IP1

No-arbitrage Under Model ambiguity and Fundamental Theorems of Asset Pricing

We will present several recent versions of the Fundamental Theorem of Asset Pricing for discrete and continuous time models under model ambiguity, with and without proportional transaction costs. This talks is based on recent collaborations with S. Biagini, K. Kardaras and M. Nutz.

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IP2

Multi-Period Mean Variance Asset Allocation: Is It Bad To Win the Lottery?

We present semi-self-financing mean-variance (MV) dynamic asset allocation strategies which are superior to self-financing MV portfolio strategies. Our strategies are built upon a Hamilton-Jacobi-Bellman (HJB) equation approach for the solution of the portfolio allocation problem. Under an HJB framework, our strategies have a simple and intuitive derivation, and can be readily employed in a very general setting, namely continuous or discrete re-balancing, jump-diffusions, and realistic portfolio constraints. MV strategies are often criticized for penalizing the upside as well as the downside. However, under our strategies, the MV portfolio optimization problem can be shown to be equivalent to maximizing the expectation of a well-behaved utility function of the portfolio wealth. We show that, for long term investors, the the use of dynamic MV strategies can achieve the same expected value with a much smaller standard deviation compared to a constant proportions strategy.

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IP3

Bid-Ask Imbalance and Trade Arrival Modeling

We consider the dynamics of trade arrivals and best bid and ask order sizes in an electronic limit order book. The joint evolution of these events is described by a three-dimensional diffusion model. We show how to construct semi-analytical solutions for the probability of price movement prior to the arrival of an aggressive market order. Finally, we calibrate the model to empirical limit order book data and discuss how it can be used to optimize order execution at the tactical level.

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IP4

Robust Meets Realistic: Interpolating Between Model-Specific and Model-Free Settings for Pricing and Hedging

Classical models in mathematical finance, even if highly complex, typically share important methodological weaknesses: failure to account for model uncertainty and failure to incorporate market information in a consistent manner. In the wake of financial crisis these have been much debated. In response, an increasingly active field of research focuses on model-free super/sub-hedging using the underlying and Vanilla options. Explicit results often rely on pathwise inequalities and embedding techniques while pricing-hedging duality is obtained using martingale optimal transport methods. However, the resulting prices and hedges are often too expensive to be practically relevant. In this talk I show how to interpolate between the two worlds. I argue that quoted option prices should be incorporated through distributional constraints while beliefs, or past data, are most naturally included through pathwise restrictions. The resulting framework is robust and flexible. It allows for realistic outputs while quantifying the impact of making assumptions. I will present abstract results about pricing-hedging duality and then discuss examples of restrictions on future realised volatility and future option prices. Based on joint works with Sergey Nadtochiy (University of Michigan) and Zhaoxu Hou and Peter Spoida (University of Oxford).

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IP5

Long-Term Valuation and Misspecified Recovery

Abstract TBD

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IP6

Moral Hazard in Dynamic Risk Management

We consider a contracting problem in which a principal hires an agent to manage a risky project. When the agent chooses volatility components of the output process and the principal observes the output continuously, the principal can compute the quadratic variation of the output, but not the individual components. This leads to moral hazard with respect to the risk choices of the agent. Using a recent theory of singular changes of measures for Ito processes, we formulate a principal-agent problem in this context, and solve it in the case of CARA preferences. In that case, the optimal contract is linear in these factors: the contractible sources of risk, including the output, the quadratic variation of the output and the cross-variations between the output and the contractible risk sources. Thus, path-dependent contracts naturally arise when there is moral hazard with respect to risk management. We also provide comparative statics via numerical examples, showing that the optimal contract is sensitive to the values of risk premia and the initial values of the risk exposures.

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IP7

Adaptive Grids in Regression Monte Carlo

Regression Monte Carlo has been enormously successful in numerical solution of optimal stopping problems. It relies on the statistical tool of regression and the probabilistic idea of a stochastic mesh to construct an approximate stopping strategy. While the former has been extensively

investigated, grid placement is typically prescribed by a basic simulation of underlying state process. We discuss the associated layers of inefficiency and introduce adaptive generation of these grids using sequential design schemes. This accomplishes active learning of the classifiers partitioning the state space into the continuation and stopping regions. As we show, adaptive refinement of the grids around the stopping boundaries can achieve an order of magnitude savings in gridding budgets. Moreover, sequential design opens the door for other statistical approaches, including Bayesian methods, kriging, and multi-armed bandits for this class of control problems. We examine dynamic regression algorithms that can implement such recursive estimation of the stopping strategy, and present several numerical examples in the context of multi-dimensional Bermudan option pricing.

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IP8

The Value of Being Lucky: Option Backdating and Non-diversifiable Risk

The practice of executives influencing their option compensation by setting a grant date retrospectively is known as backdating. Since these options are usually granted at-the-money, selecting an advantageous grant date will be valuable to the executive. There is substantial evidence that backdating took place in the US, particularly prior to the tightening of SEC reporting requirements. In this talk, we develop and solve a utility-indifference model to quantify the value of the opportunity to backdate options. We show that the magnitude of ex ante gains from backdating is significant. Our model can be used to explain why backdating was more prevalent at firms with highly volatile stock prices. Joint work with Jia Sun (China Credit Ratings) and Elizabeth Whalley (Warwick Business School)

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IP9

The Value of Queue Position in a Limit Order Book

Many financial markets are organized as electronic limit order books operating under a price-time priority rule. In practice, this creates a technological arms among high-frequency traders to establish advantageous early positions in the resulting FIFO queue. We develop a model for valuing orders based on their queue position that identifies two components of positional value: a static component that relates to the instaneneous trade-off between earning a spread and incurring adverse selection costs; and a dynamic component that captures future value that accrues by locking in given queue position. We empirically calibrated and test the model. Joint work with Kai Yuan (Columbia)

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SP1

SIAG/FME Junior Scientist Prize Lecture: Some Financial Markets with Discontinuities

We shall discuss some systems of stochastic differential equations with discontinuous and degenerate diffusion coefficients with applications to stochastic portfolio management. The underlying model is tailor-made for the financial systems with sadden changes. Allowing discontinuity in the description of the system increases the range of phenomena which might induce financial crisis. We examine long-time behaviors, ergodicity and invariant distribution of large financial markets, discuss some applications of Transportation Cost Information inequalities to portfolio comparisons, and propose some optimization problems.

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CP1

The Application of Kmv Model in Chinese Market

According to the particularity of China's ownership structure of listed company and the macroeconomic conditions, a flexible adjustment is introduced into KMV model about calculation method of default value setting and the value of equity .Using the adjusted KMV model to evaluate both ST (special treatment) companies and non ST companies to test whether the adjusted model works in China market. The outcome show the adjusted KMV model is able to differentiate between ST and non ST company in Chinese market.

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CP1

Bank Liquidity Risk Management

The Basel III liquidity standard, the liquidity coverage ratio (LCR), is being officially implemented in 2015. As a consequence, it is imperative to understand the stochastic behaviour of this global liquidity standard and its components. In particular, the LCR is defined as the quotient of high-quality liquid assets (HQLAs) to nett cash outflows (NCOs). In this conference paper, we construct a stochastic model for the LCR that enables us to solve a stochastic control problem with quadratic cost. In the sequel, we introduce the LCR reference process in terms of which optimal liquidity provisioning rate and HQLAs allocation are characterized. Furthermore, we propose an adjustment to the provisioning rate per unit of the banks NCOs for deficit via cash injections. Also, the dynamic programming algorithm for stochastic optimization is used to verify the main results. Finally, we provide the conclusions about the LCR modelling and optimization issues.

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CP1

Capital Investment and Liquidity Management with Collateralized Debt

We analyze the interaction between dividend policy and investment decision of a cash constrained firm. We depart from the standard literature by allowing the firm to issue collateralized debt to invest in productive assets with decreasing return to scale. This leads us to study a bi-dimensional singular control problem that we solve quasi-explicitly in some special cases and by means of viscosity solution in the general case.

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CP1

Hedge Fund Management with Liquidity Constraint

We investigate a model for hedge funds with a liquidity constraint seeking to optimise the manager's utility of wealth, with one and multiple period horizons. By using stochastic control techniques we state the corresponding multi-dimensional HJB partial differential equation, which is solved numerically. We examine the manager's risk-taking profiles and compare the investor's utility of wealth over different strategies (manager's profile, risk-free and Merton's optimal) testing which is more beneficial.

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CP2

High-Speed Fourier Method Estimation of Covariances from Asynchronous Data for Real-Time Cluster Analysis

We implement a parallelised covariance estimator using graphics processor units to compute correlation matrices from large, unevenly sampled financial data sets, based on the Fourier coefficient method of Malliavan and Mancino. The parallelisation uses a vectorised form of the trigonometric Fourier estimator and master-slave CPU-GPU pairing for efficient computation. The estimated sequence of high-frequency trade data correlation matrices are used for high-speed visualisation of cluster dynamics.

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CP2

Statistically Significant Fits of Hawkes Processes to Financial Data

Most fits of Hawkes processes in financial literature are not statistically significant. Using parametric fits, Kolmogorov-Smirnov tests and assuming a constant exogeneous activity rate, FX trades activity can be fitted up to about one hour provided that the kernel consists of at least two exponentials; the endogeneity factor is about 0.7. Significant fits of a full day can be achieved if one accounts for intra-day variability of exogeneous activity, which yields a larger endogeneity factor (0.8).

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CP2

Regime Change in Dynamic Correlation Matrices of Financial Data

In light of recent trends in algorithmic trading of multi-assets, this paper proposes a new computational method to estimate the correlation structure of high-dimensional financial data. We use free random variable techniques and minimize the spectral distance between the theoretical spectral density of a model and the spectral density obtained from data. By doing this, we estimate factor model parameters with moving windows, which shows regime changes in residual spaces. The mean-reversion time estimated from an Ornstein-Uhlenbeck model is revisited for comparison. We analyze a theoretical model which accounts for system dynamics of correlated assets. We return to discuss the applications of these techniques in algorithmic trading.

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CP2

Hawkes Processes and Applications in Finance

Hawkes process is a class of jump processes which has

self-exciting and clustering effect and is in general non-Markovian. Unlike Poisson process, Hawkes process has dependence across time and is a more realistic model in credit risk, high frequency trading, microstructure noise etc. Hawkes process has rich behaviors in different regimes, i.e. sublinear, subcritical, critical, supercritical and explosive regimes. Scaling limits in different regimes will be discussed, as well as some applications in finance.

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CP3

Pricing "Partial-Average" Asian Options with Binomial Method

An Asian option is path-dependent derivatives whose payoff depends on the average of the underlying asset price over some prespecified period of time. Because there's no closed-form solutions for the arithmetic Asian option, the development of efficient and accurate numerical methods becomes critical. In this paper, we present a modified binomial method for pricing arithmetic Asian options with "partial-average", which means the averaging of the asset is applied during some part of the life of the option. We extend a simple binomial method proposed by Moon and Kim (2013) to choose the representative averages among all the effective averages. Then, we use backward recursion and spline interpolation to compute the price of the option. We compare our results with Monte Carlo method.

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CP3

Flexible Finite Element Method for Option Pricing in Lévy Models

For some models Finite Element Methods (FEM) for option pricing have already proven to be efficient and of low computational cost. The known results and implementations require the system matrix in explicit form. This excludes various examples such as Normal Inverse Gaussian processes for which a standard procedure leads to an explosion of the computation time. We present a FEM method that is flexible in the Lévy processes as well as efficient and of low computational and implementation cost.

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CP3

A Radial Basis Function Partition of Unity Penalty Method for Pricing American Basket Call Options

Pricing of American options is a challenging problem due to the free boundary arising from the early exercise property. Radial basis function (RBF) approximation is used in space. To overcome the high computational cost associated with global RBF methods, we employ a partition of unity approach. The free boundary is handled with a penalty term. Numerical experiments for one and two assets show that the RBF-PU approach is more cost effective than global RBF approximation.

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CP3

Fredholm Expansions and Pde Methods Applied to Quadratic Functionals of the Ou Process

In this paper we compute the bivariate Laplace transform of quadratic functionals of the form

$$\left(\int_0^T X_t dB_t, \int_0^T X_t^2 dt\right)$$

where $(X_t)_{t\geq 0}$ is a Ornstein-Uhlenbeck process driven by a standard Brownian motion $(B_t)_{t\geq 0}$. Our method combines PDE arguments with Carleman-Fredholm determinant of associated Volterra operators that are computed by Fredholm expansions. Classical and new bond pricing formulas in the CIR model are obtained as particular cases.

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CP4

Return-Volatility Correlation Implied by the Asymmetry in Options Trading Activity

The author finds a possible cause of asymmetry in options trading activities from return-volatility correlation on the premise that traders set their net options exposure according to their anticipation of future correlation to increase the chance to benefit from both price and volatility movements. Also proposed is a way to estimate return-volatility correlation implied by deep out-of-the-money options trading activities, near the region where the normalized Vega is close to the absolute value of Delta.

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CP4

A Model Selection Method for Option Pricing

Empirical evidence on comparison of option pricing models shows that there is no consensus on a single dominating model for all contract parameters and over different time periods. We propose a clustering method to find the relevant regions of contract parameters for model selection. Then, we use a decision rule to select the most suitable model over these regions. Finally, we provide out-of-sample testing results using different assets and option pricing methods over different time periods.

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CP4

Efficient Computation of Hedge-Sensitivities Via Automatic Differentiation

Fast and accurate computation of Greeks is a pre-requisite for reliable hedging of derivative securities. We demonstrate the computation of such sensitivities through an approach called automatic differentiation. Based on the source code of a finite difference solver of the Black Scholes equation, we apply the automatic differentiation tool TAF to generate code for efficient evaluation of the sensitivitiy of the derivative price with respect the the price of the underlying asset (Delta) and its volatility (Vega). Through second and third applications of TAF we generate codes for efficient evaluation of the second (Gamma) and third (Speed) derivatives of the derivative price with respect to the price of the underlying asset and the mixed derivative with respect to the asset price and the volatitily (Vanna). Since the derivative caculation is fully automated, it simplifies the maintenance of a modelling system for hedging/calibration.

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CP4

Holding Period Information in Options Hedging

We examine the possibility of hedging downside risk for European options, given information on the holding period of our position. Given a random but bounded liquidation date, we explore whether it is possible to effectively hedge a position at lower cost than by focusing on Δ-hedging present-time sensitivities. Preliminary numerical results of this strategy are compared to standard Δ-hedging and are leveraged in the formulation of a closed-form solution.

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CP5

The Optionality of a Financially Constrained Firm

We derive a model of a leveraged generic firm that is exposed to uncertainties in the size of their future revenues. In the face of these uncertainties, the firm must make decisions that shall benefit its shareholders, such as expansion, dividend payments, borrowing levels, and closure. We present a HJB and a numerical scheme for this class of optimisation problem, and investigate how cash affects the firm's valuation and optimal operating strategies.

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CP5

Leveraged Investments and Agency Conflicts When Prices are Mean Reverting

We analyse the effect of mean reversion on the costs of shareholder-bondholder conflicts arising from partially debt-financed investments. We find that agency costs are much lower under MR dynamics and, through a novel agency cost decomposition, we show that for a high speed of mean reversion (and/or low expected growth in future profits) agency costs are driven mainly by suboptimal timing decisions (default and investment) as opposed to suboptimal financing decisions.

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CP5

An Explicit Formula for the Optimal Government Debt Ceiling

We develop a stochastic control model to study the optimal government debt ratio ceiling. We obtain an explicit solution for the government debt problem, that gives an explicit formula for the optimal debt ceiling. Moreover, we derive a practical rule for the optimal debt policy in terms of the optimal debt ceiling. This research provides the first theoretical model for the optimal government debt ceiling.

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CP5

On Linear Programing Approach to Inventory Control Problems

This work deals with inventory control problems under the discounted and long-term average criteria. The objective is to minimize the discounted or long-term average total holding and ordering costs. In contrast with the usual dynamical programming approach, this work first imbeds the inventory control problem into an infinite-dimensional linear program over a space of measures and then reduces the linear program to a simpler nonlinear optimization. This approach not only determines the value of the inventory control problem but also identifies an optimal impulse control policy within restricted classes of control policies. Ad-

ditional auxiliary and dual linear programs are introduced to verify the optimality of the impulse control policy in the general class of control policies. This is a joint work with Kurt Helmes and Richard Stockbridge.

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CP6

A General HJM Framework for Multiple Curve Modeling

We propose a general HJM approach to the modeling of multiple yield curves. In a general semimartingale setting, we model the term structure of multiplicative spreads between (normalized) FRA rates and simply compounded OIS risk-free forward rates. We derive HJM drift and consistency conditions ensuring absence of arbitrage and we show how to construct models such that spreads are greater than one and ordered with respect to the tenor's length. When the driving semimartingale is an affine process, we obtain a flexible Markovian structure which allows for simple valuation formulas for most interest rate derivatives.

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CP6

Interest Rate Derivative Pricing with Counterparty Risk and Funding Costs: A Lévy CVA Multiple-curve Model

We propose a general framework for the valuation of interest rate derivatives in the post-crisis setup. We first develop a multiple-curve HJM-type model driven by Lévy processes. To account for counterparty and funding risks, the calibrated multiple-curve model is then used as an underlying model for CVA computation. The problem of computing the counterparty risk and funding adjustments can be expressed via a pre-default Markovian BSDE, which is solved by numerical methods. We discuss the impact of these adjustments on several examples.

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CP6

Laplace Transform and Hypergeometric Functions Methods: a Unified Approach for Some Interest Rate Models

All parts of this research are focused on Whittaker functions. These functions are special cases of hypergeometric functions and contrary to the general case they have known asymptotic and analytic continuations laws. After some specific change of variables we can obtain a unified structure of Whittaker equation in all investigating models. All results are closed-form solutions and are represented in the terms of special functions and can be computed numerically.

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CP6

Bond Pricing under Regime Switching among Multiple Short Rate Models

We study the bond pricing problem under a regime switching environment where the dynamics of the short rate is switched among ones of several short rate models. This paper derives the solution to the system of partial differential equations in a form of recursive integrals by the homotopy perturbation method. The solution has the same form as the Adomian decomposition method to a system of mixed Volterra-Fredholm type integral equations. The price of an European-type derivative on the short rate is also derived in the same form.

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CP7

Pricing and Hedging Exotic Options with Transaction Cost under Jump-Diffusion Process

Numerical schemes often develop inaccuracies, when pricing financial derivatives with non-smooth payoff or its derivatives have multiple discontinues. Averaging the initial data, shifting the grid, and projection methods have been tried to deal with such discontinuities. Moreover, large error may occur in estimating the hedging parameters. A new class of Exponential Time Differencing schemes are presented which are highly efficient and reliable in dealing with path dependent exotic options with transaction cost under jump-diffusion process.

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CP7

Convergence of Monte-Carlo Computation on Var-

ious Exotic Options

This paper develops approximation methods for path-dependent functionals, which have been used in many applications involving path-dependent objective functions. In contrast to the traditional approach, this work provides a non-traditional convergence method in Monte Carlo analysis based on actual computations under the Skorohod topology. Some examples such as the approximation of discretely monitoring barrier option are considered.

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CP7

Gaussian Markov Processes and Option Pricing Theory

I will discuss the development, testing, and implementation of a less restrictive alternative to the Black-Scholes model for pricing derivatives. By relaxing the assumption of past independence but retaining the Markovian property, we are able to develop a less restrictive but equally efficient model. This is achieved by replacing Black-Scholes' underlying process, Brownian motion, with a certain Gaussian Markov process.

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CP7

Optimal Multiple Stopping with Negative Discount Rate and Random Refraction Times under Lévy Models

This paper studies a class of optimal multiple stopping problems driven by Lévy processes. Our model allows for a *negative* effective discount rate, which arises in a number of financial applications, including stock loans and real options, where the strike price can potentially grow at a higher rate than the original discount factor. Moreover, successive exercise opportunities are separated by i.i.d. random *refraction times*. Under a wide class of two-sided Lévy models with a general random refraction time, we rigorously show that the optimal strategy to exercise successive call options is uniquely characterized by a sequence of up-crossing times. The corresponding optimal thresholds are determined explicitly in the single stopping case and recursively in the multiple stopping case.

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CP8

Systemic Risk with Jump-Diffusion Processes

We illustrate what a systemic risk is by proposing an interbank borrowing and lending model using a stochastic flocking system with jump-diffusion processes. We use the Laplace transform approach and the inversion formula instead to calculate the systemic risk. We then integrate a game feature with jumps where each bank controls its rate of borrowing/lending to a central bank. We have solved an Nash equilibria with jumps in game theory with finitely many banks.

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CP8

Dynamics of Trust in Networks and Systemic Risk

Trust is a collective, self-fulfilling phenomenon that suggests analogies with phase transitions. We introduce a stylized model for the build-up and collapse of trust in networks, which generically displays a first order transition. The basic assumption of our model is that whereas trust begets trust, panic also begets panic, in the sense that sudden drops of trustworthiness may lead to sell-offs that further decreases trust. We show, using both numerical simulations and mean-field analytical arguments, that there are extended regions of parameter space where two equilibrium states coexist: a well connected network where confidence is high, and a poorly connected network where confidence is low. In these coexistence regions, spontaneous jumps between the two states can occur, corresponding to a sudden collapse of trust that is not caused by any major catastrophe. For large systems, spontaneous crises are replaced by history dependence: whether the system is found in one state or in the other essentially depends on initial conditions.

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Capital Fund Management
-

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CP8

Optimal Capital Reserve Strategies for a Bank and Its Regulator

We present a general model of a deposit taking bank and its regulator, where the bank's loans are exposed to default risk. The bank's objective is to maximise their market value of equity by appropriately controlling loan issuance, dividend payments, and endogenous closure. The regulator's objective is to minimise the overall probability of

bank closure by appropriately setting the bank's capital adequacy ratio, whilst simultaneously considering the impact upon bank lending volumes.

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CP8

Financial Contagion with Heterogeneous Link-Weight Distributions

The recent financial crisis highlighted the importance of understanding the financial system as a complex interacting system. In this paper, we focus on the contribution of heterogeneity in link-weights of financial networks. We analyze how heterogeneous link-weight distributions affect contagion in different types of financial networks. Furthermore, we explore the evolution of these networks in multiple shock scenarios.

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CP9

Optimal Liquidation in Limit Order Books under General Uncertainties

We consider the optimal strategy of a passive trader trading in the limit order book wishing to maximize his expected utility, with the asset price following Geometric Brownian Motion. We reduce the resulting Hamilton-Jacobi-Bellman PDE to a non-linear PDE with reduced dimension and number of parameters. We numerically solve the PDE before asymptotically examining it in several variables. We emphasize the adaptability of our methodologies by introducing a mean-reverting process for the asset price.

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CP9

Long-Run Price Dynamics under a Level-1 Lob with Memory and Variable Spread

Motivated by Cont and de Larrard's seminal Limit Order Book (LOB) model, a continuous-time queuing-based stochastic model is proposed. As in Cont and Larrard's model, just one level in the order book is considered; the arrivals of limit orders, market orders, and cancellations are memoryless and stationary, but to account for some of the sparsity that has been observed empirically, a more realistic approach is pursued in a model which allows for both a variable spread and, more importantly, memory by keeping the information about the standing orders at the opposite side of the book after a price change has occurred. In spite of the inherent model complexity, we are able to characterize the long-run behavior of the resultant mid-price process and, hence, our analysis shed further light on the relation between the observed macro price dynamics and the LOB features. The analysis is complemented with a numerical procedure to simulate the order book with the given constraints.

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CP9

A Stochastic Free Boundary Problem and Limit Order Book Model

We introduce a continuous model for the limit order book density with infinitesimal tick size, where the evolution of buy and sell side is described by a semilinear SPDE and the mid price defines a free boundary. Price changes are assumed to be determined by the bid-ask imbalance. We transform the resulting stochastic free boundary problem into an evolution equation to study local existence, uniqueness and further properties.

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CP9

Optimum Strategy in Market Order Execution Associated with the Poisson Cluster Process

We consider discrete optimal execution problem for market order trading under different micro structure. Order flow can be viewed as occurring to a Poisson cluster process with stochastic intensity. Interaction between price impact and price dynamics can model as a dynamic optimization with price impact as a function in the self-exciting process dynamic. With constructing numeric boundaries on the order flow, we execute the amount of notional whenever the bidding price hits or higher than the boundary.

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CP10

Set-valued Shortfall Risk Measures for Multi-asset

Markets

In a multi-asset market with frictions, existence of individual utility functions for assets is assumed and the corresponding utility-based set-valued shortfall risk measures are studied. Their values are defined as the solutions of certain convex set optimization problems. Using a recent set-Lagrange duality, dual problems are obtained and they give rise to multi-objective versions of optimized certainty equivalents. Examples include the entropic risk measure and average value at risk.

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CP10

Dynamic Optimal Portfolio Choices for Robust Preferences

This project considers an optimal dynamic portfolio choice problem for an ambiguity-averse investor. It introduces new preferences that allow the separation of risk and ambiguity aversion. The novel representation is based on generalized divergence measures that capture richer forms of model uncertainty than traditional relative entropy measures. The novel preferences are shown to have a homothetic stochastic di?erential utility representation, and render a closed form solution for the investor with constant relative risk aversion. Based on this representation, optimal portfolio policies are derived using numerical schemes with forward-backward stochastic di?erential equations and Monte Carlo simulation based on the Clark-Ocone presentation and Malliavin calculus. The optimal portfolio policy is shown to contain new hedging motives induced by the investors attitude toward model uncertainty. Ambiguity concerns introduce additional horizon e?ects, boost e?ective risk aversion, and overall reduce optimal investment in risky assets. These ?ndings have important implications for the design of optimal portfolios in the presence of model uncertainty.

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CP10

Classical Differentiability of Bsvies and Dynamic Capital Allocations

Capital allocations have been studied in conjunction with static risk measures in various papers. The dynamic case has been studied only in a discrete-time setting. We address the problem of allocating risk capital to subportfolios in a continuous-time dynamic context. For this purpose we introduce a classical differentiability result for backward stochastic Volterra integral equations and apply this result to derive continuous-time dynamic capital allocations. Moreover, we study a dynamic capital allocation principle that is based on backward stochastic differential equations and derive the dynamic gradient allocation for the dynamic entropic risk measure. As a consequence we finally provide a representation result for dynamic risk measures that is based on the full allocation property of the Aumann-Shapley allocation, which is also new in the static case.

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CP10

Shortfall Aversion

We solve the problem of optimal consumption and investment, with a representative agent who is more sensitive to declines than to increases in consumption (i.e., with shortfall aversion), and investment opportunities are constant. We solve the resulting free-boundary problem in closed form, using a combination of stochastic control and duality methods. Consumption remains constant over long intervals, increases gradually as wealth is high relative to its current consumption, and falls below its last recorded maximum when wealth is low. The model implies that in bad times consumption is more volatile and investment is higher.

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CP11

A Fast Calibrating Volatility Model for Option Pricing

We propose a new stochastic volatility model, where the volatility has a deterministic term structure modified by a scalar random variable. A closed-form approximation is derived for European option price using higher order Greeks. Through comprehensive numerical experiments on real data, we show that our model achieves accuracy comparable to the Heston model and Bates model in option pricing, while being significantly cheaper to calibrate, and to simulate from, as compared to the aforementioned models.

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CP11

The Small Maturity Implied Volatility Slope for Levy Models

We consider the at-the-money strike derivative of implied volatility as the maturity tends to zero. Our main results quantify the growth of the slope for infinite activity exponential Levy models. As auxiliary results, we obtain the limiting values of short maturity digital call options, using a novel central limit theorem for semimartingales. Finally, we discuss when the at-the-money slope is consistent with the steepness of the smile wings, as given by Lee's moment

formula.

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CP11

Pricing American Compound Option under Stochastic Volatility with Non Smooth Payoffs

We consider a two-pass free boundary PDE problem of pricing American Compound options under Heston's stochastic volatility. A penalty method approach is used to deal with the free boundary. A linearly implicit scheme based on split Adams-Moulton formulas, is implemented by treating the nonlinear penalty term explicitly, while maintaining superior accuracy and stability properties. We present the numerical experiments to demonstrate the computational efficiency, accuracy and reliability of the method for non-smooth payoffs.

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CP11

Computation of the Delta of European Options under Stochastic Volatility Models

The sensitivity analysis of options to the underlying parameters is a fundamental area of research in financial modeling. For practitioners, the information the Greeks contain is widely used for measuring and managing risk. In this study we apply Malliavin calculus techniques to compute the delta of European type options in presence of stochastic volatility. We define a general stochastic volatility model and obtain a formula for the delta within. We conclude our work with some numerical results.

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CP12

Hedging of Quantity Risk in Energy Markets

In energy markets, quantity risk is inherent. An electricity company has to deliver any demanded quantity at a fixed rate, thus facing an amplified risk due to positive correlation between quantity and prices. We address the issue of correlation risk and show that sometimes, it is more efficient for an energy company to enter a structured OTC derivative – for instance a double structure call option based on exchange traded contracts on energy and weather.

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CP12

Optimal Writing of American Call Options on Electricity with Physical Delivery: A Free Boundary Analysis of Optimal Entry

We study American call options on electricity used in real-time balancing of electrical power systems. This involves timing the purchase of electricity to be stored and delivered in the contract and pricing of the call option itself. We give a complete free boundary analysis for simple and plausible models of the electricity spot price, characterising stopping regions (with and without the smooth fit) and value functions for both single and swing options.

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CP12

Enhancement of Practice-Based Methods for the Real Option Management of Commodity Storage Assets

The real option management of commodity storage assets is an important practical problem. Practitioners heuristically manage commodity storage assets using the rolling intrinsic and basket of spread options methods, which yield typically near optimal policies and, combined with Monte Carlo simulation, lower bound estimates on the value of storage. This talk enhances these methods by developing a simple, fast, and effective dual upper bound tailored for them.

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CP12

Modeling Risks in Climate Change by Real Option Analysis

A large numbers of industries will experience climate change related damages with the climate change processes over the coming years. In this paper, we treat the sea level and the temperature as the underlying assets and propose a real option model to evaluate potential sea level rising risk management opportunities. The American real option problem is formulated to a linear parabolic variational inequality. A so-called fitted finite volume method is proposed to solve the nonlinear PDE and the convergence of

the fully discrete scheme is established. Numerical experiments are given to illustrate the theoretical results.

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CP13

A Grid Based Optimization Algorithm to Select Intertwined Markets That Maximize Trading Returns

A set, $\{x_i(t) : 1 \leq i \leq k\}$, of k price functions on a finite discrete time domain is *intertwined* if there is a linear combination, $e(t) = \alpha_0 + \alpha_1 x_1(t) + \alpha_2 x_2(t) + \ldots + \alpha_k x_k(t)$ such that $e(t)$ has at least two zero crossings. We develop an algorithm to find an optimal $e(t)$ which maximizes a nonlinear multi-objective of the total zero crossings and trading returns on a grid based on α_i values. We show the results for pair ($k = 2$) and triple ($k = 3$) trading of markets.

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CP13

A Second Order Discretization Scheme for the Extended Cox-Ingersoll-Ross Process

We propose a weak second order discretization scheme for the extended Cox-Ingersoll-Ross process. In order to preserve the nonnegativity of the process, we use two different approaches according to the current state of the scheme. When the scheme is far from the origin, we exploit the composition techniques of Ninomiya and Victoir. When the scheme approaches the origin, we generate a discrete random variable which matches the first two moments up to the second order terms. We extend our discretization scheme to the extended CIR process with jumps. We perform numerical experiments to compare our schemes with others in terms of convergence.

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CP13

Radial Basis Functions Generated Finite Differences (RBF-FD) for Solving High-Dimensional PDEs in Finance

We consider RBF-FD methods for PDEs in option pricing. Thanks to being mesh-free and yielding sparse matrices, these methods are expected to be advantageous for high-dimensional problems compared to Monte Carlo (slow convergence), RBF (dense matrices) and FD methods (require grids). Implementation has been made for Black-Scholes-Merton equation with European call option payoff in 1D and 2D. Convergence and performance as a function of boundary conditions, basis functions and shape parameters will be presented.

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CP13

Marginal Quantization of An Euler Diffusion Process and Its Application to Finance

We propose a new method to quantize the Euler diffusion process. This raises new challenging questions as the analysis of the induced quantization error. We show that at any t_k, the error is bounded by the cumulative quantization errors (up to time t_k) associated to the Euler operator. For numerics, we restrict our analysis to the one dimensional setting and show how to perform the optimal grids using the Newton algorithm. This allows us to quantize in particular local volatility diffusion processes by reducing dramatically the computational complexity of the search of optimal quantizers while increasing their computational precision with respect to the algorithms commonly proposed in this framework. Numerical tests are carried out for the pricing of European options in a local volatility model and a comparison with the MC simulations shows that the proposed method is more efficient (w.r.t. both computational precision and time complexity).

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CP14

Indifference Pricing of Variable Annuities

We consider the pricing problem of variable annuities, mainly GMDB (Guaranteed Minimum Death Benefit) and GLWB (Guaranteed Lifetime Withdrawal Benefit). The Hamilton-Jacobi-Bellman PDE (Partial Differential Equation) is derived for the corresponding utility function, and the principle of equivalent utility is applied to derive the pricing PDE for the indifference price when we employ the exponential utility function. Numerical examples are performed when the mortality follows Gompertz law.

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CP14

Regression-based Monte Carlo Methods for Stochastic Control Models: Variable Annuities with Lifelong Guarantees

We present the regression-based Monte Carlo simulation algorithms for solving the stochastic control models associated with pricing and hedging of the Guaranteed Lifelong Withdrawal Benefit (GLWB) in variable annuities, where the dynamics of the underlying fund value is assumed to

evolve according to the stochastic volatility model. The GLWB offers a lifelong withdrawal benefit even when the policy account value becomes zero while the policyholder remains alive. Upon death, the remaining account value will be paid to the beneficiary as a death benefit. The bang-bang control strategy analyzed under the assumption of maximization of the policyholders expected cash flow reduces the strategy space of optimal withdrawal policies to three choices: zero withdrawal, withdrawal at the contractual amount or complete surrender. The impact on the GLWB value under various withdrawal behaviors of the policyholder is examined. We also analyze the pricing properties of GLWB subject to different model parameter values and structural features.

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CP14

Constant Proportion Portfolio Insurance in Defined Contribution Pension Plan Management

In this study, we focus on the optimal portfolio problem in pension fund management under a portfolio insurance methodology. By extending the "Constant Proportion Portfolio Insurance" method for defined-contribution pension plans, we solve stochastic optimal control problems for each participant and obtain optimal portfolios. Assuming stochastic market dynamics, we define a stochastic lower bound on the portfolio wealth, based on the stochastic contribution payments. We also present simulation results on the performance of our algorithms.

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CP15

Equilibrium in Risk Sharing Games

We study equilibrium sharing of investment risk among agents whose random endowments constitute private information. Given the sharing rules that optimally allocate the submitted endowments, we propose a Nash game where agents' strategic choices consist of the endowments to be submitted for sharing. It is proved that the best response problem admits a unique solution and differs from the agent's true risk exposure. Then, we proceed in showing that the Nash equilibrium risk sharing admits a finite dimensional characterization, and that it exists and is unique in the case of two agents. Analysis shows that the game benefits the agents close to risk neutrality, since their expected utilities are higher at the Nash risk sharing equilibrium than the optimal risk-sharing one.

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CP15

Asymptotics for Merton Problem with Capital Gain Taxes and Small Interest Rate

We consider the Merton problem with capital gain taxes. Since closed-form solutions are generally unavailable, we provide asymptotic expansions with small interest rate and other parameters, and then obtain an explicit investment and consumption strategy that effectively approximates the optimal strategy. The expansions also offer qualitative and quantitative insights about the effects of various parameters on the optimal strategy. In addition, we find that the optimal tax-deflated fraction of initial wealth in the risky asset is higher than the "Merton line" provided that there is a positive interest rate.

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CP15

Tax-Aware Dynamic Asset Allocation

We construct sub-optimal policies for dynamic portfolio optimization problems with taxes. We consider problems with all combinations of (i) full-use-of-losses vs. limited-use-of-losses and (ii) exact tax basis vs. average tax basis. We show the dual versions of these problems based on information relaxations are generally easy to solve so that good lower and upper bounds on the optimal objective function can be obtained.

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CP15

Mean Field Games and Systemic Risk: Heterogeneous Grouping Models

In the previous paper "Mean Field Games and Systemic Risk", we proposed a simple homogeneous model of interbank borrowing and lending. We now consider heterogeneous grouping cases where parameters are identical within their own groups but different between groups. Due to this heterogeneity, a central bank must keep deposits or provide extra cash flow instead of acting as a clearing house and systemic risk happens in the more complicated manner

than the homogeneous case.

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CP16

Volatility, Risk-Premiums and Feedback Effect

We consider risk-premiums, volatility feedback effect and the leverage effect for stochastic and local volatility models, including the GARCH family. The change in risk-premiums through time can be captured by identifying the change in the risk-neutral probability measure, which is proportional to volatility of the price process. In some cases, using Malliavin calculus, we investigate the relation between the time-varying risk-premiums for various volatility models and the asymmetric relation between return and volatility.

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CP16

Asian Option Pricing Using Mellin Transform for BN-S Models with Stochastic Volatility

In this talk, we consider a friction-less financial market driven by the generalized Barndorff-Nielsen and Shephard (BN-S) model which admits Ornstein-Uhlenbeck type stochastic volatility modeling. For such market a pricing equation is derived for the floating strike put arithmetic Asian options. A solution procedure for the resulting partial differential equation is provided using the technique of Mellin transforms.

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CP16

Resolution of Policy Uncertainty and Sudden Declines in Volatility

We introduce downward volatility jumps into a general non-affine modeling framework of the term structure of variance. With both variance swap rates and the S&P 500 returns, we find that downward volatility jumps are associated with a resolution of policy uncertainty, in particular through statements from Federal Open Market Committee meetings and speeches of Federal Reserve chairmen, and that such jumps are priced with positive risk premia, which reflect the premia for the "put protection" offered by the Federal Reserve. Ignoring downward volatility jumps may lead to an exaggeration of the negative variance risk premia documented in the literature hence a biased-interpretation of the price of tail events. On the modeling side, we find that log-volatility models with at least one Ornstein-Uhlenbeck factor with two-sided jumps are superior in capturing volatility dynamics and pricing variance swaps and S&P 500 options.

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CP16

Market Option Prices and the Informational Consistency

The objective of the paper is to examine empirically a fundamental issue of informational consistency across options prices with different moneyness for the same expiry. For this objective, we develop an option pricing model that depends solely on the return distribution of underlying asset at expiry and introduce a flexible return density function depicting up to the fourth moments of return. We find the different moneyness options share similar, but not exactly the same, structural parameter information. The options with strike price far from the underlying asset price tend to exhibits economically larger volatility than the near at-the-money options. The result has a significant implication on the VIX measure at CBOE.

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CP17

Stochastic Target Problems with Controlled Probability of Success - A Probabilistic Approach

We study a stochastic target problem with a controlled probability of success on a set of deterministic dates. We reduce the problem to a problem of super-replication of a Bermudean option and study some important properties of the value function. We then apply our results to the so-called quantile hedging problem when the constraint holds on a set of deterministic dates and find an explicit solution under the framework of complete market.

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CP17

Time Consistent Portfolio Selection under Short-Selling Prohibition

In this talk, I shall introduce the time consistent strategies in the mean-variance portfolio selection with short-selling prohibition. By applying the extended Hamilton-Jacobi-Bellman equation (HJB), we obtain time consistent equilibrium control. In some numerical example, the equilibrium strategies in the model with short-selling prohibition

can outperform the strategies without short-selling prohibition. I will analyze this non-typical observation in both mathematical and economical aspects.

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CP17

Turnpike Property and Convergence Rate for an Investment Model with General Utility Functions

In this paper we aim to address two questions faced by a long-term investor with a power-type utility at high levels of wealth: one is whether the turnpike property still holds for a general utility that is not necessarily differentiable or strictly concave, the other is whether the error and the convergence rate of the turnpike property can be estimated. We give positive answers to both questions. To achieve these results, we first show that there is a classical solution to the HJB equation and give a representation of the solution in terms of the dual function of the solution to the dual HJB equation. We demonstrate the usefulness of that representation with some nontrivial examples that would be difficult to solve with the trial and error method. We then combine the dual method and the partial differential equation method to give a direct proof to the turnpike property and to estimate the error and the convergence rate of the optimal policy when the utility function is continuously differentiable and strictly concave. We finally relax the conditions of the utility function and provide some sufficient conditions that guarantee the turnpike property and the convergence rate in terms of both primal and dual utility functions.

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CP17

Optimal Investment and Risk Control Policies for An Insurer: Expected Utility Maximization

Motivated by the AIG bailout case in the financial crisis of 2007-2008, we consider an insurer whose risk is modeled by a jump-diffusion process and is negatively correlated with the stock returns in the financial market. The insurer wants to maximize her/his expected utility of terminal wealth by selecting optimal investment and risk control policies. We apply the martingale approach to obtain explicit solutions of optimal policies for various utility functions.

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MS1

Rationalizing Investors' Choices

Assuming that agents' preferences satisfy first-order stochastic dominance, we show how the Expected Utility paradigm can rationalize all optimal investment choices: the optimal investment strategy in any behavioral law-invariant (state-independent) setting corresponds to the optimum for an expected utility maximizer with an explicitly derived concave non-decreasing utility function. This result enables us to infer the utility and risk aversion of agents from their investment choice in a non-parametric way. We relate the property of decreasing absolute risk aversion (DARA) to distributional properties of the terminal wealth and of the financial market. Specifically, we show that DARA is equivalent to a demand for a terminal wealth that has more spread than the opposite of the log pricing kernel at the investment horizon.

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MS1

Equilibrium Asset Pricing with Rational and Irrational Investors

We study a multi-period asset pricing problem with rational investors having recursive utility preferences and irrational investors having additional utility of trading gains and losses represented by cumulative prospect theory. In the logarithmic utility case, we derive the unique equilibrium analytically and show the market dominance of the rational investors in the long run. Moreover, we propose a stock performance measure and show that the irrational investors hold less equities than the rational investors if and only if their loss aversion degree is higher than this measure. Finally, we develop an algorithm to compute the equilibrium in the general case.

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MS1

Rank Dependent Utility and Risk Taking in Complete Markets

We analyze the portfolio choice problem of investors who maximize rank dependent utility in a single-period complete market. We propose a new notion of less risk taking:

choosing optimal terminal wealth that pays off more in bad states and less in good states of the economy. We prove that investors with a less risk averse preference relation in general choose more risky terminal wealth, receiving a risk premium in return for accepting conditional-zero-mean noise (more risk). Such general comparative static results do not hold for portfolio weights, which we demonstrate with a counter-example in a continuous-time model.

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MS1

The Effect of Time Changing Risk Aversion on Equilibrium Pricing

In this paper, we propose an equilibrium pricing model in a dynamic multi-period stochastic framework with uncertain income. There are one tradable risky asset (stock/commodity), one non-tradable underlying (temperature), and also a contingent claim (weather derivative) written on the tradable risky asset and the non-tradable underlying in the market. The price of the contingent claim is priced in equilibrium by optimal strategies of representative agent and market clearing condition. The risk preferences are of exponential (CARA) type with a stochastic coefficient of risk aversion. Both Nash subgame perfect strategies and naive strategies are considered. From the numerical result we examine how the equilibrium prices vary in response to changes in model parameters and highlight the importance of Nash equilibrium pricing principle

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MS2

Revisiting the Risk-Neutral Approach to Optimal Policyholder Behavior: a Study of Withdrawal Guarantees in Variable Annuities

Policyholder exercise behavior presents an important risk factor. However, presented approaches – building on American option pricing – do not square with observed prices and exercise patterns. We show that including taxes into the valuation closes this gap between theory and practice. In particular, we develop a "subjective" risk-neutral valuation methodology that accounts for differences in taxation. Applications to VAs with withdrawal guarantees show that tax advantages significantly affect the value and yields realistic patterns and fees.

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MS2

Computation of Risk Measures for Variable Annuity Guaranteed Benefits

From the viewpoint of computational finance, variable annuity guaranteed benefits are variations of path-dependent financial derivatives. However the quantification and assessment of long-term liabilities pose difficult but intriguing technical challenges. It has been reported in recent industrial surveys that the current market practice of Monte Carlo simulations is often time-consuming and the cost is prohibitive. We developed several analytical solutions and algorithms for the computation of risk measures using eigenfunction expansion and numerical PDE methods.

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MS2

Hedging Costs for Variable Annuities under Regime-Switching

A general methodology is described in which policyholder behaviour is decoupled from the pricing of a variable annuity based on the cost of hedging it, yielding two weakly coupled systems of partial differential equations (PDEs): the pricing and utility systems. The utility system is used to generate policyholder withdrawal behaviour, which is in turn fed into the pricing system as a means to determine the cost of hedging the contract. This approach allows us to incorporate the effects of utility-based pricing and factors such as taxation. As a case study, we consider the Guaranteed Lifelong Withdrawal and Death Benefits (GLWDB) contract. The pricing and utility systems for the GLWDB are derived under the assumption that the underlying asset follows a Markov regime-switching process. An implicit PDE method is used to solve both systems in tandem.

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MS2

Optimal Initiation of a Glwb in a Variable Annuity: No Arbitrage Approach

This paper offers a financial economic perspective on the optimal time (and age) at which the owner of a Variable Annuity (VA) policy with a Guaranteed Living Withdrawal Benefit (GLWB) rider should initiate guaranteed lifetime income payments. Our main practical finding is that given current design parameters in which volatility (asset allocation) is restricted to less than 20%, while guaranteed payout rates (GPR) as well as bonus (roll-up) rates are less than 5%, GLWBs that are in-the-money should be turned

on by the late 50s and certainly the early 60s. Our methodology and results should be of interest to researchers as well as to the individuals that collectively have over $1 USD trillion in aggregate invested in these products.

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MS3

Filtering and Parameter Estimation of Partially Observed Diffusion Processes Using Gaussian RBFs

Asset prices can be modeled as stochastic diffusion processes involving a number of parameters. Based on market observations, these parameters can be estimated. Prices are not uniquely determined due to the ask-bid spread. We model the spread as additive noise, and show that Gaussian radial basis functions (RBFs), leads to a convenient mathematical representation. Furthermore, substantial parts of the computations can be performed analytically if RBFs are used for approximating transition densities.

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MS3

Option Pricing under Fractional Diffusion Using Radial Basis Functions

Diffusion processes in complex systems are often observed to deviate from standard laws and are better represented by fractional-order than by second-order diffusion models. Such deviations have been observed in different contexts such as dispersion of tracers in an aquifer, random displacements of living species in their search for food, or stock market volatility. We apply a new high order and efficient radial basis functions discretization to an option-pricing model with fractional diffusion.

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MS3

Efficient Pricing of Vanilla and Exotic Options with Multiple Discrete Dividends using Finite-difference Method for Algorithmic Trading System

We calculate prices of European, American, barrier, turbo, and Asian options with multiple discrete dividends. The framework is based on the finite-difference method for Black-Scholes equation. We apply analytical smoothing of final condition to improve properties of the numerical algorithm. The approach is efficient also for Asian options with dividends beyond and within the averaging period. It is implemented as a pricing application for algorithmic trading system and provides prices in real time.

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MS4

A Class of Fat-Tailed Residuals for Log-Returns Consistent with Finite Asset Price Expectations

I investigate empirical performance of the generalized hyperbolic distribution in fitting log-returns of asset prices focusing on its three special cases: Students t distribution, normal inverse Gaussian distribution, and normal reciprocal inverse Gaussian distribution. Our results illustrate that there is no one overwhelmingly dominant in fitting the data under GARCH or GJR-GARCH framework, although the NRIG distribution performs slightly better than the other two types of distribution. Some backtesting results of the NRIG distribution from a risk management perspective are provided.

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MS4

Principal Components Analysis in Yield-Curve Modeling

Abstract not available at time of publication.

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MS4

Pricing and Hedging of Futures Contracts under

Multiple Stochastic Factors

This paper focuses on two aspects of futures contracts: pricing and hedging. We first set up the pricing PDE for futures contracts and provide the verification theorem. This part is the routine work, although we consider the general stochastic differential equations for the underlying and N factors of the carry cost. Then, we introduce the concept of a futures basis, present the necessary and sufficient conditions for a set of contracts to be the futures basis, and provide the hedging formulas by the future basis and the underlying. To our best knowledge, our results concerning hedging of futures contracts are new in the literature.

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MS4

Quantifying the Mutual Information Between Innovations in the Prices of Security Options and Their Underlyings

Abstract not available at time of publication.

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MS5

Credit Valuation Adjustment and the Stochastic Grid Bundling Method

Valuation of Credit Valuation Adjustment (CVA) has become an important field as its calculation is required in Basel III, issued in 2010, in the wake of the credit crisis. *Exposure*, which is defined as the potential future loss of a default event without any recovery, is one of the key elements for pricing CVA. This paper provides a backward dynamics framework for assessing exposure profiles of European, Bermudan and barrier options under the Heston and Heston Hull-White asset dynamics. We discuss the potential of an efficient and adaptive Monte Carlo approach, the *Stochastic Grid Bundling Method* (SGBM), which employs the techniques of *simulation*, *regression* and *bundling*. Greeks of the exposure profiles can be calculated in the same backward iteration with little extra effort. Assuming independence between default event and exposure profiles, we give examples of calculating exposure, CVA and Greeks for Bermudan and barrier options.

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MS5

Second Order Weak Taylor Scheme and a Numerical Fourier Method for Backward Sdes

We present a Fourier method to solve decoupled forward-backward stochastic differential equations (FBSDEs) with second-order accuracy. The FSDE is approximated by different Taylor schemes, such as the Euler, Milstein, and Order-2.0-weak-Taylor schemes, or by exact simulation. The conditional expectations appearing are approximated by using the characteristic function for these schemes and Fourier-cosine series expansions. We apply the method to, among others, option pricing problems under the CEV and CIR processes.

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MS5

The VIX-Heston Model for Asset Liability Management

This article proposes a method of analyzing and modeling the real world dynamics of equity put/call option implied volatilities (IVs) using the risk neutral Heston model with specific parameter restrictions. In our modeling approach we construct a stable and accurate calibration method for calibrating the Heston model to historic market data. In this way the risk neutral Heston model is embedded in a real world scenario generator and can be used to generate implied volatility structures, evaluate option investment strategies or to construct hedging strategies. The proposed methodology results in a stable valuation of embedded options, which is in practice preferred by, among others, insurance companies and pension funds.

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MS5

The Time-Dependent FX-SABR Model: Efficient Calibration based on Effective Parameters

We present a framework for efficient calibration of the time-dependent SABR model [3-5] in an FX context. In a similar fashion as in [6] we derive effective parameters, which yield an accurate and efficient calibration. On top of the calibrated FX-SABR model we add a non-parametric local volatility component, which naturally compensates for possible calibration errors. By means of Monte Carlo pricing experiments we show that the time-dependent FX-SABR model enables an accurate and consistent pricing of barrier options. We compare the results with prices implied by the constant-parameter SABR model and traditional Local Volatility model [1-2]. We also consider the role of the local volatility component in pricing barrier options.

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MS6

Sequential Replacement under Uncertainty in the Population Distribution

We study the impact of uncertainty in the problem of sequential replacement of projects with unknown quality and unknown population distribution of quality. The decision-maker can operate one project at a time, observe the performance, update his belief on the quality and the population distribution, and replace it with another project from the population. Our novel result: the real option value is decreasing in the uncertainty in the population distribution.

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MS6

Optimal Mean Reversion Trading with Transaction Cost and Stop-Loss Exit

We study the optimal timing strategies for trading a mean-reverting price spread. An optimal double stopping problem is formulated to analyze the timing to start and subsequently liquidate the position subject to transaction costs and a stop-loss constraint. Modeling the price spread by an Ornstein-Uhlenbeck process, we apply a probabilistic methodology and rigorously show that the entry region is characterized by a bounded price interval that lies strictly above the stop-loss level. As for the exit timing, a higher stop-loss level always implies a lower optimal take-profit level.

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MS6

Optimal Capital Structure with Scale Effects under Spectrally Negative Levy Models

The optimal capital structure model with endogenous bankruptcy was first studied by Leland (1994) and Leland and Toft (1996), and was later extended to the spectrally negative Levy model by Hilberink and Rogers (2002) and Kyprianou and Surya (2007). This paper incorporates the scale effects by allowing the values of bankruptcy costs and tax benefits to be dependent on the firm's asset value. By using the fluctuation identities for the spectrally negative Levy process, we obtain a candidate bankruptcy level as well as a sufficient condition for optimality. The optimality holds in particular when, monotonically in the asset value, the value of tax benefits is increasing, the loss amount at bankruptcy is increasing, and its proportion relative to the asset value is decreasing. The solution admits a semi-explicit form in terms of the scale function.

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MS6

Optimal Multiple Stopping with Random Refraction Times under Levy Models

This paper studies a class of optimal multiple stopping problems driven by Lévy processes. Our model allows for a *negative* effective discount rate, which arises in a number of financial applications, including stock loans and real options, where the strike price can potentially grow at a higher rate than the original discount factor. Moreover, successive exercise opportunities are separated by i.i.d. random *refraction times*. Under a wide class of two-sided Lévy models with a general random refraction time, we rigorously show that the optimal strategy to exercise successive call options is uniquely characterized by a sequence of up-crossing times. The corresponding optimal thresholds are determined explicitly in the single stopping case and recursively in the multiple stopping case.

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MS7

Fundamental Theorem of Asset Pricing under Transaction Costs and Model Uncertainty

We prove the Fundamental Theorem of Asset Pricing for a discrete time financial market consisting of a money market account and a single stock whose trading is subject to proportional transaction cost and whose price dynamic is modeled by a family of probability measures, possibly non-dominated. Under a continuity assumption, we prove using a backward-forward scheme that the absence of arbitrage in a quasi-sure sense is equivalent to the existence of a suitable family of consistent price systems. A parallel statement between robust no-arbitrage and strictly consistent price systems is also obtained.

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MS7

Portfolio Choice with Liquid and Illiquid Assets

We find dynamic portfolio strategies for long-term investors with constant relative risk aversion, who trade in a market with three assets, one safe, one risky and liquid, and one risky and illiquid. Investment opportunities are constant and trading is continuous, but the illiquid asset incurs proportional transaction costs. Optimal investment policies entail infrequent trading in the illiquid asset compensated by hedging activity in the liquid asset. Liquid hedging posi-

tions are nonlinear, and do not vanish even for independent risky assets. This is a joint work with Paolo Guasoni.

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MS7

Balancing Small Fixed and Proportional Transaction Cost in Trading Strategies

We consider the finite horizon financial problem of optimal consumption under transaction cost. From the classical results, we know that there is a no-trade region outside which it is optimal to trade to change the position of portfolio to some optimal point in the no-trade region. We assume a balance between fixed and proportional transaction cost, such that none of them dominates the other, asymptotically. We use a heuristic equilibrium argument to demonstrate that the deviation of transaction cost value function from the Merton value function, without transaction cost, is of order $\epsilon^{\frac{1}{2}}$ where ϵ is the small fixed transaction cost. Based on this, we propose an expansion for the value function in terms of powers of $\epsilon^{\frac{1}{2}}$. In addition, we find the equilibrium distribution of the position of the portfolio in the no-trade region in two cases where we only have fixed transaction cost and where we have both fixed and proportional transaction cost.

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MS7

Trading with Small Price Impact

An investor trades a safe and several risky assets with linear price impact to maximize expected utility from terminal wealth. In the limit for small impact costs, we explicitly determine the optimal policy and welfare, in a general Markovian setting allowing for stochastic market, cost, and preference parameters. These results shed light on the general structure of the problem at hand, and also unveil close connections to optimal execution problems and to other market frictions such as proportional and fixed transaction costs. (Joint work with Ludovic Moreau and H. Mete Soner.)

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MS8

A Robust Fundamental Theorem of Asset Pricing in Continuous Time

We consider a continuous-time financial market model under a family of probability measures and show that there exists no free lunch with disappearing risk if and only if there exists an equivalent family of martingale measures.

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MS8

Market Making Via Acceptability Indices

We develop a general framework for determining dynamic bid and ask prices of dividend paying securities. We use sub-scale invariant Dynamic Acceptability Indices (DAIs) as the main tool in this study. We work with discrete time financial models, on a general probability space. We link DAIs with Backward Stochastic Difference Equations and g-Expectation. One of the key feature of the proposed pricing theory is non-homogeneity of prices in number of shares traded - a desire property from practical point of view that captures one aspect of liquidity risk. We also show that: considered market models do not admit arbitrage; bid and ask prices do shrink the super hedging pricing interval, the prices are time consistent in some appropriate sense. Finally, we provide some practical examples. This is joint work with Tomasz R. Bielecki and Tao Chen.

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MS8

Price and Risk in Discrete Time Market Models Subject to Model Misspecification

In a model independent financial market, we introduce a topological notion of Robust Arbitrage, without fixing an a-priori set of reference probability measures. This novel notion relies only on the market structure and admits a dual representation in terms of weakly open sets of probability measures. We show that the absence of Robust Arbitrage, with respect to an opportune filtration enlargement, guarantees the existence of full support martingale measures. Robust Arbitrage is also characterized by the property that any polar set of the class of martingale measures has empty interior.

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MS8

Distribution Based Risk Measures and Their Implementation

Banks and insurance companies typically use distribution-based risk measures for the evaluation of their downside risks. The statistical and numerical properties of these functionals are thus important. Recently, some authors emphasized the significance of the elicitability of risk measures, a notion closely related to Huber's M-estimators and quantile regression. The talk characterizes elicitable

distribution-based risk measures, analyzes their generalized Hampel-robustness, and explains their relationship to stochastic approximation theory.

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MS9

Systemic Risk with Central Counterparty Clearing

Abstract not available at time of publication.

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MS9

Networks of Overlapping Portfolios: Aggregation and Measures of Vulnerability

This paper quantifies the interrelations induced by overlapping portfolios. A network representation emerges, where nodes represent portfolios and edge weights aggregate the common asset holdings and the liquidity of these holdings. As a building block, we introduce a simple model of order imbalance that estimates price impacts due to liquidity shocks. In our model, asset prices are set by a competitive risk-neutral market maker and the arrival rates for the buyers and sellers depend on the common asset holdings. We illustrate the relevance of our aggregation method and the resulting network representation using data on mutual fund asset holdings. We introduce three related measures of vulnerability in the network and demonstrate a strong dependence between mutual fund returns and these measures.

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MS9

Welfare Analysis of Dark Pools

We investigate the role of a class of alternative market structures known as electronic crossing networks or 'dark pools'. Relative to traditional 'lit' intermediated dealer markets, dark pools offer investors the trade-off of reduced transaction costs in exchange for greater uncertainty of trade. In an equilibrium setting, we analyze the choice between dark and lit venues, and illustrate how this critically depends on the information available to each investor. We establish that while dark pools attract relatively uninformed investors, they still experience implicit transaction costs in the form of adverse selection. We quantify the effect of the presence of a dark pool on the transaction costs in the lit market, as well as on the overall welfare of the market. In particular, for specific model parameter values, we show that the introduction of a dark pool can increase the transaction costs in the lit market and diminish the overall welfare.

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MS9

Institutional Investors and the Dependence Structure of Asset Returns

We propose a model of a financial market with multiple assets, which takes into account the impact of a large institutional investor rebalancing its positions, so as to maintain a fixed allocation in each asset. We show that feedback effects can lead to significant excess realized correlation between asset returns and modify the principal component structure of the (realized) correlation matrix of returns. Our study naturally links, in a quantitative manner, the properties of the realized correlation matrix – correlation between assets, eigenvectors and eigenvalues – to the sizes and trading volumes of large institutional investors. In particular, we show that even starting with uncorrelated 'fundamentals,' fund rebalancing endogenously generates a correlation matrix of returns with a first eigenvector with positive components, which can be associated to the market, as observed empirically.

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MS10

On the Connection Between Mean Field Games and Symmetric N-Player Games

Mean field games, as introduced by J.M. Lasry and P.-L. Lions and, independently, by M. Huang, R.P. Malham, and P.E. Caines, are limit models for symmetric N-player games with interaction of mean field type as $N \to \infty$. The limit relation is often understood in the sense that a solution of a mean field game allows to construct approximate Nash equilibria for the corresponding N-player games. The opposite direction is of interest, too: When do sequences of Nash equilibria converge to solutions of an associated mean field game? In this direction, rigorous results are mostly available for stationary problems with ergodic costs. The aim here is to identify limit points of sequences of approximate Nash equilibria as solutions to mean field games for problems with Itô-type dynamics and costs over a finite time horizon. Limits are studied through weak convergence of associated occupation measures and identified using a probabilistic notion of solution for mean field games.

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MS10

Wealth Distribution and the Business Cycle: The Role of Private Firms

Recent recessions have been characterized by extraordinarily slow recoveries, a fact that is hard to explain with standard business cycle models. Most business cycle models assume that firm ownership is irrelevant, either by pos-

tulating that there is a representative firm or that ownership is perfectly diversified. But in contrast to this assumption, the majority of economic activity in the United States is accounted for by privately held firms, rather than publicly traded ones. Motivated by this fact, we study an economy with heterogeneous privately held firms, collateral constraints and indivisibilities in production, calibrated to the United States. We find that the presence of private firms affects how the economy responds to aggregate shocks in important ways, and in particular that our model economy has the potential to explain the observed slow recoveries. The slow dynamics of the wealth distribution are key to this result. A methodological contribution of our paper is to show how heterogeneous agent rational expectation models with aggregate shocks can be approximated numerically even when "approximate aggregation" fails due to important nonlinearities.

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MS10

Tba (Waiting for Answer of Y. Achou)

Abstract not available at time of publication.

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MS10

Mean Field Games with Major and Minor Players

Abstract not available at time of publication.

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MS11

Correspondence Between Dynamic Quasi Concave Performance Measures and Parametric Families of Dynamic Risk Measures

In order to optimize asset allocation, some performance criterion must be selected. To achieve this goal, we introduce the notion of Dynamic quasi-concave Performance Measure (DPM), on random variables bounded from below. This notion encompasses a wide variety of cases, from dynamic expected utility and dynamic certainty equivalent to dynamic acceptability indexes. We establish a one-to-one relation between DPMs and parametric families of dynamic convex risk measures. In the case of dynamic acceptability indexes these dynamic risk measures are coherent. We then define time consistency for DPM such that the positions which are considered good tomorrow are already considered good today. Under some mild continuity assumption on the DPM we prove the equivalence between time consistency for the DPM and weak acceptance consistency for the induced family of dynamic risk measures.

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MS11

On the Model-free Hedging Duality

Based on new representation results for monotone convex functionals we discuss a generalized version of the transport duality. As an application we focus on model-free versions of the fundamental theorem asset pricing and the corresponding hedging duality. The talk is based on joint work with Patrick Cheridito and Ludovic Tangpi.

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MS11

A Fourier Approach to the Computation of Risk Measures

We consider the class of risk measures associated with optimized certainty equivalents. This class includes several popular examples, such as Expected Shortfall (also known as CV@R) or the entropic risk measures. Beyond explicit formulas to compute them, they also provide a handy way to compute risk contributions in portfolio. We develop numerical schemes for the computation of such risk measures using Fourier transform methods. This leads to a very competitive method for the calculation of CV@R for instance, which is comparable in computational time to the calculation of V@R. We also address the computation of risk contributions in a portfolio of risks, for which Fourier transform methods are particularly efficient.

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MS11

A Recursive Algorithm for Dynamic Multivariate Risk Measures and a Set-Valued Bellman's Principle

A method for calculating multi-portfolio time consistent multivariate risk measures in discrete time is presented. Market models for d assets with transaction costs or illiquidity are considered. The set of risk compensating portfolio vectors at each time and state is calculated recursively backwards in time along the event tree. We motivate why the proposed procedure can be seen as a set-valued Bellman's principle. We give conditions under which the backwards calculation reduces to solving a sequence of linear, respectively convex vector optimization problems. Numerical examples include superhedging under illiquidity, the entropic set-valued risk measure, and the composed set-valued average value at risk.

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MS12

The Master Equation of Mean Field Games and Controlled McKean Vlasov Dynamics

Abstract not available at time of publication.

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MS12

Mean Field Games with Congestion

In this talk, we consider mean field games with congestion effects. Such models were originally considered by Lions who established uniqueness of solutions. We present a new class of a-priori estimates, which yield the existence of smooth solutions.

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MS12

Coalescence of Hysteresis in a Large Population: Mean Field Stackelberg Games

In this talk, I shall introduce an N-player interacting strategic game in the presence of a (endogenous) dominating player, who gives direct influence on individual agents, through its impact on their control in the sense of Stackelberg game, and then on the whole community. Each individual agent is subject to a delay effect on collecting information, specifically at a delay time, from the dominating player. The size of his delay is completely known by the agent; while to others, including the dominating player, his delay plays as an hidden random variable coming from a common fixed distribution.

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MS12

Linear-Quadratic Optimal Control Problems for Mean-Field Stochastic Differential Equations — Time-Consistent Solutions

Abstract not available at time of publication.

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MS13

Finding Local Equilibria by Splitting Multidimensional BSDEs

We consider a model of a financial market where investors take not only their own absolute performance, but also the relative performance compared to their peers into account. Finding equilibria in this setting is related to multidimensional backward stochastic differential equations (BSDEs). We introduce a new notion of local solution by splitting multidimensional BSDEs over time. From this, we deduce that there exist local but no global equilibria in our model of a financial market.

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MS13

Various Aspects of Incomplete Equilibrium Theory

In this talk we will present recent progress related to the theory of incomplete equilibrium theory incl. open problems.

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MS13

Quadratic BSDEs Arising from a Price Impact Model with Exponential Utility

We analyze a price impact model where an influential investor wants to trade illiquid assets with a representative market maker who quotes prices for these securities. In our model, the market maker's preferences are modeled through an exponential utility function and the price impact of the trading strategy of the influential investor is derived endogenously through an equilibrium mechanism. We establish a relationship between the equilibrium mechanism and a multidimensional BSDE with quadratic growth. This allows us to show that an equilibrium exists under certain conditions on the final payoffs of the traded assets, the risk aversion coefficient of the market maker and the trading strategy of the influential investor. The relationship between the equilibrium mechanism and the multidimensional quadratic BSDE also allows us to study stability and asymptotic behavior with respect to the parameters of the model. At the same time, the structure of the equilibrium problem allows us to prove novel results for the corresponding BSDE. This is a joint work with Dmitry Kramkov.

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MS13

Existence of Close to Pareto Optimal Incomplete Radner Equilibrium

We consider an equilibrium model between exponential investors whose random endowments cannot be spanned by the traded asset. We first characterize the set of endowments which induce Pareto optimal equilibrium. For endowments close to this set, we establish three existence results of equilibria which are not Pareto optimal. In a

non-Markovian setting, the first existence result is established by analysing a system of coupling quadratic BSDEs, via the techniques introduced by Tevzadze (2008). Then the first result is improved by a BMO-norm estimate in the second result. In a Markovian setting, equilibrium is established using partial regularity results for system of parabolic PDEs with quadratic nonlinearity in gradient.

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MS14

Valuation and Hedging of Contracts with Funding Costs and Collateralization

The research presented in this work is motivated by recent papers by Brigo et al. (2011), Burgard and Kjaer (2009), Crépey (2012), Fujii and Takahashi (2010), Piterbarg (2010) and Pallavicini et al. (2012). Our goal is to provide a sound theoretical underpinning for some results presented in these papers by developing a unified framework for the non-linear approach to hedging and pricing of OTC financial contracts. We introduce a systematic approach to valuation and hedging in nonlinear markets, that is, in markets where cash flows of the financial contracts may depend on the hedging strategies. Our systematic approach allows to identify primary sources of and quantify various adjustment to valuation and hedging, primarily the funding and liquidity adjustment and credit risk adjustment. We propose a way to define no-arbitrage in such nonlinear markets, and we provide conditions that imply absence of arbitrage in some specific market trading models. Accordingly, we formulate a concept of no-arbitrage price, and we provide relevant (non-linear) BSDE that produces the no-arbitrage price in case when the contract's cash flows can be replicated.

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MS14

Efficient Options Pricing under Levy Processes with CVA and FVA

We generalize the CVA-FVA model of Piterbarg (2010) by introducing jumps in the dynamics of the underlying asset. We develop an efficient explicit-implicit scheme for European options, barrier options with CVA-FVA. The advantage of the scheme is that one only needs an explicit analytic formula for the characteristic exponent of the process. The scheme is easy to implement using FFT as the main computational tool. Numerical results are provided for some common Levy models like KoBoL, Variance Gamma, double exponential jump diffusion.

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MS14

Underexposed Risk Snapshots - The Dangers of Risk-Neutral Exposures

As per regulations and common risk management practice, the credit risk of a portfolio is managed via its potential future exposures (PFEs), expected exposures (EEs), and related measures, the expected positive exposure (EPE), effective expected exposure (EEE) and the effective expected positive exposure (EEPE). Notably, firms use these exposures to set economic and regulatory capital levels. Their values have a big impact on the capital that firms need to hold to manage their risks. Due to the growth of CVA computations, and the similarity of CVA computations to exposure computations, firms find it expedient to compute these exposures under the risk neutral measure. Here we show that exposures computed under the risk neutral measure are essentially arbitrary. They depend on the choice of numéraire, and can be manipulated by choosing a different numéraire. Even when restricting attention to commonly used numéraire exposures can vary by a factor of two or more. As such, it is critical that these calculations be done under the real world measure, not the risk neutral measure.

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MS14

Dynamic Replication Strategies under Funding and Collateral Costs

We develop a framework for dynamic hedging of collateralized claims in presence of funding costs. We derive closed form expressions for the total valuation adjustment as well as for the super-hedging strategy of an European claim, under a framework where corporate bonds referencing investor and counterparty may be used to hedge CVA and DVA risk. We decompose the XVA in terms of default- and collateralization free price under funding constraints, funding-adjusted CVA, funding-adjusted DVA and funding costs of the collateralization procedure. We numerically illustrate the impact of counterparty risk and funding costs on the total adjustment.

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MS15

Price Contagion Through Balance Sheet Linkages

We study price linkages between assets held by financial institutions that maintain fixed capital structures over time. We consider a market consisting of a banking and nonbanking sector. Firms in the banking sector actively manage

their leverage ratios to conform with pre-specified target levels. We find that if leverage targeting banks become too large relative to the nonbanking sector, as measured by elasticity-weighted assets, the financial system may enter a regime of excess volatility and correlation. Our analysis suggests that regulatory policies aimed at stabilizing the system by imposing capital constraints on banks may have unintended consequences: banks' deleveraging activities may amplify asset return shocks and lead to large fluctuations in realized returns. The same mechanism can cause spill-over effects, where assets held by leverage targeting banks can experience hikes or drops caused by shocks to otherwise unrelated assets held by the same banks. We show that these effects can be mitigated by encouraging banks to implement asset allocation strategies with higher exposure to liquid, rather than illiquid, assets.

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MS15

Systemic Risk and the Macroeconomy: An Empirical Evaluation

We propose an empirical criterion for evaluating systemic risk measures based on their ability to predict quantiles of future macroeconomic shocks. We construct 17 measures of systemic risk in the US and Europe spanning several decades. We propose dimension reduction estimators for constructing systemic risk indexes from the cross section of measures and prove their consistency in a factor model setting. Empirically, systemic risk indexes provide significant predictive information for the lower tail of future macroeconomic shocks, even out-of-sample.

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MS15

A Structural Model for Asset Price Contagion and Systemic Risk

We develop a structural model for the analysis of systemic risk in financial markets based on asset price contagion. Specifically, we describe a mechanism of contagion where exogenous random shocks to agents in an economy force portfolio rebalancing. This creates an endogenous chain reaction as agents trade in reaction to price changes. Our approach allows us to quantify the effect of attributes such as leverage and portfolio diversity on asset price contagion.

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MS15

Large Portfolio Asymptotics and Fluctuation Analysis for Losses from Default

The past several years have made clear the need to better understand the behavior of risk in large interconnected financial networks. Interconnections often make a system robust, but they can act as conduits for risk. In this talk, I will present recent results on modeling the dynamics of correlated default events in the financial market. An empirically motivated system of interacting point processes is introduced and we study how different types of risk, like contagion and exposure to systematic risk, compete and interact in large-scale systems. A law of large numbers for the loss from default is proven and used for approximating the distribution of the loss from default in large, potentially heterogeneous portfolios. Fluctuation analysis and conditional Gaussian approximations are used to improve the approximations

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MS16

Optimally Thresholded Realized Power Variations for Levy Jump Diffusion Models

Thresholded Realized Power Variations are some of the most popular nonparametric estimators for continuous-time processes with jumps. A common practical issue in their application lies in the necessity of choosing a suitable threshold for the estimator, a problem which so far has not fully been addressed. In this talk, an objective selection method for the threshold is proposed based on desirable optimality properties of the estimators. Concretely, we introduce a well-posed optimization problem which, for a fixed sample size and time horizon, selects a threshold that minimizes the expected total number of jump misclassifications committed by the thresholding mechanism associated with these estimators. The leading term of the optimal threshold sequence is shown to be proportional to the Levy's modulus of continuity of the underlying Brownian motion, hence theoretically justifying and sharpening several selection methods previously proposed in the literature based on power functions or multiple testing procedures. Furthermore, building on the aforementioned asymptotic characterization, we develop an estimation algorithm, which allows for a feasible implementation of the newfound optimal sequence.

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MS16

Convergence Rate of the Truncated Realized Covariance When Prices Have Infinite Variation Jumps

We consider two processes driven by Brownian motions plus drift and jumps with infinite activity. Given discrete observations it is possible to separately estimate the integrated covariation IC between the two Brownian parts and the sum of the co-jumps by using a threshold principle (truncated realized covariance) allowing to isolate the jumps over a given threshold. This gives insight into the dependence structure of the processes and has important applications in finance. We establish here the speed of convergence of $\hat{IC}$ when the small jump components of the two processes are Lévy. We find that such a speed is heavily influenced by the small jumps dependence structure other than by their jump activity indices. This work follows Mancini and Gobbi (2011) and Jacod (2008), where the asymptotic normality of $\hat{IC}$ was obtained when the jump components have finite activity or finite variation.

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MS16

Short-Time Expansions for Close-to-the-Money Options under a Levy Jump Model with Stochastic Volatility

A second order short maturity approximation for ATM option prices is presented for a large class of exponential Lévy models, with or without a Brownian component. We also show that the formulas can be extended to include the case of "close-to-the-money" strike prices, and to the case where the continuous Brownian component is replaced by an independent stochastic volatility process with leverage.

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MS16

Asymptotic Methods for Portfolio Risk Management

We present sharp asymptotics for the left tail of the distribution function of the sum of exponentials of components of a multidimensional time-changed Brownian motion. These results have a wide range of applications in risk analysis of long only portfolios, such as variance reduction methods for precise estimation of tail event probabilities by Monte Carlo, asymptotic formulas for implied volatility of basket options and systematic design of stress tests for long-only portfolios.

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MS17

Bertrand & Cournot Mean Field Games

We study how continuous time Bertrand and Cournot competitions, in which firms producing similar goods compete with one another by setting prices or quantities respectively, can be analyzed as continuum dynamic mean field games. Interactions are of mean field type in the sense that the demand faced by a producer is affected by the others through their average price or quantity. Motivated by energy or consumer goods markets, we consider the setting of a dynamic game with uncertain market demand, and under the constraint of finite supplies. The continuum game is characterized by a coupled system of partial differential equations: a backward HJB PDE for the value function, and a forward Kolmogorov PDE for the density of players. Asymptotic approximation enables us to deduce certain qualitative features of the game in the limit of small competition. We find that, in accordance with the two-player game, a large degree of competitive interaction causes firms to slow down production.

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MS17

Uniqueness of Random Equilibriums in Large Population Stochastic Control

Uniqueness of equilibriums in large population stochastic control, such as mean-field games, may be a challenging question. We here discuss the case when agents are submitted to a common noise, which renders the equilibriums random. It turns out that randomness of the equilibriums may restore uniqueness on the model. Specific examples are discussed.

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MS17

Mean Field Games Systems with Local Coupling

We present some recent results on systems of mean field games with local coupling between the value function and the mean field distribution. Under general structure conditions on the Hamiltonian and coupling, we prove existence and uniqueness of the weak solution, characterizing this solution as the minimizer of some optimal control of Hamilton-Jacobi and continuity equations. We also prove that this solution converges in the long time average to the solution of the associated ergodic problem.

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MS17

On a Boltzmann Type Price Formation Model

In 2007 Lasry & Lions introduced a price formation model that describes the evolution of price by a system of parabolic equations for the trader densities (as functions of the bid-ask price), with the agreed price entering as a free boundary. The authors motivated the model using mean field game theory, but the detailed microscopic origin remained unclear. In this talk we provide a simple agent based trade model with standard stochastic price fluctuations together with discrete trading events. By modeling trading events between vendors and buyers as kinetic collisions we obtain a Boltzmann-type model for the densities. Then we prove rigorously that in the limit of large trading frequencies, the proposed Boltzmann model converges to the Lasry and Lions free boundary problem. We also analyze other asymptotic limits beyond the scales that the free boundary model can describe and illustrate our analytical results with numerical simulations.

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MS18

The Systemic Effects of Benchmarking

I analyze the portfolio construction problem for a group of risk-neutral investors with two sets of goals. On one hand, they wish to maximize the return on their investments within the boundaries of their risk aversion. On the other hand, they wish to outperform a market benchmark. Benchmarking induces excessive risk-taking behavior among certain types of investors. I study the implications of this excessive risk-taking behavior for systemic risk.

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MS18

Risk Measures for Financial Networks

We define systemic risk measures for a network of interconnected banks to be the risk of the system to the obligations the financial firms have to the outside economy. Since the value that is of interest to a regulator is the capital requirements for each financial firm which makes the overall system acceptable, it is natural to consider systemic risk measures as set-valued risk measures.

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MS18

Stochastic Intensity Models of Wrong Way Risk: Wrong Way CVA Need Not Exceed Independent CVA

Wrong way risk can be incorporated in Credit Value Adjustment (CVA) calculations in a reduced form model. Hull and White [2012] introduced a CVA model that captures wrong way risk by expressing the stochastic intensity of a counterparty's default time in terms of the financial institutions credit exposure to the counterparty. We consider a class of reduced form CVA models that includes the formulation of Hull and White and show that wrong way CVA need not exceed independent CVA.

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MS18

Likelihood Inference for Large Financial Systems

We consider the problem of parameter estimation for large interacting stochastic systems. Maximum likelihood estimation is computationally intractable due to the scale and complexity of such systems. Weak convergence results are exploited to develop approximate maximum likelihood estimators for such systems. An important application is systemic risk in banking systems and other large financial systems.

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MS19

Barrier Options, CDS and Quanto CDS in Lévy Models with Stochastic Interest Rate

Recently, advantages of conformal deformations of the contours of integration in pricing formulas for European options have been demonstrated in the context of wide classes of Lévy models, the Heston model and other affine models. Similar deformations were used in one-factor Lévy models, where the Wiener-Hopf factorization is applicable, to price options with barrier and lookback features and CDSs. In the present paper, we generalize this approach to models of structural default with the stochastic interest rate, and design an algorithm which is almost as fast as in the case of the constant interest rate. Similar results are obtained for quanto CDS, where an additional stochastic factor: the

exchange rate is introduced.

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MS19

Ghost Calibration and Pricing Barrier Options and CDSs in Spectrally One-Sided Lévy Models: the Parabolic Laplace Inversion Method

Recently, the advantages of conformal deformations of the contours of integration in pricing formulas were demonstrated in the context of wide classes of Lévy models and the Heston model. In the present paper we construct efficient conformal deformations of the contours of integration in the pricing formulas for barrier options and CDS in the setting of spectrally one-sided Lévy models. We demonstrate that the proposed method is more accurate than the standard realization of Laplace inversion in many cases. We also exhibit examples in which the standard realization is so unstable that it cannot be used for any choice of the error control parameters. This may lead to a *ghost calibration*: a situation where a parameter set of a model is declared to be a "good fit' to the data only because the errors of calibration and of the numerical method used for pricing (almost) cancel each other out.

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MS19

On Additive Subordination with an Application in Cross Commodity Modeling

We study additive subordination, which is a natural generalization of Bochner's subordination, and show that it is a useful technique for constructing time-inhomogeneous Markov processes with analytical tractability. As an application, we develop the first analytically tractable model for crack spread option valuation in the literature that is able to calibrate the implied volatility surface of each commodity. Moreover, our model can generate implied correlation patterns that are consistent with market observations and economic intuitions.

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MS19

Modeling Electricity Prices: A Time Change Approach

We develop a new framework for modeling electricity spot prices by time changing the basic affine jump diffusion, which successfully captures seasonal spikes. Our model is easy to estimate from data and it is tractable for pricing electricity derivatives.

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MS20

Model Uncertainty and Its Impact on the Pricing of Derivative Instruments

Abstract not available at time of publication.

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MS20

Martingale Optimal Transport in the Skorokhod Space

The dual representation of the martingale optimal transport problem in the Skorokhod space of multi dimensional *càdlàg* processes is proved. The dual is a minimization problem with constraints involving stochastic integrals and is similar to the Kantorovich dual of the standard optimal transport problem. The constraints are required to hold for very path in the Skorokhod space. This problem has the financial interpretation as the robust hedging of path dependent European options.

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MS20

Model Uncertainty and Optimal Transport

Abstract not available at time of publication.

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MS20

On Arbitrage and Duality under Model Uncertainty and Portfolio Constraints

We consider the fundamental theorem of asset pricing (FTAP) and hedging prices of options under non-dominated model uncertainty and portfolio constrains in discrete time. We first show that no arbitrage holds if and only if there exists some family of probability measures such that any admissible portfolio value process is a local super-martingale under these measures. We also

get the non-dominated optional decomposition with constraints. From this decomposition, we get duality of the super-hedging prices of European options, as well as the sub- and super-hedging prices of American options. Finally, we get the FTAP and duality of super-hedging prices in a market where stocks are traded dynamically and options are traded statically.

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MS21

Interconnected Balance Sheets, Market Liquidity, and the Amplification Effects in a Financial System

Abstract not available at time of publication.

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MS21

Rehypothecation and Systemic Risk

Abstract not available at time of publication.

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MS21

Efficient Risk Analysis for Mortgage Pools and Mortgage-backed Securities

Typical mortgage pools of interest are very large and computationally expensive to simulate. We develop a dynamic law of large numbers and a dynamic central limit theorem in order to tractably calculate pool loss and prepayment distributions for a broad class of models. Importantly, this large pool approximation is not a "top-down or reduced-form model" but instead takes full advantage of the rich information available from the high-dimensional loan-level data. Computational cost is often several orders of magnitude less than simulation of the actual pool with a similar level of accuracy.

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MS21

Information Contagion in Financial Networks

This paper studies the effect of incomplete information within a banking network, in which banks have obligations to one another and outside depositors. Within this framework, we analyze how incomplete information about the viability of bank assets affects the fragility of the system. In particular, we show that fluctuations in expectations and higher-order beliefs can be amplified and lead to systemic risk. Fragility depends both on the topology of the network as well as the structure of higher-order beliefs. Our results have implications for regulatory policies such as mandatory disclosure policies and stress tests.

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MS22

Convergence of ADI Schemes for Two-dimensional Convection-diffusion Equations with Mixed Derivative Term

Alternating Direction Implicit (ADI) schemes are well-known in the numerical solution of multidimensional time-dependent partial differential equations (PDEs) arising in financial mathematics. The Craig-Sneyd (CS), Modified Craig-Sneyd (MCS) and Hundsdorfer-Verwer (HV) schemes form three popular ADI schemes. A structural analysis of their fundamental properties, notably convergence, is of main interest. Up to now, however, a convergence result is only known in the literature for the HV scheme and only in the case of one-dimensional PDEs. In this talk we shall present a new analysis revealing that, under natural stability and smoothness conditions, the CS, MCS and HV schemes all possess a temporal order of convergence equal to two, uniformly in the spatial mesh width, whenever they are applied to two-dimensional convection-diffusion equations with mixed derivative term. The obtained convergence results will be illustrated by numerical experiments for contemporary stochastic volatility models.

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MS22

High-Order Splitting Methods for Forward PDEs and PIDEs

We construct finite-difference schemes for forward and backward PIDEs such that option prices obtained by solving both the forward and backward equations are consistent. This approach is partly inspired by Andreassen, Huge 2011 who reported a pair of consistent finite-difference schemes of first-order approximation in time for an uncorrelated local stochastic volatility model. We extend this to the second-order in both space and time and also take into account correlations, jumps and discrete dividends.

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MS22

Efficient Implicit Predictor-Corrector Methods for Pricing American Options under Regime Switching

An implicit predictor-corrected method is presented for one and two assets American options under multi-state regime

switching. The method is based on exponential time differencing approach which makes it highly efficient while maintaining excellent stability and convergence properties in each regime with different interest rates. The impact of regime switching on option prices for different jump rates is illustrated. Numerical experiments on American options with convex and nonconvex payoffs demonstrate reliability of the method.

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MS22

Pricing Options under Stochastic Volatility Models with Jumps

We consider partial integro-differential equation (PIDE) formulations for pricing options under the Bates and SVCJ models. The time discretization is performed using the two-step implicit-explicit scheme called IMEX-CNAB. We treat the differential operator implicitly and the integral operator explicitly. For American options, we employ an operator splitting method to decouple the early exercise constraint. Numerical experiments demonstrate the good efficiency of the proposed methods.

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MS23

When Option Pricing Meets Optimal Execution

In this talk, we show how ideas coming from optimal execution models la Almgren-Chriss can be used to solve specific option pricing problems. We present a model to price and hedge call options (with physical settlement or cash settlement) when liquidity costs matter, that is when the underlying is illiquid and/or when the nominal is large. We also briefly discuss the case of Accelerated Share Repurchase contracts in the same modeling framework.

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MS23

Algorithmic Trading with Learning

Abstract not available at time of publication.

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MS23

Simulating and Analyzing Order Book Data: The Queue-Reactive Model

Abstract not available at time of publication.

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MS23

Title Not Available at Time of Publication

Abstract not available at time of publication.

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MS24

Parametric Inference and Dynamic State Recovery from Option Panels

We develop a new parametric estimation procedure for option panels observed with error. We exploit asymptotic approximations assuming an ever increasing set of option prices in the moneyness (cross-sectional) dimension, but with a fixed time span. We develop consistent estimators for the parameters and the dynamic realization of the state vector governing the option price dynamics. The estimators converge stably to a mixed-Gaussian law and we develop feasible estimators for the limiting variance. We also provide semiparametric tests for the option price dynamics based on the distance between the spot volatility extracted from the options and one constructed nonparametrically from high-frequency data on the underlying asset. Furthermore, we develop new tests for model fit over specific regions of the volatility surface and for the stability of the risk-neutral dynamics over time. A comprehensive Monte Carlo study indicates that the inference procedures work well in empirically realistic settings. In an empirical application to S&P 500 index options, guided by the new diagnostic tests, we extend existing asset pricing models by allowing for a flexible dynamic relation between volatility and priced jump tail risk. Importantly, we document that the priced jump tail risk typically responds in a more pronounced and persistent manner than volatility to large negative market shocks.

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MS24

Simulated Likelihood Estimators for Discretely Ob-

served Jump-Diffusions

This paper develops an unbiased Monte Carlo approximation to the transition density of a jump-diffusion process with state-dependent drift, volatility, jump intensity, and jump magnitude. The approximation is used to construct a likelihood estimator of the parameters of a jump-diffusion observed at time intervals that need not be short. The estimator is asymptotically unbiased for any sample size. It is consistent and has the same limiting normal distribution as the true but uncomputable likelihood estimator. Numerical results illustrate our approach.

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MS24

Nonparametric Tests for Constant Betas in Jump-Diffusions

PlWe derive a nonparametric test for constant beta over a fixed time interval from high-frequency observations of a bivariate Ito semimartingale. Beta is defined as the ratio of the spot continuous covariation between an asset and a risk factor and the spot continuous variation of the latter. The test is based on the asymptotic behavior of the covariation between the risk factor and an estimate of the residual component of the asset, that is orthogonal (in martingale sense) to the risk factor, over blocks with asymptotically shrinking time span. Rate optimality of the test over smoothness classes is derived.

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MS24

Assessment of Uncertainty in High Frequency Data: The Observed Asymptotic Variance

No text

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MS25

Optimal Execution and Order Flow Imbalance

We examine optimal execution models that consider informational costs to the trader. Most existing optimal execution literature ignores the traders order side relative to the prevailing order flow. We model the influence on the flow imbalance process and develop an indefinite-horizon stochastic control problem which allows the trader to react to changing order flow by endogenizing the trading horizon T. We then investigate several tractable approximations that are shown to be quite accurate.

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MS26

A Class of Distributions with Analytic Characteristic Functions

In this talk, we consider a class of distributions with characteristic functions that are analytic in a horizontal strip in the complex plane. Distributions in this class can be inverted from their characteristic functions very efficiently using simple rules with exponentially decaying approximation errors. The results can be used for accurate valuation of option contracts in models with jumps and stochastic volatility. Numerical examples illustrate the effectiveness of the schemes.

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MS26

A martingale approach to long term risk and Ross recovery: theory

We start with a general pricing kernel in the semimartingale asset pricing framework and study existence of the long-term forward measure, the long-term limit of T-maturity forward measures. We then show that in the ergodic Markovian environment the Hansen-Scheinkman factorization of the pricing kernel into the permanent and transitory components naturally emerges, and Ross recovery emerges as the special case. The strength of our semimartingale approach is that we naturally extend these concepts to non-Markovian models.

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MS26

Sticky Reflecting Ornstein-Uhlenbeck Processes and Interest Rate Modeling with Zero Lower Bound

We study sticky reflecting Ornstein-Uhlenbeck processes which are solutions to SDEs with sticky boundary conditions. We construct sample paths of the solution by means of time change and represent the transition semigroups in terms of spectral expansion. As an application, we propose a Markovian short rate model with zero lower bound based on sticky OU processes under which zero coupon bond and interest rate derivative prices have analytical solutions though eigenfunction expansion.

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MS26

A martingale approach to long term risk and Ross recovery: examples

We give explicit treatment of a number of asset pricing models where the long-term bond process and the long-term forward measure exist, including affine diffusions, as well as non-Markovian Heath-Jarrow-Morton models.

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MS27

Optimal Transport and Skorokhod Embedding

Model-independent pricing has grown into an independent field in Mathematical Finance during the last 15 years. A driving inspiration in this area has been the fruitful connection to the Skorokhod embedding problem. We discuss a more recent approach to model-independent pricing, based on a link to Monge-Kantorovich optimal transport. Based on a similar technique in optimal transport we derive a "monotonicity principle" that is applicable to model-independent pricing. This transport-viewpoint also sheds new light on Skorokhod's classical problem.

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MS27

Model-Independent Hedging under Portfolio Constraints

We study model-independent superhedging of exotic options under portfolio constraints. The hedging portfolio contains static positions in liquidly traded options, and a dynamic trading strategy, subject to constraints, on the risky asset. By the theory of optimal transport, we establish a superhedging duality, which admits a connection to convex risk measures. We also derive a model-independent fundamental theorem of asset pricing. Our method covers a large class of Delta constraints and Gamma constraint.

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MS27

Quantile Hedging in a Semi-Static Market with Model Uncertainty

With model uncertainty characterized by a convex, non-dominated set of probability measures, investors minimize the cost of hedging a contingent claim with given expected success ratio, by semi-static strategy in stocks and options. We prove duality results that link this quantile hedging price to a randomized composite hypothesis testing problem, and obtain the optimal hedging strategy in complete markets. In incomplete markets, an approximation procedure is proposed, by discretization of the path space.

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MS27

Minimizing the Probability of Lifetime Ruin Under Ambiguity Aversion

We study the robust stochastic control problem of an individual who targets at a given rate of consumption and seeks to minimize the probability of lifetime ruin when she does not have perfect confidence in the drift of the risky asset. In analyzing the HJB equation, we establish the existence and uniqueness of viscosity solution using Perrons method, and then upgrade regularity by working with an equivalent convex problem obtained via the Cole-Hopf transformation.

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MS28

Rare Event Simulations using shaking transformations on stochastic processes

Based on reversible transformation on the state space (such as continuous or cadlag paths), we introduce different Markov chains that enter in the design of two different methods for estimating rare event probability. One is based on interacting particle systems (IPS) and the other on time-average on a single path (POP) using ergodic theorem. We discuss the associated convergence rates and provide numerical experiments. Our examples cover situations related to insurance and finance among others. Both algorithms are accurate, with a seemingly advantage to POP.

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MS28

Global Ranking Problems, Sequential Design and Applications to Real Options

We consider sequential design approaches to the problem of determining the pointwise index of the largest function among a family of N maps $x \mapsto f_i(x)$, $i = 1, 2, \ldots, N$,

over a multi-dimensional domain $x \in \mathcal{X}$. The f_i's are unknown but can be noisily sampled. Our context is motivated by the extension of the sequential Regression Monte Carlo approach to optimal switching problems. Applications to valuation of real options for irreversible capacity expansion will be presented.

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MS28

Improved Greeks for American Options Using Simulation

This paper revisits the estimation and approximation of the Greeks for American style options and compares various methods in term of bias, convergence and overall performance. Using the constrained least squares Monte Carlo method of Létourneau and Stentoft (2014) a new, simple and computationally efficient method is proposed, which is based on differentiating the holding value function. The proposed method is shown to perform well compared to existing methods.

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MS28

An Iterative Simulation Approach for Solving Stochastic Control Problems in Finance

We develop a variable sample size, iterative, contraction method to solve stochastic optimization problems with continuous choice variables, and study its asymptotic convergence. We use the method to solve first order optimality conditions for high-dimensional discrete-time stochastic control problem under general constraints, in a framework that employs Monte-Carlo simulation in every step. We illustrate the method using applications from Finance.

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MS30

A Robust Spectral Method for Pricing Options under Local Volatility

We constructed a spectral method for solving PDEs modelling standard European and American options under local volatility. In the case of European options, the PDE is discretised directly in space, whereas the free boundary problem arising from American options is reformulated as a variational inequality which is then transformed into a nonlinear PDE on fixed boundaries by adding a penalty term. The resulting nonlinear PDE is discretised using an adaptive rational spectral method.

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MS30

On the Sensitivity of Calibrated American Put Values to Short Rate Volatility

We demonstrate that for a wide class of Equity-Interest rate hybrid models the price of the American put decreases with increasing interest rate volatility. Specifically we assume the Equity volatility is local in spot and spot-rate correlation is non-negative. The model is required to calibrate perfectly to vanillas and zero coupons. We deduce that the price of American put is maximal when interest rate volatility is zero and the model reduces to Dupire local volatility.

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MS30

A New Hybrid Monte Carlo-Finite Difference Method to Obtain Counterparty Exposure Profiles and Sensitivities

After the credit crunch, financial institutions are more and more interested in the Expected Exposure (EE) of their derivatives. This EE is also needed to compute the Credit Valuation Adjustment (CVA). To measure EE we introduce the Finite Difference Monte Carlo (FDMC) method. By combining two well-known methods in options pricing, highly accurate probability densities of future option prices can be obtained. In this presentation we show how FDMC can be extended to compute CVA and its sensitivities of a portfolio. Next to that, we show that it can be applied to higher dimensional ($n \geq 2$) models.

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MS30

Dimension Reduction Techniques in Space and Discontinuous Galerkin in Time to Price High-Dimensional Options

A multi-dimensional Black-Scholes equation to price basket options is solved using adaptive finite differences. These problems suffer from the "curse of dimensionality" which is here tackled by using a dimension reduction technique; a principal component analysis together with an asymptotic expansion. In time we employ a discontinuous Galerkin scheme. We will present the favorable properties of this methodology in terms of accuracy and computational time.

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MS31

Asymptotic Approximations for Some Path-Dependent Contracts

We give asymptotic formulas for approximate valuation of some path-dependent contracts.

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MS31

Explicit Implied Vols for Multifactor Local-Stochastic Vol Models

We consider an asset whose risk-neutral dynamics are described by a general class of local-stochastic volatility models and derive a family of asymptotic expansions for European-style option prices and implied volatilities. Our implied volatility expansions are explicit; they do not require any special functions nor do they require numerical integration. To illustrate the accuracy and versatility of our method, we implement it under five different model dynamics: CEV local volatility, quadratic local volatility, Heston stochastic volatility, 3/2 stochastic volatility, and SABR local-stochastic volatility.

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MS31

Convergence of the Discrete Variance Swap in Time-Homogeneous Diffusion Models

In stochastic volatility models based on time-homogeneous diffusions, we provide a simple necessary and sufficient condition for the discretely sampled fair strike of a variance swap to converge to the continuously sampled fair strike. It extends Theorem 3:8 of Jarrow, Kchia, Larsson and Protter (2013). In particular it gives an affirmative answer to a problem posed in that paper in the case of the 3/2 stochastic volatility model. We also give precise conditions (not based on asymptotics) when the discrete fair strike of the variance swap is higher than the continuous one and discuss the convex order conjecture proposed by Griessler and Keller-Ressel (2014) in this context.

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MS32

Robust Nash Strategies in Mean Field LQG Games

We consider a mean field game in a linear-quadratic-Gaussian (LQG) setting. All agents' dynamics are affected by a common disturbance signal in the drift term, as an unknown L_2 function of time, which models the uncertainty in the decision environment. Each agent wishes to minimize its worst case cost where the disturbance acts first to maximize. We obtain a set of decentralized strategies as a robust ϵ-Nash equilibrium in an N player game. The solution is based on open-loop information and is characterized by a system of forward backward stochastic differential equations (FBSDEs).

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MS32

Mean Field Models for Dynamic Matching Markets

We present recent progress in the application of mean field models to dynamic matching markets. In particular we consider a decentralized two-sided matching market in which agents arrive and depart asynchronously. As a result, it is possible that an agent on one side of the market (a buyer) identifies an agent on the other side of the market (a seller) who is a suitable match, only to find that the seller is already matched. We find using a mean field approach that lack of knowledge about availability can create large welfare losses to both buyers and sellers. We consider a simple intervention available to the platform: limiting visibility of sellers. We find that this intervention can significantly improve the welfare of agents on both sides of the market; sellers pay lower application costs, while buyers are less likely to find that the sellers they screen have already matched. Somewhat counterintuitively, the benefits of showing fewer sellers to each buyer are greatest in markets in which there is a shortage of sellers. In this talk, we describe the nonasymptotic model, its formal mean field limit, and some of the key techniques employed to establish

an approximation theorem.

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MS32

Mean Field Games with a Common Noise

This talk presents some recent results on stochastic differential mean field games (MFGs) with common noise. The concepts of strong and weak solutions are introduced in analogy with the theory of stochastic differential equations, and existence of weak solutions for MFGs holds under very general assumptions. Using an analog of the famous result of Yamada and Watanabe, existence and uniqueness of a strong solution can be shown to hold in some cases. Finally, it turns out that the notion of weak solution is the right one from the perspective of the n-player games: Every sequence of approximate Nash equilibria in the n-player games admits certain limits as n tends to infinity, and every limit is a weak solution of the MFG. Conversely, every weak solution of the MFG can be obtained as the limit of a sequence of approximate Nash equilibria in the n-player games.

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MS33

Perturbation Analysis on Decision-Making for Investment Portfolios Under Partial Information

It is well-known that solving the Markowitz problem will result in portfolio weights that don't resemble the weights used in real-life investment. The Black-Litterman is a practical solution to this problem, wherein investors' views on upcoming performance are incorporated into the optimization along with any degree of uncertainty that the investor may have in these views. In this paper we consider a Merton-type portfolio problem wherein the framework is adapted to incorporate filtering and the views of market experts. Our results use perturbation theory to analyze a partial information HJB equation, from which we find an intuitive interpretation of the model parameters and of how stochasticity in expected returns affects optimal investment.

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MS33

Asymptotic Single Risk Factor Model of Credit Risk: Empirical Evidence from Australia

Prevailing states of the Australian economy recovered from the asymptotic single risk factor model implemented by the Basel II internal ratings-based approach find general agreement with macroeconomic indicators. Since the depths of the financial crisis of 2007-09 were reached after the implementation of Basel II, our analysis measures the impact of the crisis on the Australian banking sector. Access to internal bank data collected by the prudential regulator distinguishes our research from other empirical studies on the recent crisis.

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MS33

Short Rate Models with Stochastic Volatility

We look at a class of non-affine short rate models with lognormal stochastic volatility as a low-dimensional alternative to LIBOR Market Model. For efficient calibration to swaption vol grids, we first obtain asymptotic expansions of zero bond price in the presence of time-dependent parameters and in multi-dimensional setting. We then formulate the problem of calibrating to market-consistent SABR parameter matrix as an optimal projection of forward swap rate process onto the SABR process.

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MS33

Optimal Consumption With Habit Formation In Markets with Transaction Costs And Unbounded Random Endowment

This paper studies the utility maximization problem on consumption with addictive habit formation in the markets with proportional transaction costs and unbounded random endowment. To model the proportional transaction costs, we adopt Kabanov's multi-asset framework with a cash account. At the terminal time t=T, the investor can receive an unbounded random endowment for which we propose a new definition of acceptable portfolio processes depending on the strictly consistent price system (SCPS). We prove a type of super-hedging theorem for a family of workable contingent claims using the acceptable portfolios and random endowment which enables us to obtain the consumption budget constraint result under the market frictions. With the path dependence reduction and the embedding approach, the existence and uniqueness of the

optimal consumption are proved using the auxiliary primal and dual processes and the convex duality analysis

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MS34

Wrong Way and Gap Risks Modeling: A Marked Default Time Approach

We use marked stopping times to model the defaults of two counterparties. The role of the mark is to convey some information about the defaults, in order to account for various possible wrong-way risk and gap risk scenarios and features. The corresponding CVA, DVA and FVA equations and studied. Specific tools are required to analyze the cure period (time interval between the default and the liquidation) and the ensuing gap risk of diverging evolutions of the portfolio and of its collateral. In particular, the liquidation time is predictable (as announced by the default time), which modifies the nature of the pricing problems. The case of counterparty risk on credit derivatives, a major wrong-way and gap risk concern, poses specific dependence modeling and dimensionality challenges. To address these, we resort to dynamic copula models of portfolio credit risk and we apply the above-mentioned approach in these setups.

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MS34

Derivative Pricing under Collateralization and Differential Rates

The increasing practice of collateralization has a deep impact on the valuation of derivatives. Assuming cash collateral, and that collateral posting occurs in continuous time, Piterbarg (2010) derived an option pricing formula under the assumption of an unsecured funding rate that is different than the collateral rate. In this talk, we extend Piterbarg's (2010) result on European-style derivative pricing under collateralization, by relaxing the assumption of a single unsecured funding rate. Introducing different lending and borrowing rates has the effect of producing nonlinear price functionals for general claims. Buyer and seller prices diverge, and values of derivative portfolios are not the sum of the individual deal values. Conditions under which no-arbitrage price bounds can be derived explicitly are given and numerical examples showcased.

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MS34

Joint Measure Calibration and Mean Reversion Skew for Interest Rates

We propose a model for interest rates which produces both risk neutral and real world distributions. The model is calibrated to market implied prices and historical regressions of rates of different maturity. The interest rate mean reversion estimated using the model is found to depend on rate level and increase rapidly for rates above 10 percent, which eliminates implausible scenarios for rates and FX produced by flat reversion models.

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MS35

Integral Representation Theorems for Martingales Motivated by the Problems of Endogenous Completeness and Market Completeness with Derivative Securities

We present conditions, which guarantee the endogenous completeness of a dynamic equilibrium market and the completeness of markets in which, in addition to stocks, one may also trade derivative securities. From a purely mathematical point of view we prove the following integral representation theorem: let $\mathbb{Q}$ and $\mathbb{P}$ be two equivalent probability measures, S_F a martingale under $\mathbb{Q}$, ψ a vector of random variables and let $S_t^B = \mathbb{E}^{\mathbb{Q}}[\psi|\mathcal{F}_t]$. We present conditions on model primitives which guarantee that every local martingale under $\mathbb{Q}$ can be represented as a stochastic integral with respect to the martingale $S = (S^F \ S^B)^\star$.

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