Universität Trier

Stochastic Models and Control Workshop 2017

PROGRAM

March 22—24, 2017
University of Trier
Germany

Sponsored by Research Training Group

ALGORITHMIC OPTIMIZATION

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WELCOME

Dear attendees,

We would like to welcome you to the Stochastic Models and Control Workshop 2017. Continuing the tradition of the successful workshops in this series held in Wittenberg (2009), Bad Herrenalb/Karlsruhe (2011), Berlin (2013), and in Kaiserslautern (2015), the 2017 meeting aims to provide a stimulating environment for discussions of recent developments, and a platform for presentations of current research in our field.

We gratefully acknowledge financial support from the German Research Foundation (DFG) within the research training group Algorithmic Optimization (2126).

The workshop takes place at Nells Park Hotel, Dasbachstraße 12 in 54292 Trier. For further information, please consult the SMC website

www.alop.uni-trier.de/stochastic-models-and-control

and the hotel website

www.nellsparkhotel.de

We wish you a pleasant stay in Trier and hope you will enjoy the conference.

The local organizers

Program

	Wednesday	Thursday	Friday
08:30	Registration / Welcome Address		
09:00	Mogens Steffensen	Łukasz Stettner	Johannes Muhle-Karbe
09:20			
09:40	Sascha Desmettre	Pavel Gapeev	Martin Herdegen
10:00	Break	Break	Break
10:10	Anna Jaśkiewicz	Miklós Rásonyi	Mete Soner
10:30			
10:50	Dariusz Zawisza	Todor Bilarev	Tiziano de Angelis
11:10	Coffee Break	Coffee Break	Coffee Break
11:40	Gunther Leobacher	Paolo Guasoni	Huyên Pham
12:00	Peter Hieber		
12:20	Ralf Wunderlich	Holger Kraft	Jörn Sass
12:40	Dorothee Westphal	Matthias Lenga	Anton Shardin
13:00	Lunch Break	Lunch Break	Lunch Break
14:20	Goran Peskir	Nizar Touzi	Johan Andreasson
14:40			Ari-Pekka Perkkiö
15:00	Moritz Voß	Robert Stelzer	Daniel Bartl
15:20	Break	Break	Break
15:30	Martin Larsson	Luitgard Veraart	Huy Ngoc Chau
15:50			Harold Moreno-Franco
16:10	Yaroslav Melnyk	Peter Frentrup	Farewell Coffee
16:30	Coffee Break	Coffee Break	
17:00	Michaela Szölgyenyi	Carlo Ciccarella	
17:20	Alessandro Balata	Christian Vonwirth	
17:40		Anastasiia Zalashko	
	Conference Dinner		

Daily Schedule — Wednesday, March 22

08:30—9:00	**Registration/Welcome Address**
09:00—9:40	**Mogens Steffensen** *Time-consistent consumption and investment*
09:40—10:00	**Sascha Desmettre** *Worst-case optimal investment in incomplete markets*
10:00—10:10	**Break**
10:10—10:50	**Anna Jaśkiewicz** *Optimal growth model with risk sensitive preferences*
10:50—11:10	**Dariusz Zawisza** *General solution to the stochastic control on the half line with some optimal consumption and dividend applications*
11:10—11:40	**Coffee Break**
11:40—12:00	**Gunther Leobacher** *Utility indifference pricing of insurance catastrophe derivatives*
12:00—12:20	**Peter Hieber** *Funding life insurance contracts with guarantees: How can we optimally respond to the policyholder's needs?*
12:20—12:40	**Ralf Wunderlich** *Expert opinions and utility maximization in a market with partially observable Gaussian drift*
12:40—13:00	**Dorothee Westphal** *Expert opinions for multivariate stock returns with Gaussian drift*
13:00 –14:20	**Lunch Break**
14:20—15:00	**Goran Peskir** *Constrained dynamic optimality and binomial terminal wealth*
15:00—15:20	**Moritz Voß** *Linear quadratic stochastic control problems with singular stochastic terminal constraint*
15:20—15:30	**Break**
15:30—16:10	**Martin Larsson** *Measure-valued polynomial diffusions and large equity markets*
16:10—16:30	**Yaroslav Melnyk** *Utility maximization under small jump intensity*
16:30—17:00	**Coffee Break**
17:00—17:20	**Michaela Szölgyenyi** *Convergence of Euler-Maruyama for SDEs in stochastic control*
17:20—17:40	**Alessandro Balata** *Regress later Monte Carlo for controlled Markov processes*
19:00	**Conference Dinner**

Daily Schedule — Thursday, March 23

09:00—9:40	**Łukasz Stettner** *Long run impulse control problems*
09:40—10:00	**Pavel Gapeev** *On the perpetual American options on a traded account*
10:00—10:10	**Break**
10:10—10:50	**Miklós Rásonyi** *Optimal investment with general preferences in markets with frictions*
10:50—11:10	**Todor Bilarev** *Multiplicative impact model with transient impact: Modeling issues and superhedging of European options*
11:10—11:40	**Coffee Break**
11:40—12:20	**Paolo Guasoni** *Should commodity investors follow commodity prices?*
12:20—12:40	**Holger Kraft** *Predictors and portfolios over the life cycle*
12:40—13:00	**Matthias Lenga** *Representable American options*
13:00 –14:20	**Lunch Break**
14:20—15:00	**Nizar Touzi** *Continuous-time principle-agent problem: A Stackelberg stochastic differential game*
15:00—15:20	**Robert Stelzer** *Shall you invest more risky when you are still young?*
15:20—15:30	**Break**
15:30—16:10	**Luitgard Veraart** *Adjustable network reconstruction with applications to CDS exposures*
16:10—16:30	**Peter Frentrup** *Optimal liquidation under stochastic order book imbalance*
16:30—17:00	**Coffee Break**
17:00—17:20	**Carlo Ciccarella** *Sailboat trajectory optimization*
17:20—17:40	**Christian Vonwirth** *Optimal portfolio policies under partial information and convex constraints: Solving the duality problem explicitly*
17:40—18:00	**Anastasiia Zalashko** *Anticipation of information via causal transport*

Daily Schedule — Friday, March 24

09:00—9:40	**Johannes Muhle-Karbe** *Option market making with imperfect competition*
09:40—10:00	**Martin Herdegen** *Equilibrium liquidity premia*
10:00—10:10	**Break**
10:10—10:50	**Mete Soner** *Optimal dividends with random profitability*
10:50—11:10	**Tiziano de Angelis** *The dividend problem with a finite horizon*
11:10—11:40	**Coffee Break**
11:40—12:20	**Huyên Pham** *Randomized filtering and Bellman equation for partial observation control problem*
12:20—12:40	**Jörn Sass** *Model reduction and mutual funds for portfolio optimization in hidden Markov models*
12:40—13:00	**Anton Shardin** *Partially observable stochastic optimal control problems for an energy storage*
13:00 –14:20	**Lunch Break**
14:20—14:40	**Johan Andreasson** *A least-squares Monte Carlo dynamic programming approach to retirement modelling*
14:40—15:00	**Ari-Pekka Perkkiö** *Convex integral functional of regular processes*
15:00—15:20	**Daniel Bartl** *Pointwise dual representation of dynamic convex expectations*
15:20—15:30	**Break**
15:30—15:50	**Huy Ngoc Chau** *Stochastic algorithm with a mixing process and discontinuity in the parameters*
15:50—16:10	**Harold Moreno-Franco** *Singular stochastic control problem for Lévy diffusions*
16:10	**Farewell Coffee**

Abstracts

Mogens Steffensen

Time-consistent consumption and investment

We present some developments in consumption-investment problems with consistency issues. First, we review the mean-variance consumption-investment problems that have been studied in the recent literature. Second, we present some alternative quadratic objectives and present the corresponding optimal portfolios. Finally, we show how consistency issues show up also in utility optimization in case of non-linear aggregation of certainty equivalents of consumption.

Sascha Desmettre

Worst-case optimal investment in incomplete markets

We study the worst-case optimal portfolio problem (compare [1]) of an investor with logarithmic preferences facing the possibility of a market crash with stochatsic market coefficients by adapting the martingale approach developed in [2]. With the help of a BSDE approach (compare [3]) we are able to characterise the resulting indifference optimal strategies in a fairly general setting. Under suitable conditions on the market price of risk, also optimality of the indifference strategies holds in the sense of [2]. We demonstrate our approach for the Heston stochastic volatility model and the Kim-Omberg stochastic excess return model and solve the corresponding BSDEs via solving their asscociated PDEs, using a utility crash-exposure transformation.

This is joint work with Sebastian Merkel (University of Mannheim).

References:
[1] Korn, R., Wilmott, P., 2002, *Optimal Portfolios under the Threat of a Crash*, International Journal of Theoretical and Applied Finance 5 (2), 171187.
[2] Seifried, F.T., 2010, *Optimal Investment for Worst-Case Crash Scenarios: A Martingale Approach*, Mathematics of Operations Research 35, 559-579.
[3] El-Karoui, N., Peng, S., Quenez, M.C., 1997, *Backward Stochastic Differential Equations in Finance*, Mathematical Finance 7(1), 1-71.

Anna Jaśkiewicz

Optimal growth model with risk sensitive preferences

This talk is concerned with a one-sector optimal growth model with i.i.d. productivity shocks that are allowed to be unbounded. The utility function is assumed to be non-negative and unbounded from above. The novel feature in our framework is that the agent has risk sensitive preferences and he/she uses the entropic risk measure to evaluate discounted payoff in a recursive way. Under mild assumptions imposed on the productivity and utility functions we prove that the maximal discounted non-expected utility in the infinite time horizon satisfies the corresponding optimality equation and the agent possesses a stationary optimal policy. A new point used in our analysis is an inequality for the so-called associated random variables.

This talk is based on a joint paper with N. Bäuerle.

Dariusz Zawisza

General solution to the stochastic control on the half line with some optimal consumption and dividend applications

We consider a semilinear parabolic equation with its domain concentrated on the half line $(0, +\infty)$. The equation corresponds directly to stochastic control and stochastic game problems with a compact control space and an uncertain time horizon given by a stopping time. This is a typical problem for many financial and actuarial applications. We provide a set of general assumptions to ensure that there exists a smooth classical solution to that equation. In the proof we use the fixed point theorem to the simplified equation and extend it by making some transformations and approximations. Such result can be seen as a very comfortable starting point to consider other control problems, for example those with unbounded control space. Some examples concerning consumption and dividend problems will be provided. The talk will be based on current research work.

Gunther Leobacher

Utility indifference pricing of insurance catastrophe derivatives

We propose a model for an insurance loss index and the claims process of a single insurance company holding a fraction of the total number of contracts that captures both ordinary losses and losses due to catastrophes. In this model we price a catastrophe derivative by the method of

utility indifference pricing. The associated stochastic control problem is treated by techniques for piecewise deterministic Markov processes (PDMPs).

We perform a numerical study that illustrates our results. This motivates research on the simulation of PDMPs in general.

Joint work with A. Eichler (FH Upper Austria) and M. Szölgyenyi (WU Vienna).

Peter Hieber

Funding life insurance contracts with guarantees: How can we optimally respond to the policyholder's needs?

In a low interest rate environment, life insurance contracts with guarantees seem to be unattractive for the policyholders. That is why, in order to still acquire new business, insurance companies need to be more innovative in their contract design. We examine so-called flexibility riders where (in contrast to traditional life insurance products) it is the policyholder who can to some extent decide on the investment strategy of the accumulated premiums (examples of products that are currently offered are Allianz IndexSelect, AXA Twin Star, or Swiss Life Champion). Therefore, we solve an optimal asset allocation problem maximizing the expected utility of the policyholder's insurance contract payoff. Due to caps and investment guarantees, the contract's payoff is option-like, forcing the objective function to be a partially flat and non-concave function of the backing asset pool's returns. We apply results on non-concave utility maximization by, e.g., Carpenter [2001] and Reichlin [2013] to the setup of an equity-linked life insurance contract with guarantee. For a constant relative risk aversion (CRRA) investor, we determine closed-form expressions for the utility-maximizing investment strategy of the policyholder. This provides insights on how to improve insurance contract design to better suit the policyholder's needs.

This is joint work with An Chen and Thai Nguyen.

Ralf Wunderlich

Expert opinions and utility maximization in a market with partially observable Gaussian drift

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We consider a continuous-time financial market with partial information on the drift and solve utility maximization problems which include expert opinions on the unobservable drift. Stock returns are driven by a Brownian motion and the drift depends on a factor process which is an Ornstein Uhlenbeck process. Thus the drift is hidden and has to be estimated from observable quantities. If the investor only observes stock prices then the best estimate is the Kalman filter.

However, to improve the estimate, an investor may also rely on expert opinions providing a noisy estimate of the current state of the drift. This reduces the variance of the filter and thus improves expected utility. That procedure can be seen as a continuous-time version of the classical Black-Litterman approach.

For the associated portfolio problem with logarithmic utility explicit solutions are available in the literature. In this talk we consider the case of power utility. Here, we apply dynamic programming techniques and solve the corresponding dynamic programming equation for the value function. Diffusion approximations for high-frequency discrete-time experts allow to simplify the problem and to derive more explicit solutions. We illustrate our findings by numerical results.

Joint work with Hakam Kondakji.

Dorothee Westphal

Expert opinions for multivariate stock returns with Gaussian drift

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We investigate a financial market with multivariate stock returns where the drift is an unobservable Ornstein-Uhlenbeck process. Information is obtained by observing stock returns and unbiased expert opinions.

The optimal trading strategy of an investor maximizing expected logarithmic utility of terminal wealth depends on the conditional expectation of the drift given the available information, the filter. We investigate properties of the filters and their conditional covariance matrices. This includes the asymptotic behaviour for an increasing number of expert opinions on a finite time horizon and conditions for convergence on an infinite time horizon with regularly arriving expert opinions.

In the situation where the number of expert opinions goes to infinity on a finite time horizon we distinguish between the case where experts have some minimal level of reliability and experts whose uncertainty increases with increasing frequency of information dates. The latter case leads to a diffusion approximation where the limiting diffusion can be interpreted as a continuous-time expert.

We deduce properties of the value function using its representation as a functional of the conditional covariance matrices.

This is joint work with Jörn Sass (TU Kaiserslautern) and Ralf Wunderlich (BTU Cottbus-Senftenberg).

Goran Peskir

Constrained dynamic optimality and binomial terminal wealth

Assuming that the stock price follows a geometric Brownian motion and the bond price compounds exponentially, we recently derived a dynamically optimal control for the investor aiming to minimise the variance of his terminal wealth over all admissible controls such that the expectation of the terminal wealth is bounded below by a given constant. We showed that the dynamically optimal wealth process solves a meander type equation which makes the wealth process hit the given constant exactly at the terminal time. This was done under no pathwise constraint on the wealth process which could take low/negative values of unlimited size. In this talk we consider the analogous variance minimising problem upon imposing the guarantee that the (discounted) wealth process always stays above a given constant regardless of whether the investment is unfavourable. We show that the dynamically optimal wealth process can be characterised as the unique (strong) solution to a stochastic differential equation with time-dependent coefficients. By analysing this stochastic differential equation (extending Feller's test to time-inhomogeneous diffusions that is of independent interest) we show that the dynamically optimal terminal wealth can only take two values. This binomial nature of the dynamically optimal strategy stands in sharp contrast with other known portfolio selection strategies encountered in the literature. A direct comparison shows that the dynamically optimal (time-consistent) strategy outperforms the statically optimal (time-inconsistent) strategy in the variance minimising problem.

Joint work with Jesper Pedersen (Copenhagen).

Moritz Voß

Linear quadratic stochastic control problems with singular stochastic terminal constraint

We provide a probabilistic solution to a linear quadratic optimal stochastic control problem with stochastic coefficients and a possibly singular stochastic terminal state constraint on a set with positive but not necessarily full probability. The analysis of such a control problem arises from optimal tracking problems of a given predictable target process where the terminal position is also constrained to match a specific exogenously prescribed random target level on a certain set of scenarios. The main novelty of our contribution is the characterization of the optimal control and the corresponding optimal value by an optimal signal process which reveals not only necessary and sufficient conditions under which the problem admits a finite value, but also allows us to tackle the delicate random singularity at terminal time via a suitable time consistent approximation of the optimization problem.

This is joint work with Peter Bank.

Martin Larsson

Measure-valued polynomial diffusions and large equity markets

Large equity markets can be studied by replacing a large, but finite, set of market weights by its corresponding limiting object, which is a probability measure on a suitable Polish space. In particular, limiting procedures of this kind play an important role in stochastic portfolio theory. The aim of this talk is to discuss a parametric family of limiting models referred to as measure-valued polynomial diffusions, which can be viewed as a generalization of the classical Fleming-Viot process. The arguments leading to well-posedness of the associated martingale problem suggest numerical methods for calculating quantities of interest, such as moments, of the measure-valued diffusion. This has interesting implications even in the finite-dimensional case.

Based on joint work with Christa Cuchiero and Sara Svaluto-Ferro.

Yaroslav Melnyk

Utility maximization under small jump intensity

This article provides asymptotic analysis of a utility maximization problem with respect to a small jump intensity. By virtue of a dynamic programming approach we establish optimality at second order of the leading-order approximation of the optimal strategy for a jump-modulated Black-Scholes market. By means of a generalized version of the envelope theorem we argue that this result can be extended to an arbitrary order and is independent of the underlying problem.

Michaela Szölgyenyi

Convergence of Euler-Maruyama for SDEs in stochastic control

When solving certain stochastic control problems in insurance- or financial mathematics, the optimal control policy sometimes turns out to be of threshold type, meaning that the control depends on the controlled process in a discontinuous way. The stochastic differential equations (SDEs) modeling the underlying process then typically have a discontinuous drift coefficient. This motivates the study of a more general class of such SDEs.

We introduce a certain transformation of the state space by which the drift is "made continuous". This transformation is used to prove strong convergence with positive rate of the

Euler-Maruyama scheme for multidimensional SDEs with discontinuous drift. This can be used to solve high dimensional optimal control problems approximatively. Joint work with G. Leobacher (KFU Graz).

Alessandro Balata

Regress later Monte Carlo for controlled Markov processes

In this talk I will present a method to avoid the curse of dimensionality introduced in regression Monte Carlo methods by the endogeneity of controlled MP (i.e. we avoid the discretisation of the state space used in Kushner and Dupuis [2001]). We build on the method introduced in Kharroubi et al. [2014] without however using any control randomization; rather, we use regression to decouple the value of the controlled process in one time step to the following one allowing the backward decision on the control to be dependent on the present state only and the future information to be used solely for training. The key to our solution is the regress later approach, mostly used for American option pricing and studied by Glasserman and Yu [2002] and Beutner et al. [2013]. It consists of projecting $V(t+1, X_{t+1})$ over the space generated by $\{\phi_k(t+1, X_{t+1})\}_{k=1}^K$ and then computing, possibly analytically,

$$\mathbb{E}[V(t+1, X_{t+1})|X_t] = \sum_{k=1}^{K} \alpha_k^{t+1} \mathbb{E}[\phi_k(t+1, X_{t+1})|X_t].$$

The regress later approach allow us to: avoid randomisation of the control improving speed and accuracy; place training points freely leading to faster convergence; use policy iteration without resimulation saving computational time (Longstaff and Schwartz [2001]-type approach), either using an innovative algorithm based on a coupling argument or solving iteratively a fixed point problem.

This is joint work with Jan Palczewski (University of Leeds).

Łukasz Stettner

Long run impulse control problems

A control consisted of an increasing sequence of stopping times at which we choose controls or the states of the process to which it is shifted is called impulse control. In the talk we shall mainly study impulse control problems corresponding to shifts of the state process for average reward per unit time criterion. We shall also point out problems which appear when we consider long run risk sensitive criterion or in other words we study asymptotics of power or

negative power utility from terminal wealth. The studies of such problems require suitable ergodic properties and therefore they are often called ergodic control problems. These problems lead to optimal stopping with additive or multiplicative functionals. The techniques used to solve the problems are based on the solutions to additive or multiplicative Poisson equations. The purpose is to show the existence of a continuous solution to the suitable Bellman equations, which allows then to characterize optimal controls (under suitable assumptions). The talk will be mainly based on the paper:

J. Palczewski, L. Stettner, Impulse control maximising average cost per unit time: a non-uniformly ergodic case, SIAM J. Control Optim., to appear.

Pavel Gapeev

On the perpetual American options on a traded account

We formulate and solve the problem of rational valuation of perpetual American options on a traded account in the Black-Merton-Scholes model under the fixed and proportional costs for the trading and exercise operations. The resulting optimal stochastic impulse control problem is decomposed into a multi-step optimal stopping problem for the operational times and a subsequent optimisation problem for the strategies of the holders. The optimal times are shown to be the first times at which the risky asset price hits certain constant boundaries and the optimal positions of the holders have a switching character between these times. The proof is based on the analysis of the associated ordinary free-boundary problem and an application of the local time-space formula.

Miklós Rásonyi

Optimal investment with general preferences in markets with frictions

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We consider a model of an illiquid market where trading faster leads to more unfavourable prices and the cost of illiquidity is superlinear in the trading speed. We consider an investor who, in the spirit of cumulative prospect theory, may have a non-concave utility function and may distort probabilities by exaggerating the likelihood of extreme events. The existence of optimal strategies for such agents is shown in great generality. Our main tool will be an extension of the well-known Skorohod representation theorem for sequences of weakly convergent random variables.

This is joint work with Ngoc Huy Chau.

Todor Bilarev

Multiplicative impact model with transient impact: Modeling issues and superhedging of European options

In this talk, we will first discuss modeling issues in a market model with a single risky asset and a large trader whose actions have impact on the asset's price in a transitive way, i.e. the impact from a trade is decreasing in time. We postulate the evolution of the asset's price process in a multiplicative way that guarantees positivity of prices. At first, the gains from trading can be uniquely defined for continuous strategies of finite variation. We extend the model to general (càdlàg) trading strategies by continuously extending the gains functional in a suitable topology on the space of strategies (the Skorokhod $M1$ topology in probability), i.e. by requiring that the gains functional is continuous (on the input strategy/control) with respect to this topology.

Having specified our model for a general class of trading strategies/controls, we consider the problem of pricing European options by superreplication that we formulate as a stochastic target problem. In special coordinates, a version of the (geometric) dynamic programming principle holds and thus the minimal superreplication price can be characterized as the viscosity solution of a non-linear PDE with gradient constraints.

This talk is based on joint projects with Dirk Becherer and Peter Frentrup from Humboldt-Universität zu Berlin.

Paolo Guasoni

Should commodity investors follow commodity prices?

Many long-term investors have access to commodities through an index, though mean-reverting prices and low correlation among commodities returns imply that two-fund separation does not hold. Mean-reversion generates an intertemporal-hedging demand for commodities that does not vanish with risk aversion, in contrast to typical models of stock prices. Comparing the utility-maximizing policies of investors observing only the index to those of investors observing all commodities, the welfare gain peaks at risk-neutrality, which maximizes additional returns, and at moderate risk aversion, which maximizes intertemporal-hedging gains. Additional information is equivalent to an increase in return of multiple percentage points for typical risk aversion.

Holger Kraft

Predictors and portfolios over the life cycle

We show that the net corporate payout yield predicts both the stock market index and house prices and that the log home rent-price ratio predicts both house prices and labor income growth. We incorporate the predictability in a rich life-cycle model of household decisions involving consumption of both perishable goods and housing services, stochastic and unspanned labor income, stochastic house prices, home renting and owning, stock investments, and portfolio constraints. We find that households can significantly improve their welfare by optimally conditioning decisions on the predictors. For a modestly risk-averse agent with a 35-year working period and a 15-year retirement period, the present value of the higher average life-time consumption amounts to roughly $179,000 (assuming both an initial wealth and an initial annual income of $20,000), and the certainty equivalent gain is around 5.5% of total wealth (financial wealth plus human capital). Furthermore, every cohort of agents in our model would have benefited from applying predictor-conditional strategies along the realized time series over our 1960-2010 data period.

This is joint work with Claus Munk (Copenhagen Business School) and Farina Weiss (Goethe University Frankfurt).

Matthias Lenga

Representable American options

We call a given American option representable if there exists a European claim which dominates the American payoff at any time and such that the values of the two options coincide within the continuation set associated to the American claim. This concept has interesting implications from a probabilistic, analytic and financial point of view. Above that, it provides the practitioner with a new computational method for American option pricing.

We aim at analyzing and linking together the mathematical notions of representable American claims, embedded American payoffs (in the sense of Jourdain and Martini, 2001) and cheapest dominating European options. This process reveals a new duality structure between European and American valuation problems which we deem as very fruitful for future research. Relying on methods from infinite-dimensional optimization, we make a first step towards verifying representability of certain American claims. Furthermore, we will present some numerical results and benchmark our pricing algorithm against high-precision methods from the literature.

The talk is based on joint work with Sören Christensen (UHH) and Jan Kallsen (CAU Kiel).

Nizar Touzi

Continuous-time principle-agent problem: A Stackelberg stochastic differential game

We provide a systematic method for solving general Principal-Agent problems with possibly infinite horizon. Our main result reduces such Stackelberg stochastic differential games to a standard stochastic control problem, which may be addressed by the standard tools of control theory. Our proofs rely on the backward stochastic differential equations approach to non-Markovian stochastic control, and more specifically, on the recent extensions to the second order case. The infinite horizon setting requires an extension of second order BSDEs to the random horizon setting.

Robert Stelzer

Shall you invest more risky when you are still young?

In this talk we consider a stochastic control problem appearing for example when investing a fraction of a time-varying random salary in the financial market in order to get a lump-sum payment at retirement. In a one-dimensional Black-Scholes market we consider the problem of maximizing the expected utility of the terminal wealth resulting from investing an initial wealth and a continuous endowment stream which is given by a geometric Brownian correlated with the stock price dynamics. As we assume that the salary/endowment stream is not perfectly correlated with the stock price, this results in an incomplete market.

For power utility functions we are able to reduce the resulting HJB equation by one dimension which allows us to nicely compute the optimal wealth and the optimal strategy numerically. Furthermore, we are able to show asymptotics for the value function and the optimal strategy.

Based on these results we study whether the popular investment advice (behind e.g. so called target date funds) that young people should invest more in stocks than older ones is indeed true. It turns out that the truth of this rule critically depends on the correlation between the stock market and the personal income in our model.

This talk is based on joint work with An Chen and Carla Mereu (both Ulm University).

Luitgard Veraart

Adjustable network reconstruction with applications to CDS exposures

This paper is concerned with reconstructing weighted directed networks from the total in- and out-weight of each node. This problem arises for example in the analysis of systemic risk of partially observed financial networks. Typically a wide range of networks is consistent with this partial information. We develop an empirical Bayesian methodology that yields consistent networks that also have certain desired global topological properties such as a given mean density. Furthermore we propose a new fitness based model within this framework. We apply our methodology to a novel data set containing 89 financial networks of credit default swap exposures. The performance of the reconstruction methodology is very good under a wide range of performance criteria and also compared to other existing reconstruction methods. In particular, we are able to reconstruct the degree distribution of the underlying networks with remarkable precision if a good estimate of the true density of the underlying network is available.

This is joint work with Axel Gandy (Imperial College London).

Peter Frentrup

Optimal liquidation under stochastic order book imbalance

We solve explicitly a two-dimensional singular control problem of finite fuel type in infinite time horizon. The application problem stems from the optimal liquidation of an asset position in a financial market with multiplicative and stochastic price impact. The optimal control is obtained via an Ornstein-Uhlenbeck process reflected at some non-constant free boundary. To solve the variational inequality and prove optimality, we obtain new results of independent interest on the Laplace transform of the inverse local time of diffusion processes reflected at elastic boundaries.

Carlo Ciccarella

Sailboat trajectory optimization

We study the optimal strategy for a sailboat to reach an upwind island under the hypothesis that the wind direction fluctuates according to a Brownian motion. The problem is singular because we assume that there is no loss of time when tacking. We exhibit the optimal strategy.

The proof of optimality, since the HJB equation does not admit a closed form solution, involves an intricate estimate of derivatives of the value function. Finally we explicitly provide the asymptotic behavior of the value function and we give some new insights on the stochastic flow of a reflected SDE.

Christian Vonwirth

Optimal portfolio policies under partial information and convex constraints: Solving the duality problem explicitly

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We consider an investor who wants to maximize her expected utility of terminal wealth by trading in a high-dimensional financial market with one riskless asset and several stocks. The stock returns are driven by a Brownian motion and the drift is an unknown random variable that has to be estimated from the observable stock prices in addition to some expert's opinion as proposed in Cvitanic et al (2006). The best estimate given these observations is the Kalman-Bucy-Filter.

The investor is restricted to portfolio strategies satisfying several convex constraints (for instance due to legal restrictions or fund characteristics) covering in particular no-short-selling and no-borrowing constraints. One popular approach to constrained portfolio optimization is the convex duality approach of Cvitanic and Karatzas (1992). They introduce auxiliary markets with shifted parameters and obtain corresponding dual problems.

First we solve these dual problems in the cases of logarithmic and power utility using stochastic control. Here we apply a reverse separation approach in order to obtain areas where the value function is differentiable. It turns out that these areas have a straightforward interpretation allowing to differ between active stocks (which are invested in) and passive stocks. Afterwards we solve the auxiliary markets given the optimal dual process and obtain explicit optimal portfolio policies. A verification theorem guarantees the validity of our results.

Following our approach the resulting optimal strategies can be calculated entirely explicitly. To this end, we have to consider all possible subsets of active stocks. An efficient algorithm is presented and we close with an analysis of simulated and historical data.

This is joint work with Jörn Sass (TU Kaiserslautern).

Anastasiia Zalashko

Anticipation of information via causal transport

We study the optimal transport under the causal constraint. Loosely speaking, causal transport plans are a relaxation of adapted processes in the same sense as Kantorovich transport plans are

an extension of Monge-type transport maps. The developed techniques allow us to give a new light on some problems, for which the time-information structure is central, as enlargement of filtrations and optimal stopping. In particular, we provide a necessary and sufficient condition for a Brownian motion to remain a semimartingale in an enlarged filtration in terms of certain minimization problems over sets of causal transport plans. The latter are also used in order to give an estimate of the value of having additional information for some classical stochastic optimization problems.

Based on the joint work with B. Acciaio and J. Backhoff.

Johannes Muhle-Karbe

Option market making with imperfect competition

Option pricing models typically consider either monopolistic market makers, or settings with infinite competition. Real markets, however, are often dominated by a few large dealers with substantial market power. We study how such imperfect Nash competition between them is reflected in equilibrium option prices. Joint work with Bruno Bouchard and Martin Herdegen.

Martin Herdegen

Equilibrium liquidity premia

In a continuous-time model with mean-variance investors and quadratic transaction costs, we show that the equilibrium expected return can be characterised as the solution to a system of coupled but linear forward-backward stochastic differential equations (FBSDEs). Explicit formulas obtain in the small-cost limit, which allow to assess the comparative statics of equilibrium liquidity premia.

Joint work Masaaki Fukasawa and Johannes Muhle-Karbe.

Mete Soner

Optimal dividends with random profitability

We study the classical the optimal dividend problem of a firm. The cash flow of the company is modelled as in the classical book of Dixit and Pindyck. Namely, the instantaneous expected revenue rate, which we call the firm profitability, is a mean reverting processes and the revenue

process is also subject to noise. In the simpler problem, the only financial decision taken by the firm is the size and the timing of the dividends and the bankruptcy occurs when the cash level is below a certain threshold. In a similar paper, Anderson and Carverhill (RFS, 2012) this threshold is defined as the cash level below which debt obligations cannot be met. We investigate the corresponding stochastic optimal control problem through the dynamic programming approach. We show that if the profitability falls below a certain value, then strategic bankruptcy is optimal. Also for negative but small values of profitability this strategy would still be optimal, if the total cash holdings is not large. For other values of profitability a positive target cash level is set as a decreasing function of profitability.

This is joint work with Max Reppen and Jean-Charles Rochet.

Tiziano de Angelis

The dividend problem with a finite horizon

We characterise the value function of the optimal dividend problem with a finite time horizon as the unique classical solution of a suitable Hamilton-Jacobi-Bellman equation. The optimal dividend strategy is realised by a Skorokhod reflection of the fund's value at a time-dependent optimal boundary. Our results are obtained by establishing for the first time a new connection between singular control problems with an absorbing boundary and optimal stopping problems on a diffusion reflected at an elastic boundary.

This is a joint paper with E. Ekstrom, University of Uppsala.

Huyên Pham

Randomized filtering and Bellman equation for partial observation control problem

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We study the optimal control problem of partially observed stochastic systems. By using a control randomization method, we provide a backward stochastic differential equation (BSDE) representation for the value function in a general framework including path-dependence in the coefficients (both on the state and control) and without any non degeneracy condition on the diffusion coefficient. In the standard Markovian case, this BSDE representation has important implications: it allows us to obtain a corresponding randomized dynamic programming principle (DPP) for the value function, which is obtained from a flow property of an associated filter process. This DPP is the key step towards our main result: a characterization of the value function of the partial observation control problem as the unique viscosity solution to the corresponding dynamic programming Hamilton-Jacobi-Bellman (HJB) equation. The latter is formulated as a new, fully non linear partial differential equation on the Wasserstein space

of probability measures, and is derived by means of the recent notion of differentiability with respect to probability measures introduced by P.L. Lions in his lectures on mean-field games at the Collège de France. An important feature of our approach is that it does not require any condition to guarantee existence of a density for the filter process solution to the controlled Zakai equation, as usually done for the separated problem. We give an explicit solution to our HJB equation in the case of a partially observed non Gaussian linear quadratic model. Finally, if time permitting, we discuss the issue of numerical treatment of the proposed randomized BSDE for solving partial observation control problem.

Based on joint works with E. Bandini (Luiss University), A. Cosso (Politecnico Milano), and M. Fuhrman (Universita di Milano).

Jörn Sass

Model reduction and mutual funds for portfolio optimization in hidden Markov models

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A multivariate continuous-time regime switching model, where the observation process is a diffusion process whose drift and volatility coefficients jump governed by a continuous-time Markov chain, can explain some of the stylized facts of asset returns. In the special case that the volatility matrix is constant, the underlying Markov chain can not be observed and has to be estimated by its filter. Portfolio decisions then depend on this filter and its dynamics. In fact it turns out that optimal portfolio policies and filter equations rely on the same signal to noise matrix. This can be used to reduce the dimension of the model to the dimension of this matrix if it has full rank. The eigenvalues of this matrix then provide a way to decompose the optimal portfolio in investments in mutual funds. In contrast to classical mutual fund theorems in continuous time, their composition is constant over time but the optimal policy is not.

We provide convergence and decomposition results for optimization and filtering. Further we analyze the case of signal to noise matrices which are not of full rank and look at extensions to regime switching models. We discuss consistency of the corresponding discrete-time and continuous-time models in view of filtering and portfolio optimization.

Anton Shardin

Partially observable stochastic optimal control problems for an energy storage

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We address the valuation of an energy storage facility in the presence of stochastic energy prices as it arises in the case of a hydro-electric pump station. The valuation problem is related to the problem of determining the optimal charging/discharging strategy that maximizes the expected value of the resulting discounted cash flows over the lifetime of the storage. We

use a regime switching model for the energy price which allows for a changing economic environment described by a non-observable Markov chain.

The valuation problem is formulated as a stochastic control problem under partial information in continuous time. Applying filtering theory we find an alternative state process containing the filter of the Markov chain, which is adapted to the observable filtration. For this alternative control problem we derive the associated Hamilton-Jacobi-Bellman (HJB) equation which is not strictly elliptic. Therefore we study the HJB equation using regularization arguments.

We use numerical methods for computing approximations of the value function and the optimal strategy. Finally, we present some numerical results.

This talk is based on joint work with Ralf Wunderlich (BTU Cottbus-Senftenberg).

Johan Andreasson

A least-squares Monte Carlo dynamic programming approach to retirement modelling

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When used to model the retirement phase, utility based lifecycle models are typically set up as a Dynamic Programming Problem. Analytical solutions are often difficult to find, and require numerical approximations which become computationally expensive as the number of dimensions increase. This paper applies the Least-Squares Monte Carlo (LSMC) method to an expected utility maximizing retirement model. We present a modification of Langrene et al's (2014) probabilistic numerical algorithm that combines Dynamic Programming with LSMC. Our modification accounts for difficulties in using LSMC with utility functions and improves the exploration of the state space. This approach allows us to model higher dimensions with less computations, hence more stochastic risk factors and control variables can be included. In addition, the optimal control is given as a parametric estimate.

Finally, we evaluate the optimal decisions in an extended retirement model that includes multiple types of annuities, housing scaling options, habit consumption level and stochastic interest rates.

Ari-Pekka Perkkiö

Convex integral functional of regular processes

This talk gives dual representations for convex integral functionals on the linear space of regular processes. This space turns out to be a Banach space containing many more familiar classes of stochastic processes and its dual can be identified with the space of optional Radon measures with essentially bounded variation. Combined with classical Banach space techniques, our results allow for a systematic treatment of stochastic optimization problems over BV processes

and, in particular, yields a maximum principle for a general class of singular stochastic control problems. Examples to currency market models and irreversible investment are given. The talk is based on a joint work with Teemu Pennanen, King's College London.

Daniel Bartl

Pointwise dual representation of dynamic convex expectations

In this talk we focus on discrete-time dynamic convex expectations $(\mathcal{E}_t)$ with domain and range the upper semianalytic functions. It is shown that $\mathcal{E}_t$ is pointwise continuous from below and continuous from above on the continuous functions if and only if a dual representation of $\mathcal{E}_t$ in terms of conditional expectations minus the convex conjugate of $\mathcal{E}_t$ holds true, where the conjugate is lower semianalytic with pointwise weakly compact level sets. Moreover, we provide a dual characterization of the dynamic property, i.e. we show that $\mathcal{E}_t = \mathcal{E}_t \circ \mathcal{E}_{t+1}$ if and only if the convex conjugate of $\mathcal{E}_t$ has an additive form. We illustrate the results through robust versions of classical examples.

Huy Ngoc Chau

Stochastic algorithm with a mixing process and discontinuity in the parameters

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In this talk, we estimate the tracking error of a fixed gain stochastic approximation scheme. The underlying process is not assumed Markovian, a mixing condition is required instead. Furthermore, the updating function may be discontinuous in the parameter. Some applications are introduced.

This is joint work with Chaman Kumar, Miklós Rásonyi and Sotirios Sabanis.

Harold Moreno-Franco

Singular stochastic control problem for Lévy diffusions

In this talk, we will analyze a singular stochastic control problem, where the controlled process is governed by a Lévy diffusion. This type of problem is closely related to a Hamilton-Jacobi-Bellman (HJB) equation, whose operator is an elliptic integro-differential operator, which corresponds to the infinitesimal generator of the Lévy diffusion.

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