Submittee: Christoph Frei
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Title: PIMS Summer School 2016 in Mathematical Finance
Event Type: Summer-School

Location:
University of Alberta

Dates:
June 25 - July 6, 2016 (the summer school was followed by the Sixth International IMS-FIPS Workshop, which took place July 7-9, also at the University of Alberta)

Topic:
The summer school had two themes:
1. Informational and Imperfect Financial Markets (lecturers: Marek Rutkowski, Agnes Sulem and Thaleia Zariphopoulou)
2. Market Microstructure and Algorithmic Trading (lecturers: Robert Almgren, Alvaro Cartea and Sebastian Jaimungal)

Methodology:
60 participants attended an intensive program over two weeks with two themes. Each theme contained three lecture series, with each 4 or 5 lectures of 60min length. An excursion to Jasper between the two themes and a barbecue event provided additional opportunities for informal interaction. The summer school was followed by the Sixth International IMS-FIPS Workshop, which allowed the participants of the summer school to attend presentations of researchers in the field, give themselves talks and further discuss their research ideas.

Scientific Highlights:
As some participants wrote in the event evaluation, the scientific program as a whole was a highlight. The lectures during the two weeks reflected the full breadth of mathematical finance: from theoretical to applied topics, all of which were delivered at a high scientific level and included the latest developments in the field.

Organizers:
Frei, Christoph, Department of Mathematical and Statistical Sciences, University of Alberta;
U.S. Partner: Fouque, Jean-Pierre, Department of Statistics and Applied Probability, University of California Santa Barbara
Choulli, Tahir, Department of Mathematical and Statistical Sciences, University of Alberta;
Melnikov, Alexander, Department of Mathematical and Statistical Sciences, University of Alberta;

Speakers:
Robert Almgren (Quantitative Brokers):
Abstract: The lectures presented some aspects of market microstructure that are important for constructing effective trading algorithms. Theory was developed as much as possible, but the flavour was practical. Contents:
1. Introduction: Structure of double auction markets. Differences between equities, futures, and fixed income. Market data and some of its challenges. Contents:
2. Descriptive statistics: Intraday and cross-asset profiles. Tick size effects. High frequency volatility measurement.
3. Implied quoting in futures markets, and its importance for identifying hidden liquidity.
4. Market simulation for algorithm development: Markov models or data replay?
5. Trading benchmarks, market impact, and optimal algorithm design.

Alvaro Cartea (Department of Mathematics, University of Oxford) and Sebastian Jaimungal (Department of Statistical Sciences, University of Toronto): Algorithmic and High-Frequency Trading
Abstract: The course covered different aspects of algorithmic trading. The first part of the course reviewed stochastic optimal control and discussed relevant topics in market microstructure. The course focused on developing models for algorithmic trading. In particular, models to: execute (buy or sell) large blocks of equity, make markets (i.e. provide liquidity), target VWAP and other schedules, trade pairs or collection of assets, and execute in dark pools. Examples with trading data and implementation of various models were presented. Contents:
1. Stochastic optimal control and other stochastic calculus tools
2. Microstructure:
a. Grossman-Miller
b. Kyle
3. Limit order book (equity)
4. Optimal liquidation: Almgren-Chriss
a. Temporary price impact
b. Permanent price impact
c. Inventory control and urgency
d. Price Limiter
5. Execution in Dark Pools
6. Optimal execution with Order Flow information
7. Execution targets: VWAP, TWAP
8. Market Making
9. Co-integration of assets and Pairs Trading
10. Limit order book trading signals: volume imbalance
11. Stale quotes, latency arbitrages, and Last Look in Foreign Exchange markets

Marek Rutkowski (School of Mathematics and Statistics, University of Sydney):
Abstract: The standard approach to pricing and hedging of financial derivatives, which was widely used by the financial industry before the financial crisis 2007/2008, hinges on a number of crucial assumptions made in order to lubricate the mathematical analysis. These simplifications have proved detrimental in the ensuing chaos of the crisis, partially because of the breakdown of a previously held belief that large financial institutions are virtually infallible. The objective of these lectures was to incorporate into the mathematical framework the possibility of default and, crucially, the growing need for banks to capture the funding costs associated with hedging portfolios. This allowed for developing market models, based on a suitable extension of classic arbitrage pricing theory, which are able to control default risk and describe the consequential satellite mechanism of collateralisation. Multiple funding sources were also included into the pricing models. The main mathematical goals that were achieved are as follows:
- To develop an economic model describing the dynamics of self-financing portfolios under a temporary assumption of the absence of default risk of counterparties, but with different funding

costs for risky assets used to establish hedging portfolios.
- To extend this model to account for the effects of collateralisation and default events.
- To explore the issue of arbitrage and build a sound basis for the fair pricing framework with funding costs and counterparty risk.
- To analyse the pricing and hedging problems in terms of non-linear Backward Stochastic Differential Equations (BSDEs).
- To address the issue of asymmetry of pricing,which is due to different funding costs incurred by the counterparties, through multi-dimensional BSDEs.

Agnes Sulem (INRIA Paris): Nonlinear Pricing in Imperfect Financial Markets
Abstract: The aim of the lectures was to study pricing and hedging issues for various options (European, American, game options) in the case of imperfections on the market. These imperfections were taken into account via the nonlinearity of the wealth dynamics. Moreover, the possibility of a default was considered. In this setting, the pricing system was expressed as a nonlinear g-expectation/g-evaluation induced by a nonlinear BSDE (backward stochastic differential equation) with jumps. A large class of imperfect market models can fit in this framework, including imperfections like different borrowing and lending interest rates, taxes on the profits from risky investments, or the case of a "large investor seller", in the sense that the trading strategy of the seller affects the market prices. In particular, superhedging issues for American and game options in this context were addressed and their links with generalized optimal stopping problems and Dynkin games were studied.

Thaleia Zariphopoulou (Department of Mathematics and Department of Information, Risk, and Operations Management, University of Texas at Austin): An introduction to the forward performance approach
Abstract: The lecture started with an introduction to the forward performance criterion and its connection to the classical expected utility approach. In turn, the forward stochastic PDE and a detailed analysis of the time-monotone case in Ito-diffusion markets were presented. Long-term (turnpike) results were discussed as well as the cases of partial information and model ambiguity. In the sequel, forward performance process with non-zero volatility were presented. The family of homothetic forward processes were analyzed and its connection with ergodic and infinite-horizon BSDE, and with the long-term limit of the classical expected utility, were discussed. Finally, a discrete-time family of forward processes was presented, and results for predictable forward processes were given for completely monotonic utility data.

Links:
http://www.mathfinance2016.com

File Uploads:
Additional Upload 1: http://www.pims.math.ca/files/final_report/regional_distribution.pdf

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