British Columbia
10:40 – 11:10	***Morning Break***	
11:10 – 11:50	Information theory subject to uncertainty	Prof. Charalambos Charalambous University of Cyprus
11:50 – 12:30	PDE approach to utility maximization for market models with hidden Markov processes	Prof. Wolfgang Runggaldier Universita degli Studi di Padova, Italy
12:30 – 2:00	***Lunch Break***	

Afternoon Session (dual track)
Track # 1 (Quantitative Finance Emphasis)
Chairperson: Prof. Abel Cadenillas
Esso Theatre, Room 257

Time	Title	Speaker
2:00 – 2:25	Pricing Options and Variance Swaps in Markov-Modulated	Prof. Anatoliy Swishchuk University of Calgary
2:25 – 2:50	SDEs in Hilbert spaces. White Noise Approach	Dr. Alexei Filinkov Adelaide University
2:50 – 3:15	Swing options in a mean-reverting world	Prof. Tony Ware University of Calgary
3:15 – 3:45	***Afternoon Break***	
3:45 – 4:10	Optimal Superhedging under Nonconvex Constraints, a BSDE Approach	Prof. Michael Kohlmann University of Konstanz Germany
4:10 – 4:35	Stock Loan	Prof. Xun-Yu Zhou Chinese University of HK
4:35 – 5:00	Investment and Uncertainty, Debt and Taxes	Prof. Gordon Sick University of Calgary

Day 2 – Tuesday, 26 July, 2005 – Track #2 – PM.

Afternoon Session (dual track)
Track # 2 (Electrical Engineering Emphasis)
Chairperson: Prof. Andrew Heunis
RGO Room, Room 465

Time	Title	Speaker
2:00 – 2:25	Singular control problems and maximum principle	Prof. Francois Dufour University of Bordeaux France
2:25 – 2:50	Robust control of a partially observed Markov chain	Prof. John Moore Australian National University
2:50 – 3:15	Portfolio optimization with partial information	Dr. Joern Sass Austrian Academy of Sciences
3:15 – 3:45	***Afternoon Break***	
3:45 – 4:10	Option pricing model based on jump telegraph processes	Prof. Nikita Ratanov Universidad del Rosario Bogota, Colombia
4:10 – 4:35	On a multivariate Markov chain model for credit risk measurement	Mr. Tak Keun Siu Heriot-Watt University Edinburgh, Scotland
4:35 – 5:00	Conditional independence in multi-target tracking	Dr. Martin Clark Imperial College London, UK

Conference Reception and Dinner

6:30 PM	Calgary Chamber of Commerce, 100 – 6 Ave. S.W., Calgary

Day 3 – Wednesday, 27 July, 2005 – Track #1 – AM and PM.

Morning Session (single track)
Chairperson: Prof. Ekkehard Kopp
Esso Theatre, Room 257

Time	Title	Speaker
9:00 – 9:25	GARCH options in incomplete markets	Prof. Giovanni Barone-Adesi Universita della Svizzera Italiano, Lugano
9:25 – 9:50	Dynamic principal agent problems with perfect information	Prof. Abel Cadenillas University of Alberta
9:50 – 10:15	On the strong approximation of jump-diffusions	Mr. Nicolas Bruti Liberati University of Technology Sydney, Australia
10:15 – 10:40	***Morning Break***	
10:40 – 11:05	On the innovations conjecture of nonlinear filtering with dependent data	Prof. Andrew Heunis University of Waterloo Ontario
11:05 – 11:30	Stochastic methods for assessment and management of mortality risk	Prof. Alexander Melnikov University of Albertas
11:30 – 11:55	Optimal investment for insurer with jump diffusion	Prof. Hailiang Yang University of Hong Kong
12:00 – 1:30	***Lunch Break***	

Afternoon Session - Special Panel Session
Chairperson: TBA
Esso Theatre, Room 257

Time	Title	Speaker
1:30 – 2:20	Risk-Managing a Multi-Commodity Portfolio	Prof. Helyette Geman ESSEC Business School and Université Paris Dauphine
2:20 – 2:35	Closing Remarks	(Organizing Committee)

2. Tutorial Program, Sunday 24/July/2005

1. Stochastic Calculus for Fractional Brownian Motion

Dr. John van der Hoek

Adelaide University

Abstract: In this tutorial the following topics will be covered:

1. White Noise Analysis (WNA),
2. Fractional Brownian Motion (FBM),
3. Construction of FBM in WNA,
4. Stochastic Integration with respect to FBM,
5. Basic properties and identities,
6. Ito-type formulas for FBM,
7. Stochastic Differential Equations driven by FBM,
8. Some applications of FBM to financial modelling.

2. White Noise Theory and its Applications in Quantitative Finance

Dr. Alexei Filinkov
Adelaide University

Abstract: We study models for the term structure of forward interest rates when the dynamics involve the following stochastic evolution equation:

$$dX(t) = [AX(t) + F(t)]dt + BdW(t),\ X(0) = X_0,\ (1)$$

where X takes values in a separable Hilbert space H. Here A is the generator of a semigroup, $B:H \to H$ is a bounded linear operator, $W(\cdot)$ is an (infinite dimensional) H-valued cylindrical Wiener process.

These models arise both when modelling forward interest rates in the real world sense (for use in econometrics and risk analysis) and in the risk neutral formulation (for use in derivatives pricing).

The motivation for using the infinite dimensional noise in these models can be summarized as follows:

1. the non arbitrage conditions are too restrictive on drift when only finite number of Brownian motions is used in modelling the noise;
2. it is more natural to solve a model with an infinite dimensional noise and then to select for appropriate purposes a model with a finite dimensional noise.

Typical examples include the HJM model (in the parameterization of Musiela), second order term structure models and generalizations.

3. Information Theory and Stochastic Control of Uncertain System

Prof. Charalambos Charalambous
University of Cyprus

Mr. Farzad Rezaei

Abstract: The aim of the workshop is to present similarities as well as difference in Information Theory and Stochastic Control. The emphasis will be on addressing issues related to uncertainty of the models employed, introduce new definitions and problems in Information Theory, Stochastic Systems (Control, Estimation), while establishing some of their intimate relations. The workshop will identify specific research areas as well as provide an introduction to some of the methodologies and results which are currently available on 1) Robust Information Theory, 2) Robust Control and Estimation of Stochastic Systems, and 3) Robust Control and Communication Subject to Uncertainty.

Following an introduction to basic concepts of classical and statistical Thermodynamic, the emphasis will be on

1. developing the subject of robust information theory, in which Shannon's blocks of information transmission, such as source coding, data compression, capacity are subject to uncertainty and power constraints. Emphasis will be given on developing robust information theory via a measure theoretic approach.
2. Enhancing the knowledge in dealing with uncertainty when the systems are governed by nonlinear stochastic differential equations using information theoretic concepts, such as relative entropy, free energy and the Cramer transform of Large Deviations theory.
3. Establishing important connections between information theory, robustness and statistical mechanics, through entropy rate functionals, dissipation inequalities and partition functions
4. Studying the stabilizability of control systems under limited capacity communication constraints using information theoretic concepts such as robust capacity and robust entropy rate.

A detailed description is found at http://www.eng.ucy.ac.cy/chadcha/. Acknowledgement: The work of this projected is supported by the European Commission under a Marie Curie research grant ICCCSYSTEMS

4. Change of Measure Techniques in Filtering Estimation and Control

Prof. Lakhdar Aggoun
Sultan Qaboos University

Dr. W. P. Malcolm
National ICT Australia, (Canberra)

Abstract: This tutorial will consist of two components. In the first component, given by Lakhdar Aggoun, the fundamental details of change of measure estimation techniques will be established. For example, Radon Nikodym derivatives, the abstract form of Bayes' rule canonical representations of Markov chains, Martingales and Girsanov's Theorem.

In the second component of this tutorial, given by W. P. Malcolm, emphasis will be placed upon applications, in particular filtering. Here change of measure techniques will be used to develop unnormalised information state dynamics, M-ary detection schemes, and in particular, smoother dynamics.

3. Seminar Abstracts

1. Mathematical Finance in the management of Equity Structured Products

Dilip Madan
University of Maryland

Abstract: In this seminar we describe the products now being traded and present a rationale for their existence. This will be followed by a discussion of the theory of hedging to acceptability and its implications. I will close with examples of pricing particular products and decomposing their risks.

2. Benchmarking and fair pricing applied to two market models

Eckhard Platen
University of Technology, Sydney

Abstract: This paper considers a market containing both continuous and discrete noise. Modest assumptions ensure the existence of a growth optimal portfolio. Non-negative self-financing trading strategies, when benchmarked by this portfolio, are local martingales under the real-world measure. This justifies the fair pricing approach, which expresses derivative prices in terms of real-world conditional expectations of benchmarked payoffs. Two models for benchmarked primary security accounts are presented, and fair pricing formulas for some common contingent claims are derived.

3. Stochastic Calculus for fractional Brownian motion

John van der Hoek
Adelaide University

Abstract: We review some tools from stochastic calculus for fractional Brownian motion with applications to pricing of derivatives on assets whose dynamics are driven by fractional Brownian motions. We will address questions on how contingent claims are replicated and valued in such markets.

4. PDE Evaluation in the reduced form Credit risk model

Monique Jeanblanc

Université d'Evry Val d'Essonne, France

Abstract: Our aim is to make precise the Partial Differential Equation evaluation equations for defaultable claims in different settings, depending on the choice of the traded assets. We start with a general model for the dynamics of the traded assets in the case where there are three assets and we shall specify some particular models.

The notation are the same as in our previous papers in particular we assume that there exists such that the process

$$dM_t = dH_t - \xi_t t dt = dH_t - \lambda_t(1 - H_t)dt,$$

where $H_t = 1_{\{t<\tau\}}$ is a martingale. We recall that, under H hypothesis, the representation theorem holds. In what follows, we are working mainly with a constant or deterministic, in order to give the main ideas, which, quite surprisingly, are not so well known. In the first part, we study the evaluation problem via a PDE approach and we give the hedging strategies of a contingent claim. In a second part, we shall study the case of several defaults, using different martingales M_i. All computational details are available on request.

5. Policy Iteration for American Options

Christian Bender

Weierstrass Institute Berlin, Germany

Abstract: We survey recent results by Kolodko and Schoenmakers (2004) and Bender and Schoenmakers (2004) on the evaluation of options with early exercise opportunity via policy improvement. Stability is discussed and simulation results basing on the plain Monte-Carlo estimator for the conditional expectations are presented.

6. Predictability Analysis of Asset Price Dynamics under the HMM Paradigm

Rogemar Mamon

Brunel University, West London, England

Abstract: This paper aims to demonstrate the filtering of asset prices within the set-up of a hidden Markov model (HMM). Optimal estimation of the Markov chain in discrete time together with the determination of adaptive filters for the parameters of the asset model is reviewed. Empirical work is implemented on data of gold prices between 2000 and 2004. The predictability of gold prices is analysed through the assessment of h-step ahead forecasts (h > 0) against the Diebold and Killian (2001) metric. The findings suggest that under the framework of a geometric Brownian motion whose drift and volatility are permitted to shift amongst economic regimes in accordance with a Markov chain dynamics, gold market prices are quite predictable up to a certain extent in the very short term but almost impossible to predict in the long term.

7. Exponential Affine Futures and Forward Prices

Cody Hyndman

University of Waterloo, Canada

Abstract: We employ the method of stochastic flows introduced by Elliott and van der Hoek (2001) to show why, when the factors process is defined by Gaussian dynamics, or affine-square root processes (as in Bjork and Landen (2002)), the forward and futures price of a risky asset is an exponential affine function. Using the risk neutral measure for the reinvested futures price as numeraire the futures price is obtained by solving an ordinary differential equation. Similarly, using the risk neutral measure for the forward price reinvested in the zero-coupon bond as numeraire the forward price is obtained by solving an ordinary differential equation. The key result is that the conditional expectation of the Jacobian of the stochastic flow associated with the factors process is deterministic under both new measures. Examples illustrate the approach.

8. Inflation uncertainty, asset valuation

Alexander David

Haskayne School of Business, University of Calgary, Canada

Abstract: We study four puzzling aspects of the credit risk premium:

1) The high credit spreads observed along with low expected default losses, the credit spreads puzzle,
2) The positive and slow response of credit spreads to shocks in the short rate (the 'momentum' effect),
3) The significant time variation in expected corporate bond index returns, and
4) The changing sign of the risk-return relationship for corporate bond excess-returns.

We provide an equilibrium structural form credit risk model that partially rationalizes all four findings. Investors in the model learn jointly of the hidden states of real fundamental growth and inflation. Inflation as a state variable has a negative market price of risk and serves a signalling role: in periods of rising inflation expectations, credit spreads increase due to the higher risks of an earnings slowdown but expected returns decline. Credit spreads are convex functions of firms' solvency ratios, which change dramatically with the state of inflation, and hence average spreads are larger than the spread evaluated at the average solvency ratio by several authors. Variations in the speed of learning are shown to justify part of the momentum effect, generate 14-16 percent of the variation in returns, and a risk-return relationship that was strongly negative in the 1970s, close to zero in the 1980s, and positive in the 1990s. In addition, our pricing formulae permit us to provide an internally consistent method of backing out asset values and volatilities from data on fundamentals, equity values, and the term structure of interest rates when asset volatility is stochastic.

9. Two-time-scale Markov Chains and Applications to Filtering

George Yin

Wayne State University, USA

Abstract: This work is concerned with two-time-scale Markov chains in discrete time. Asymptotic properties of such systems, including asymptotic expansions of probability vectors and transition matrices and asymptotic distributions are presented. These results are applied to a near-optimal hybrid filtering problem, and a discrete-time approximation to Wonham filter in continuous time.

10. On Some Measurable Selection Conditions in Finite Horizon Discrete Time Weak Markov Control

Allanus Tsoi

University of Missouri, Columbia USA

Abstract: The concept of discrete time weak Markov control was introduced in the paper -'Discrete Time Weak Markov Control-Dynamic Programming Equation with Finite Horizon' by Tsoi, in which a dynamic programming theorem was given. As in the usual discrete time Markov control model, the above theorem for the weak Markov control imposes an important assumption about the measurability of the functionals which appear in the dynamic programming equations. In this paper we give conditions under which this measurability assumption is fulfilled.

11. Some Applications of M-ary detection in Finance

William Paul Malcolm

National ICT Australia, (Canberra)

Abstract: In modern Electrical Engineering, the term M-ary detection generally refers to what is known as sequential hypothesis testing in the statistics community. Here, M is any natural number greater than or equal to the number 2. Some common applications of M-ary detection in Electrical Engineering are determining which from a collection of candidate dynamical systems might best explain an observed process. In this context the term best refers to the technique of maximum likelihood. In this article we consider the application of M-ary detection schemes in three areas of mainstream interest in quantitative finance . In the first two studies, we develop M-detection filters for finite state volatility estimation. A fundamental task in financial modeling is that of calibrating asset price models, that is, estimating the parameters of mean return and volatility. Popular techniques used to estimate these parameters are based upon maximum likelihood estimation, such as the Expectation Maximisation (EM) algorithm and its variants. These methods can be slow to converge and computationally intensive. Further, in practice, precise estimates of volatilities are often not necessary. For example, in option pricing with Markov modulated volatility models, a 10% error in volatility estimation is usually taken as acceptable. In the third application, we develop M-ary detection filters for an application in Paris trading, based on scalar-valued Gauss-Markov models evolving in discrete time. This application further develops the primary results presented in an earlier paper with J. van der Hoek and R. J. Elliott. Computer simulations are provided to demonstrate the performance of the schemes presented.

12. Credit Rating Process as a Hidden Markov Chain. Theory and Implementation

Malgorzata W. Korolkiewicz
University of South Australia

Abstract: We propose a Hidden Markov Model of credit rating dynamics. We suppose that the Markov chain governing the ”true” credit rating evolution is hidden in ”noisy” observations represented by the posted credit ratings. We introduce a new probability measure to obtain recursive estimates for the state of the Markov chain governing the ”true” credit rating evolution and use the EM algorithm to estimate the parameters of the model. We then apply the model to a data set of Standard and Poor’s credit ratings.

13. On some partially observable control problems arising in Operations Research

Alain Bensoussan

University of Texas at Dallas, USA

Abstract: We present models inspired from Zakai equation involving un-normalized conditional probability in the context of inventory control, with partial information. We study the infinite dimensional Bellman equation, and prove existence of optimal feedback. The applications are non observable inventory, random delays, and Markovian demand.

14. Adaptive Brownian Dynamics Simulation for Structural Estimation of Bio-Nanotubes

Vikram Krishnamurthy
University of British Columbia, Canada

Abstract: Cell membranes of all animal, plant and bacterial cells are composed of two layers of lipid molecules called the lipid bilayer making them impermeable to ions. Ion transportation into and out of cells is mediated by large membrane protein molecules called ion channels. Ion channels are biological nanotubes whose opening and closing may be intrinsic or gated. Their primary function is to facilitate the diffusion of ions across the cell membrane. In this paper we consider the ion permeation problem in ion channels. The permeation problem seeks to explain the working of an ion channel at an Angstrom unit spatial scale by studying the propagation of individual ions through the ion channel at a femto second time scale. This setup is said to be at a mesoscopic scale since the individual ions (e.g., Sodium ions) are of the order of a few * in radius and are comparable in radius to the ion channel. At this mesoscopic level, point charge approximations and continuum electrostatics break down. The discrete finite nature of each ion needs to be taken into consideration. Also, failure of the mean field approximation in narrow channels implies that any theory that aspires to relate channel structure to its function must treat ions explicitly. We show how Brownian dynamics simulation can be used to model the propagation of individual ions. Furthermore we also show how stochastic gradient learning based schemes can be used to control the evolution of Brownian dynamics simulation to predict the structure of an ion channel. Finally, we show how an adaptive controlled Brownian dynamics simulation approach employing a discrete stochastic approximation controller can be used to estimate the shape of ion channels. We illustrate the algorithm by predicting the shape of a Sodium ion channel.

15. Information Theory Subject to Uncertainty

Charalambos D. Charalambous
University of Cyprus

Abstract: In this talk, we shall develop the subject of robust information theory, in which Shannon's blocks of information transmission, such as source coding, data compression, and capacity are subject to uncertainty. Specific emphasis will be given to probabilistic uncertainty models.

16. PDE approach to utility maximization for market models with hidden Markov factors

Wolfgang Runggaldier
University of Padova, Italy

Abstract: We consider the problem of maximizing expected utility from terminal wealth for a power utility of the risk-averse type assuming that the dynamics of the risky assets are affected by hidden “economic factor” that evolve as a finite-state Markov process. For this partially observable stochastic control problem we determine the corresponding complete observation problem that turns out to be of the risk sensitive type and for which the Dynamic programming approach leads to a nonlinear PDE that, via a suitable transformation, can be made linear. By means of a probabilistic representation we obtain a unique viscosity solution to the latter PDE that induces a unique viscosity solution to the former. This probabilistic representation allows us to obtain on one hand regularity results, on the other a computational approach based on Monte Carlo simulation.

17. Pricing Options and Variance Swaps in Markov-Modulated Brownian and Fractional Brownian Market

Anatoliy Swishchuk

The University of Calgary

Abstract: The Markov-modulated (B,S)-securities market is a (B,S)-security market, consisting of riskless asset, bond B, and risky asset, stock S, in random media X, or (B,S)-security market driven by a Markov process T_X from X. We study the pricing options and variance swaps for Markov-modulated Brownian and fractional Brownian (B,S)-security markets (including Hu and Oksendal (1999) and Elliott & van der Hoek (2000) schemes). Using martingale characterization of Markov processes, we state incompleteness of Markov-modulated Brownian (B,S)-security markets without and with jumps and find minimal martingale measure. Black-Scholes formulae for Markov-modulated Brownian (B,S)-security markets without and with jumps are derived. Incompleteness of Markov-modulated fractional Brownian (B,S)-security markets in Hu & Oksendal and Elliott & van der Hoek schemes without and with jumps are established and Black-Scholes formulae for these schemes are derived. Perfect hedging in Markov-modulated Brownian and Brownian fractional (B,S)-security market (without and with jumps) is not possible since we have incomplete market. Following the idea proposed by Foellmer and Sondermann (1986) and Foellmer and Schweizer (1993) we look for the strategy locally minimizing the risk. The residual risk processes are presented in all these schemes. Variance swaps for stochastic volatility driven by Markov process are also studied.

18. Stochastic differential equations in Hilbert spaces. White Noise Approach

Alexei Filinkov

Adelaide University

Abstract: Let H be a separable Hilbert space. As in [1], we introduce spaces of H-valued stochastic distributions $S(H)_{-\rho}$, $\rho \in [0,1]$:

$$S(H)_1 \subset S(H)_\rho \subset S(H)_0 \subset L^2(H) \subset S(H)_{-0} \subset S(H)_{-\rho} \subset S(H)_{-1};$$

and consider basic examples: H-valued cylindrical Wiener process W and H-valued singular white noise process $dW(t) = W(t)$, $t > 0$, which in general, are elements of space $S(H)_{-0}$. It is crucial for our main results on evolution equations that white noise is (infinitely) differentiable in $S(H)_{-1}$. Our main results are devoted to $S(H)_{-1}$ solutions of the stochastic evolution equation

$$\frac{dX(t)}{dt} = AX(t) + F_0(t) + [F_1(t) \Diamond X(t) + F_2(t)] \Diamond BW(t); t \in [0,T]; X(0) = \xi \in S(H)_{-\rho}$$

where $\Diamond$ is Wick product in $S(H)_{-1}$, $F_0, F_1,$ and F_2 are continuous $S(H)_{-1}$ processes; B is a bounded linear operator on H and A is either the generator of a C_0-semigroup or the generator of an integrated semigroup on H. We illustrate our results with the stochastic heat and wave equations and their generalizations. We also discuss applications of our results in the framework of the white noise approach to modelling forward interest rates. This includes the Heath-Jarrow-Morton (HJM) model in Musiela parametrization, second order term structure models, etc.

References

[1] A. Filinkov and J. Sorensen, *Differential equations in spaces of abstract stochastic distributions*, Stochastics and Stochastics Reports, **72** (2002), no. 3-4, 129-173.

[2] G. Da Prato and J. Zabczyk, *Stochastic Equations in Infinite Dimensions*, Cambridge University Press, Cambridge, 1992.

[3] I.V. Melnikova and A. Filinkov, *Abstract Cauchy Problems: Three Approaches*, CRC Press, London, 2001.

19. Swing options in a mean reverting world

Tony Ware
University of Calgary

Abstract: Swing options can be seen as generalisations of American or Bermudan options that give the holder a certain constrained freedom to exercise partially at some discrete set of times, or indeed to exercise continuously at some rate of their choosing. In this way they are closely related to passport options. They are used in the energy industry to value natural gas storage facilities and power delivery contracts. Elliott and Cadenillas address the question of pricing swing options for log-normal and mean-reverting assets, describing conditions under which they reduce to American options and also describing a set of variational inequalities that serve to define the solution in more general settings. In this paper we develop a finite-element approach to this class of problems which can be applied in the presence of strong mean-reversion in the underlying prices. We explore the continuous-time limit under various types of exercise constraint, while addressing issues of accuracy and computational complexity.

20. Optimal Superhedging under Nonconvex Constraints – A BSDE Approach

Michael Kohlmann

University of Konstanz, Germany

Abstract: We apply theoretical results of S. Peng on supersolutions for BSDEs to the problem of finding optimal superhedging strategies in a Black-Scholes market under constraints. Constraints may be imposed simultaneously on wealth process and portfolio. They may be nonconvex, time-dependent, and random. Recent advances on numerical methods (see e.g. the articles by Ma - Protter - San Martin - Torres (2002), Bouchard - Touzi (2004) and the references in there) make hope for a better applicability of BSDE-methods which turned out to be extremely useful to model realistic markets: In this paper it is shown that more realistic constraints on the portfolio may e.g. be formulated in terms of the amount of money invested, the portfolio proportion, or the number of shares held.

21. Stock Loan

Xun-Yu Zhou
Chinese University of Hong Kong

Abstract: A client, who owns one share of a stock, obtains a loan from a bank with the share of the stock as collateral. The client may regain the stock by repaying the bank the principal and interest, or surrender the stock instead of repaying the loan. Such a loan is called a stock loan, which is a popular service provided by many banks and financial firms. This paper analyzes the reasonable values of the principal, the loan interest and the fee charged by the bank for providing the service in a stock loan.

22. Investment under Uncertainty, Debt and Taxes

Gordon Sick

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Abstract: We present a capital budgeting valuation framework that takes into account both personal and corporate taxation. This has implications even for all-equity-financed projects. It is also important when the firm or project is partially financed by debt, of course. The setting is a Miller equilibrium economy with differential taxation of debt and equity income that is generalized to allow cross-sectional variation in corporate tax rates. We show broad circumstances under which taxes do not affect the martingale operator (the martingale operator is the same before and after personal taxes, which we call "valuation neutrality") and in which there are no tax-timing options.

One implication of this is that the appropriate discount rate for riskless equity-financed flows (martingale expectations or certainty equivalents) is an equity rate that differs from the riskless debt rate by a tax wedge. This tax wedge factor is the after-tax retention rate for the corporate tax rate that corresponds to tax neutrality in the Miller equilibrium. We then extend this result to the valuation of the interest tax shield when the firm has an exogenous debt policy, where the debt may or may not have default risk. Interest tax shields accrue at a net rate corresponding to the difference between the corporate tax rate that will be faced by the project and the Miller equilibrium tax rate. Depending on the financing system, interest tax shields can be incorporated by using a tax-adjusted discount rate or by implementing an APV-like approach with additive interest tax shields.

We also analyze the effect of uncertainty and debt financing on the value of investment real options and on the exercise policy, including the effect of default risk. For low uncertainty, a rise in leverage reduces the time value of the real option and increases the probability of being exercised. This last effect on the exercise policy is completely offset when the firm is close to default (i.e., a high coupon). In this situation, more debt or more uncertainty reduces the probability of investing.

Keywords: Investment under uncertainty, real options, capital structure, risk-neutral valuation, corporate and personal taxation, default risk, interest tax shields, cost of capital, tax-adjusted discount rates.

23. Singular control problems and maximum principle

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Abstract: In this paper, an optimal singular stochastic control problem is considered. For this model, it is obtained a general stochastic maximum principle by using a time transformation. This is the first version of the stochastic maximum principle that covers nonlinear singular control.

24. Robust Control of a Partially Observed Markov Chain

John Moore
Australian National University

Abstract: In this paper we develop results for the optimal control of a partially observed Markov chain. Although this problem is formulated and to some extent solved in earlier work, there is innovation in our current results in that the robust information state filter of Clark is used to compute simplified control results. In particular, dynamic programming partial differential equations are simplified, as are the adjoint partial differential equations for the stochastic minimum principle. The results of the paper apply to signal models with observations observed through Brownian motion and/or counting processes. Also the corresponding risk sensitive versions of the results for both estimation and control results are new.

25. Portfolio Optimization under Partial Information, A HMM for jumping stock returns

Joern Sass

RICAM, Austrian Academy of Sciences

Abstract: In Sass and Haussmann (2004) we consider a multi-stock market model where prices satisfy a stochastic differential equation with instantaneous rates of return modeled as an unobserved continuous time, finite state Markov chain. The investor wishes to maximize the expected utility of terminal wealth but for his investment decisions only the prices are available to him. In that paper we derived an explicit representation of the optimal trading strategy in terms of the unnormalized filter of the drift process, using HMM filtering results and Malliavin calculus. In this talk we show how to extend the optimization results when we replace in the stock returns the Brownian motion by a simple Levy process, i.e. when we allow also for Poisson jumps in the stock returns.

Reference

J. Sass and U.G. Haussmann (2004): *Optimizing the terminal wealth under partial information: The drift process as a continuous time Markov chain*, Finance and Stochastics **8**, 553-578.

26. Option pricing model based on jump telegraph processes

Nikita Ratanov

Universidad del Rosario, Columbia

Abstract: In this paper we introduce a financial market model based on continuous time random motions with alternating constant velocities and with jumps occurring when the velocity switches. If jump directions are in the certain correspondence with the velocity directions of the underlying random motion with respect to the interest rate, the model is free of arbitrage. The replicating strategies for options are constructed in details. Closed form formulas for the option prices are obtained.

27. On a Multivariate Markov Chain Model for Credit Risk Measurement

Tak Kuen Siu

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Abstract: In this paper, we propose the use of a multivariate Markov chain model to incorporate the dependency of the multivariate categorical time series of ratings of credit risks in a portfolio. We employ the idea of actuarial credibility theory to estimate credit transition probability matrices. The estimate of each credit transition matrix is given by a linear combination of both the prior estimate of the credit transition probability matrix and the empirical credit transition probability matrix. These estimates can be easily computed by solving a set of Linear Programming (LP) problems. The estimation procedure can be implemented easily on Excel spreadsheets without requiring much computational effort and time.

28. Conditional independence in multi-target tracking

J. Martin C. Clark
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Abstract: Multi-target tracking is one of the more challenging problems in the field of nonlinear filtering. Typically, each of a number of objects, or 'targets', generates, within an image window, a process of observation points, randomly related to its 'state' (that is, position, velocity or some other attribute). The composite field of undistinguished points, further corrupted by the presence of random 'clutter' points, forms the observation process. The complexity of these problems forces the tracking algorithm designer into making a number of simplifying assumptions. In the design of sequential algorithms, a common assumption is that the current conditional distribution of the joint state of a group of targets can be reasonably approximated by the product of the conditional marginal distributions for the individual targets; essentially, the targets are taken to be conditionally independent of each other. This presentation focuses on this issue of conditional independence, for an idealized formulation of the problem. 'The observation process is taken to be a 'Cox' process that is a blend of separate 'space-time' Poisson processes, the intensity measure of each characterizing a target or clutter. It is then natural to consider a 'scheme' of such processes, in which the intensity magnitudes of the target Poisson processes, and that associated with the Poisson process representing clutter, both increase, possibly at different rates. Conditions are presented that justify the assumption of an asymptotic form of conditional independence.

29. GARCH options in incomplete markets

Giovanni Barone-Adesi

Institute of Finance, University of Lugano Switzerland

Abstract: We propose a new method to compute option prices based on GARCH models. In an incomplete market framework, we allow for the volatility of asset return to differ from the volatility of the pricing process and obtain adequate pricing results. We investigate the pricing performance of this approach over short and long time horizons by calibrating theoretical option prices under the Asymmetric GARCH model on S&P 500 market option prices. A new simplified scheme for delta hedging is proposed.

30. Dynamic Principal-Agent Problems with Perfect Information

Abel Cadenillas

University of Alberta, Edmonton, Canada.

Abstract: We consider a general principal-agent setting in continuous-time, when both have perfect information. The agent can control both the drift and the volatility of the stochastic process the principal is interested in. We apply martingale/duality methods familiar from the theory of continuous-time portfolio selection. Our results depend on whether the agent can control the drift independently of the volatility, or not, and whether principal and agent have the same utility functions. As an application of some of our results, we show that if principal and agent have the same CRRA utility, or they both have (possibly different) CARA utilities, the optimal contract is (ex-post) linear; if they have different CRRA utilities, the optimal contract is nonlinear. We also present an example in which a call option-type contract is optimal. Finally, we establish an approach for solving the principal-agent problem in very general models and with a general cost function, and show how the approach works in non-trivial examples.

31. On the Strong Approximation of Jump-Diffusions

Nicola Bruti Liberati

University of Technology, Sydney

Abstract: In financial modeling, filtering and other areas the underlying dynamics are often specified via stochastic differential equations (SDEs) of jump-diffusion type. The class of jump-diffusion SDEs that admit explicit solutions is rather limited. Consequently, there is a need for the systematic use of discrete time approximations in corresponding simulations. This paper presents a survey and new results on strong schemes, which are relevant for scenario analysis, filtering and hedge simulation. We present a convergence theorem for the construction of strong approximations of any given order for jump-diffusion SDEs driven by Wiener processes and Poisson random measures. The paper covers also derivative free, drift-implicit and jump adapted strong approximations. For the commutative case particular schemes are obtained. Finally, a numerical study on the accuracy of several strong schemes applied to the Merton model will be presented.

32. On the innovations conjecture of nonlinear filtering with dependent data

Andrew Heunis

Dept. ECE, University of Waterloo

Abstract: We establish the innovations conjecture for a nonlinear filtering problem corresponding to a model in which the signal to be estimated is conditioned by the observations. The approach uses only elementary stochastic analysis, together with an extension due to J.M.C. Clark of a theorem of Yamada and Watanabe which asserts that a given solution of a stochastic differential equation is a strong solution when pathwise uniqueness holds among candidate solutions with the same distribution as the given solution. The main result complements earlier work of N.V. Krylov, who used an approach based on stochastic partial differential equations to establish the innovations conjecture for a similar model.

33. Stochastic methods for assessment and management of mortality risk

Alexander Melnikov

University of Alberta, Edmonton.

Abstract: The paper discusses assessment and valuation of mortality risk with the help of stochastic technique. In particular, quantile hedging is used to compare four classical survival models and to derive ideas and recommendations for mortality risk management in context of equity linked life insurance. Calculations are performed in a typical Black-Scholes setting for the switching-of-funds equity-linked contract. To illustrate the approach, the authors present numerical results based on mortality data for males and females in Alberta.

34. Optimal Investment for Insurer with Jump-Diffusion Risk Process

Hailang Yang
The University of Hong Kong

Abstract: In this paper, we study optimal investment policies of an insurer with jump-diffusion risk process. Under the assumptions that the risk process is compound Poisson process perturbed by a standard Brownian motion and the insurer can invest in the money market and in a risky asset, we obtain the close form expression of the optimal policy when the utility function is exponential. We also study the insurer's optimal policy for general objective function, a verification theorem is proved by using martingale optimality principle and Ito's formula for jump-diffusion process. In the case of minimizing ruin probability, numerical methods and numerical results are presented for various claim-size distributions.

35. Risk-Managing a Multi-Commodity Portfolio

Helyette Geman
Université Paris Dauphine & ESSEC, France

Abstract: The talk will start with some fundamentals of spot and Futures commodity markets, with a special focus on energy commodities such as oil and natural gas. The unique properties of electricity will then be depicted: overlapping spot, adjustment, reserves and forward markets, spikes in price trajectories, collapse of the spot-forward relationship. Lastly, some options specific to energy markets, e.g., spread, swing and other volumetric options will be discussed.

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