Second Conference
Frontiers in Stochastic Modelling for Finance

Palermo, Italy · 25–27 October 2023

List of participants

- Samantha Ajovalasit, Università di Palermo, Italia
- Erhan Bayraktar University of Michigan, USA
- Cyril Benezet, ENSIIE, France,
- Guillaume Bernis, BPCE Vie, France
- Giorgia Callegaro, Università di Padova, Italia
- Laura Carosi, Università di Pisa, Italia
- Claudia Ceci, Università di Roma la Sapienza, Italia
- Etienne Chevalier, Université d'Evry Val d'Essonne, France
- Ilaria Colivicchi, Università di Firenze, Italia
- Fulvia Confortola, Politecnico di Milano, Italia
- Andrea Consiglio, Università di Palermo, Italia
- Cristina Di Girolami, Università di Bologna, Italia
- Bernard Gourion, BPCE, France
- Guanxing Fu, The Hong Kong Polytechnic University, China
- Julien Guyon, ENPC INRIA, France
- Yadh Hafsi, Horizon and Université Paris Saclay, France
- Caroline Hillairet, ENSAE Paris CREST, France
- Alexis Houssard, BPCE and Université de Paris Cité, France
- Ahmed Kebaier, Université d'Evry Val d'Essonne, France
- Immacolata Oliva, Università di Roma la Sapienza, Italia
- Vathana Ly Vath, ENSIIE, France,
- Federico Maglione, Università di Firenze, Italia
- Simone Pavarana, Albert-Ludwigs-Universitat Freiburg, Germany
- Sergio Pulido, ENSIIE, France
- Johannes Ruf, London School of Economics, United Kingdom
- Simona Sanfelici, Università di Parma, Italia
- Martin Schweizer, ETH Zurich, Switzerland
- Andrea Simonetti, Università di Palermo, Italia

- Simone Scotti, Università di Pisa, Italia
- Carlo Sgarra, Università di Bari, Italia
- Nizar Touzi, New York University, USA
- Stephane Villeneuve, Toulouse School of Economics, France
- Chao Zhou, National University of Singapore, Singapore

Committee

- Samantha Ajovalasit, Università di Palermo, Italia
- Giorgia Callegaro, Università di Padova, Italia
- Laura Carosi, Università di Pisa, Italia
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- Simone Scotti, Università di Pisa, Italia
- Nizar Touzi, New York University, USA
- Chao Zhou, NUS, Singapore

Program

Wednesday morning, 25 October 2023

8:45–9:00	Opening
	Chair: TBA *Filtration*
9:00–9:30	**Martin Schweizer** A new stochastic Fubini theorem
9:30–10:00	**Caroline Hillairet** Bi-revealed utilities in a defaultable universe
10:00–10:30	**Fulvia Confortola** Progressive enlargement of filtrations and control problems for step processes
10:30–11:00	Coffee break
	Chair: TBA *Robust optimisation and Jumps*
11:00–11:30	**Carlo Sgarra** Optimal portfolios for Hilbert-valued stochastic volatility models with jumps
11:30–12:00	**Immacolata Oliva** Robust optimal consumption and portfolio choice in complete markets with co-jumps
12:00–12:30	**Guillaume Bernis** Clustering effects for derivative pricing
12:30–13:30	Lunch

Wednesday afternoon, 25 October 2023

13:30–16:30 Free discussion time

Chair: TBA
Insurance

16:30–17:00 **Claudia Ceci**
Optimal reinsurance via BSDEs
in a partially observable model with jump clusters

17:00–17:30 **Ilaria Colivicchi**
A parametric insurance policy for beekeepers and honey production:
random forest regressions and real world pricing.

17:30–18:00 **Andrea Simonetti**
Attribute concentration in small groups:
the Reverse Hypergeometric distribution

Thursday morning, 26 October 2023

	Chair: TBA *Arbitrage and Numerical Methods*
9:00–9:30	**Ahmed Kebaier** The interpolated drift implicit Euler scheme multilevel Monte Carlo method for pricing barrier options and applications to the CIR and CEV models
9:30–10:00	**Bernard Gourion** Model free arbitrability bounds for the implied volatility and its skew
10:00–10:30	**Cyril Benezet** An optimal transport approach for the multiple quantile hedging problem
10:30–11:00	Coffee break
	Chair: TBA *Stochastic Control*
11:00–11:30	**Guanxing Fu** Mean-field liquidation games with market drop-out
11:30–12:00	**Nizar Touzi** Martingale model risk sensitivity
12:00–12:30	**Yadh Hafsi** Uncovering market disorder and liquidity trends detection
12:30–13:30	Lunch

Thursday afternoon, 26 October 2023

13:30–16:30 Free discussion time

Chair: TBA
Markets and Statistics

16:30–17:00 **Julien Guyon**
Does the term-structure of equity at-the-money skew really follow a power law?

17:00–17:30 **Simona Sanfelici**
Identifying the number of latent factors of stochastic volatility models

17:30–18:00 **Sergio Pulido**
Understanding the worst-kept secret of high-frequency trading

Friday morning, 27 October 2023

	Chair: TBA *Stochastic control*
9:00–9:30	**Stephane Villeneuve** Money and taxes implement optimal dynamic contracts
9:30–10:00	**Cristina Di Girolami** A dam management problem with energy production as an optimal switching problem
10:00–10:30	**Simone Paravana** A stochastic control perspective on term structure models with roll-over risk
10:30–11:00	Coffee break
	Chair: TBA *Asset allocation*
11:00–11:30	**Johannes Ruf** Growth in fund models
11:30–12:00	**Alexis Houssard** TBA
12:00–12:30	Bus to Terrasini
12:30–14:00	Conference Lunch
14:00–17:00	Visit of Terrasini

Book of Abstracts

An optimal transport approach for the multiple quantile hedging problem (Cyril Benezet)

We consider the multiple quantile hedging problem, which is a class of partial hedging problems containing as special examples the quantile hedging problem (Föllmer & Leukert 1999) and the PnL matching problem (introduced in Bouchard & Vu 2012). In complete non-linear markets, we show that the problem can be reformulated as a kind of Monge optimal transport problem. Using this observation, we introduce a Kantorovitch version of the problem and prove that the value of both problems coincide. In the linear case, we thus obtain that the multiple quantile hedging problem can be seen as a semi-discrete optimal transport problem, for which we further introduce the dual problem. We then prove that there is no duality gap, allowing us to design a numerical method based on SGA algorithms to compute the multiple quantile hedging price.

This is a joint work with J.-F. Chassagneux and M. Yang

Clustering effects for derivative pricing (Guillaume Bernis)

We propose an extension of the Γ-OU Barndorff-Nielsen and Shephard model taking into account jump clustering phenomena. We assume that the intensity process of the Hawkes driver coincides, up to a constant, with the variance process. By applying the theory of continuous-state branching processes with immigration, we prove existence and uniqueness of strong solutions of the SDE governing the asset price dynamics. We exploit a measure change of self-exciting Esscher type in order to describe the relation between the risk-neutral and the historical dynamics, showing that the Γ-OU Hawkes framework is stable under this probability change. By exploiting the affine features of the model we provide an explicit form for the Laplace transform of the asset log-return, for its quadratic variation and for the ergodic distribution of the variance process. We show that the proposed model exhibits a larger flexibility in comparison with the Γ-OU model, in spite of the same number of parameters required. We calibrate the model on market vanilla option prices via characteristic function inversion techniques, we study its sensitivities and propose an exact simulation scheme. The main financial result is that implied volatility of options written on VIX is upward shaped due to the self-exciting property of Hawkes processes, in contrast with the usual downward slope in the Γ-OU Barndorff-Nielsen and Shephard model.

This is a joint work with R. Brignone, S. Scotti and C. Sgarra

Optimal reinsurance via BSDEs in a partially observable model with jump clusters (Claudia Ceci)

We investigate the optimal reinsurance problem when the loss process exhibits jump clustering features and the insurance company has restricted information about the loss process. We maximize expected exponential utility of terminal wealth and show that an optimal solution exists. By exploiting both the Kushner-Stratonovich and Zakai approaches, we provide the equation governing the dynamics of the (infinite-dimensional) filter and characterize the solution of the stochastic optimization problem in terms of a BSDE, for which

we prove existence and uniqueness of solution. After discussing the optimal strategy for a general reinsurance premium, we provide more explicit results for same special cases under the expected value premium principle.

This is a joint work with M. Brachetta, G. Callegaro and C. Sgarra.

A parametric insurance policy for beekeepers and honey production: random forest regressions and real world pricing (Ilaria Colivicchi)

In the past years, climate change has affected honey production more and more and the reduction has become a significant risk for beekeepers. In this paper, we discuss the pricing of a parametric insurance policy drafted to cover the potential losses in terms of honey production due to unfavorable climate conditions: the payment of the insurance benefit is triggered by the breaching of predefined thresholds of a weather index, measured over specific relevant periods. The effectiveness of the coverage is verified by the means of random forests, where the honey production is forecast under different real word weather scenarios and the beekeepers' loss is compared with the insurance benefit reimbursed (or not) by the policy. The random forest technique is put along with more common ones, such as ordinary least squares regression and mixed linear models. A practical example is given for the Italian market, where the pricing is derived and assessed for three different zones: North, Centre, and South.

This is a joint work with S. Dell'Acqua and V. Russo.

Progressive enlargement of filtrations and control problems for step processes (Fulvia Confortola)

In the present work we address stochastic optimal control problems for a step process X under a progressive enlargement of the filtration.

We denote by $\mathbb{F}$ the filtration generated by X: This filtration represents the information available in a market in which an agent (i.e., the controller) handles. We progressively enlarge $\mathbb{F}$ to $\mathbb{G}$ by a random time τ, that can be regarded as the occurrence time of an external shock event, as the death of the agent (e.g., life insurance) or the default of part of the market (e.g., credit risk).

We then study two related classes of control problems.

The first one consists in optimization problems over $[0, T]$. They can be regarded as control problems of an insider trader who has private information on τ, that is, she can use $\mathbb{G}$-predictable controls. Moreover, the control problem over $[0, T]$ allows to consider terminal costs which may depend on the default time τ, i.e., *defaultable costs*, for example of the form $g = g_1 1_{\{\tau > T\}} + g_2 1_{\{\tau \leq T\}}$. It is evident that the associated control problem cannot be solved in the reference filtration $\mathbb{F}$ because the random variable g is $\mathcal{G}_T$-measurable but not $\mathcal{F}_T$-measurable, in general.

The second class of control problems we look at is over the random horizon $[0, T \wedge \tau]$. These can be understood as control problems of an agent who only disposes of the information available in the market, that is, she only uses $\mathbb{F}$-predictable controls but, for some reasons, she has exclusively access to the market up to τ.

We solve these control problems following a dynamical approach based on a class of BSDEs driven by the jump measure in the enlarged filtration $\mathbb{G}$.

This is a joint work with E. Bandini and P. Di Tella.

A dam management problem with energy production as an optimal switching problem (Cristina Di Girolami)

We consider an optimal stochastic control problem for a dam. Electrical power production is operating under an uncertain setting for electricity market prices and water level which has to be kept under control. Indeed, the water level inside the basin cannot exceed a certain threshold for safety reasons, and at the same time cannot decrease below another threshold in order to keep power production active. We model this situation as a mixed control problem with regular and switching controls under constraints. We characterize the value function as solution of an HJB equation and provide some numerical approximating methods. We shall illustrate by numerical examples the main achievements of the present approach.

This is a joint work with E. Chevalier, M. Gaigi, E. Giovannini and S. Scotti.

Mean-field liquidation games with market drop-out (Guanxing Fu)

We consider a novel class of portfolio liquidation games with market drop-out ("absorption"). More precisely, we consider mean-field and finite player liquidation games where a player drops out of the market when her position hits zero. In particular round-trips are not admissible. This can be viewed as a no statistical arbitrage condition. In a model with only sellers we prove that the absorption condition is equivalent to a short selling constraint. We prove that equilibria (both in the mean-field and the finite player game) are given as solutions to a non-linear higher-order integral equation with endogenous terminal condition. We prove the existence of a unique solution to the integral equation from which we obtain the existence of a unique equilibrium in the MFG and the existence of a unique equilibrium in the N -player game. We establish the convergence of the equilibria in the finite player games to the obtained mean-field equilibrium and illustrate the impact of the drop-out constraint on equilibrium trading rates.

This is a joint work with P. Hager and U. Horst

Model free arbitrability bounds for the implied volatility and its skew (Bernard Gourion)

New arbitrability bounds derived for the quotations of the vanilla option?s market are exposed here for the implied volatility, its skew and its convexity. First, exploiting preceding theoretical results from Fukasawa, the implied volatility for any strike is shown to be comprised between finite lower and upper bounds that are derived from the existing implied volatilities derived from market quotes. These bounds are then proved to be narrower than other existing ones in the literature. Moreover any model not perfectly calibrated to each market quote is shown to expose its user to arbitrages not only on the quoted strike but in a compact interval around any such quoted range, this interval being as wide as the error of calibration is big. Second, the skew of implied volatility at quoted strike is also shown to be comprised between two levels shaping an interval narrower than other ones exposed in preceding theoretical papers as these two bounds are derived from market quotes too. These results enforce the Durrleman condition existing on the convexity of the implied volatility and bring strong constraints for a model to be arbitrage free as they provide bounds for any finite level of strike. A practical example with the SVI parametric shape calibrated to SX5E market data is given for illustration of the method at the end of the paper.

This is a joint work with A. Houssard.

Does the term-structure of equity at-the-money skew really follow a power law? (Julien Guyon)

Using two years of S&P 500, Eurostoxx 50, and DAX data (2020-2021), we empirically investigate the term-structure of the at-the-money-forward (ATM) skew of equity indexes. While a power law (2 parameters) captures the term-structure well away from short maturities, the power law fit deteriorates considerably when short maturities are included. By contrast, 3-parameter shapes that look like power laws but do not blow up at vanishing maturity, such as time-shifted power laws (TSPL), are shown to fit well regardless of whether short maturities are included or not. Our study shows that the term-structure of equity ATM skew has a power-law shape for maturities above 1 month but has a different behavior, and in particular may not blow up, for shorter maturities. The 3-parameter shapes are derived from non-Markovian variance curve models using the Bergomi-Guyon expansion. A simple 4-parameter term-structure similarly derived from the (Markovian) two-factor Bergomi model is also considered and provides even better fits. The extrapolated zero-maturity skew, far from being infinite, is distributed around a typical value of 1.5 (in absolute value). Our analysis thus shows that in order to accurately capture the whole term-structure of ATM skew one should use classical Markovian two-factor stochastic volatility models or (more parsimonious but non-Markovian) TSPL models rather than rough volatility models.

This is a joint work with M. El Amrani

Uncovering market disorder and liquidity trends detection (Yadh Hafsi)

The primary objective of this study is to systematically examine and detect notable changes in liquidity within a limit order book. In this context, we present a new methodology for mathematically quantifying a financial instrument's liquidity based on observing its order book limit. The proposed metric holds potential for enhancing the aggressiveness of optimal execution algorithms, minimizing market impact and transaction costs, and serving as a reliable indicator of market liquidity for market makers. As part of our approach, we employ Marked Hawkes processes to model trades-through which constitute our liquidity proxy. Subsequently, our focus lies in accurately identifying the moment when a significant increase or decrease in its intensity takes place. We consider the minimax quickest detection problem of unobservable changes in the intensity of a doubly-stochastic Poisson process. The goal is to develop a stopping rule that minimizes the robust Lorden criterion, measured in terms of the number of events until detection, for both worst-case delay and false alarm constraint. We prove our procedure's optimality in the case of a Cox process with simultaneous jumps, while considering a finite time horizon. Finally, this novel approach is empirically validated by means of an analysis of real market data.

This is a joint work with V. Ly Vath and E. Chevalier.

Bi-Revealed Utilities in a defaultable universe (Caroline Hillairet)

This talk investigates the inverse problem of bi-revealed utilities in a defaultable universe, defined as a standard universe (represented by a filtration $\mathbb{F}$) perturbed by an exogenous defaultable time τ. We assume that the standard universe does not take into account

the possibility of the default, thus τ adds an additional source of risk. The defaultable universe is represented by the filtration $\mathbb{G}$ *up to time* τ (τ included), where $\mathbb{G}$ stands for the progressive enlargement of $\mathbb{F}$ by τ. The basic assumption in force is that τ avoids $\mathbb{F}$-stopping times. The bi-revealed problem consists in recovering a consistent dynamic utility from the observable characteristic of an agent. The general results on bi-revealed utilities, first given in a general and abstract framework, are translated in the defaultable $\mathbb{G}$-universe and then are interpreted in the $\mathbb{F}$-universe. The decomposition of $\mathbb{G}$-adapted processes $X^{\mathbb{G}}$ provides an interpretation of a $\mathbb{G}$-characteristic $X^{\mathbb{G}}_{\tau}$ stopped at τ as a reserve process. Thanks to the characterization of $\mathbb{G}$-martingales stopped at τ in terms of $\mathbb{F}$-martingales, we establish a correspondence between $\mathbb{G}$-bi-revealed utilities from characteristic and $\mathbb{F}$-bi-revealed pair of utilities from characteristic and reserves. In a financial framework, characteristic can be interpreted as wealth and reserves as consumption. This result sheds a new light on the consumption in utility criterion: the consumption process can be interpreted as a certain quantity of wealth, or reserves, that are accumulated for the financing of losses at the default time.

This is a joint work with N. El Karoui and M. Mrad.

TBA (Alexis Houssard)

The interpolated drift implicit Euler scheme multilevel Monte Carlo method for pricing barrier options and applications to the CIR and CEV models (Ahmed Kebaier)

Recently, Giles et al. 2019 proved that the efficiency of the Multilevel Monte Carlo (MLMC) method for evaluating Down-and-Out barrier options for a diffusion process $(X_t)_{t\in[0,T]}$ with globally Lipschitz coefficients, can be improved by combining a Brownian bridge technique and a conditional Monte Carlo method provided that the running minimum $\inf_{t\in[0,T]} X_t$ has a bounded density in the vicinity of the barrier. In the present work, thanks to the Lamperti transformation technique and using a Brownian interpolation of the drift implicit Euler scheme of Alfonsi, we show that the efficiency of the MLMC can be also improved for the evaluation of barrier options for models with non-Lipschitz diffusion coefficients under certain moment constraints. We study two example models: the Cox-Ingersoll-Ross (CIR) and the Constant of Elasticity of Variance (CEV) processes for which we show that the conditions of our theoretical framework are satisfied under certain restrictions on the models parameters. In particular, we develop semi-explicit formulas for the densities of the running minimum and running maximum of both CIR and CEV processes which are of independent interest. Finally, numerical tests are processed to illustrate our results.

This is a joint work with M. Ben Derouich.

Robust optimal consumption and portfolio choice in complete markets with co-jumps (Immacolata Oliva)

In this paper, we study a robust, dynamic, continuous-time optimal consumption and portfolio allocation problem for investors with recursive preferences who have access to both stock and derivatives markets. We assume that the stock price process follows a stochastic volatility model, with instantaneous precision as the unique state variable, allowing for discontinuities in all the dynamics. We obtain a closed-form approximate solution to the

optimization problem for a non-unitary value of the elasticity of intertemporal substitution of consumption, being able to derive an exact solution as a special case. Our theoretical findings show that the optimal policies are remarkably affected by the ambiguity-aversion parameters to diffusive and jump risks. The effectiveness of the theoretical results is confirmed by a detailed numerical analysis we carried out on real data. Finally, we prove that investors who do not believe in ambiguity may suffer considerable wealth losses.

This is a joint work with I. Stefani.

Understanding the worst-kept secret of high-frequency trading (Sergio Pulido)

Volume imbalance in a limit order book is often considered as a reliable indicator for predicting future price moves. In this work, we seek to analyse the nuances of the relationship between prices and volume imbalance. To this end, we study a market-making problem which allows us to view the imbalance as an optimal response to price moves. In our model, there is an underlying efficient price driving the mid-price, which follows the model with uncertainty zones. A single market maker knows the underlying efficient price and consequently the probability of a mid-price jump in the future. She controls the volumes she quotes at the best bid and ask prices. Solving her optimization problem allows us to understand endogenously the price-imbalance connection and to confirm in particular that it is optimal to quote a predictive imbalance. The value function of the market maker's control problem can be viewed as a family of functions, indexed by the level of the market maker's inventory, solving a coupled system of PDEs. We show existence and uniqueness of classical solutions to this coupled system of equations. In the case of a continuous inventory, we also prove uniqueness of the market maker's optimal control policy.

A stochastic control perspective on term structure models with roll-over risk (Simone Pavarana)

In this paper, we consider a generic interest rate market in the presence of roll-over risk, which generates spreads in spot/forward term rates. We do not require classical absence of arbitrage and rely instead on a minimal market viability assumption, which enables us to work in the context of the benchmark approach. In a Markovian set- ting, we extend the control-theoretic approach of Gombani and Runggaldier (Math. Finance 23 (2013) 659–686) and derive representations of spot/forward spreads as value functions of suitable stochastic optimal control problems, formulated under the real-world probability and with power-type objective functionals. We determine endogenously the funding–liquidity spread by relating it to the risk-sensitive optimisation problem of a representative investor.

This is a joint work with C. Fontana and W. J. Runggaldier.

Growth in fund models (Johannes Ruf)

For purposes of long-term investment portfolio choice, we study estimation of growth in fund models. The latter are statistical descriptions of markets where all asset returns are spanned by the returns of a lower-dimensional collection of funds, modulo orthogonal noise; equivalently, they may be characterised as models where the global growth-optimal portfolio

only involves investment in the aforementioned funds. The loss of growth due to estimation error in fund models under local frequentist estimation is determined entirely by the number of funds. Furthermore, under a general filtering framework for Bayesian estimation, the loss of growth increases as the investment universe does. A shrinkage method that targets maximal growth with the least amount of deviation is proposed. Empirical evidence suggests that shrinkage gives a stable estimate that more closely follows growth potential than an unrestricted Bayesian estimate.

This is a joint work with C. Kardaras and H. Keun Koo.

Identifying the number of latent factors of stochastic volatility models (Simona Sanfelici)

We provide a procedure to identify the number of latent factors of stochastic volatility models. The methodology relies on the non-parametric Fourier estimation method introduced by [Malliavin and Mancino, 2002] and applies to high-frequency data. Based on the Fourier analysis, we first estimate the latent volatility process and then the volatilities and covariances of the processes that are gradually identified, such as volatility of volatility and leverage. The analysis of the eigenvalues spectrum of the Gram matrix can reveal information about the actual number of factors driving the process at hand. We corroborate our analysis by numerical simulations on single and multi factor models. Finally, we apply our methodology to intraday prices from the S&P 500 index futures.

This is a joint work with E. Allaj and M. E. Mancino.

A new stochastic Fubini theorem (Martin Schweizer)

We present a new stochastic Fubini theorem which is based on the idea of using stochastic integrals of measure-valued processes. One application is to study the behaviour of a stochastic Volterra-type semimartingale.

This is a joint work with T. Choulli.

Optimal portfolios for Hilbert-valued stochastic volatility models with jumps (Carlo Sgarra)

Benth and Sgarra have recently proposed an operator-valued stochastic volatility model with jumps in order to describe the dynamics of forward prices in power markets. In the present paper we want to deal with the portfolio optimization problem in the setting proposed by Benth, Ruediger and Suss. We formulate the optimal stochastic control problem, and we discuss existence and uniqueness of the solution. We provide some qualitative analysis of the solution obtained. Surprisingly, an explicit solution can be computed, and, to our knowledge, this is one of the very few cases in which an infinite-dimensional control problem with jumps admits an explicit solution.

This is a joint work with F. E. Benth and A. Cosso.

Attribute concentration in small groups: the Reverse Hypergeometric distribution (Andrea Simonetti)

In the framework of urn models, we introduce a new probability distribution to measure the attribute concentration among group members. The related urn problem is a particular occupancy problem, where we are interested in the configuration of how specific marbles are allocated in the urns instead of which or how many urns are filled. We characterise the new distribution, which we name Reverse Hypergeometric distribution, and present an exact statistical test. The distribution allows us to test an excess of intra-group similarity against a null hypothesis when similarity among attributes of group members occurs randomly. We compare the new distribution with related probability distributions, specifically the Multivariate Hypergeometric and the Multinomial. The simulation results show that the proposed distribution overcomes the Multinomial in detecting the excess of intra-group similarity. Moreover, we present a real world application in finance regarding the study of sector concentration in small and illiquid portfolios of households in a European country. Specifically, we grouped the households by age, sex (male or female) and place where they live (city or countryside). We perform the tests for each group by years from 1995 to 2015. The results show how the proposed distribution is more suitable and flexible than the Multinomial distribution to model the probabilities of attribute configurations. The introduced parsimonious model depends on a single parameter, and it properly describes the excess of similarity revealed in the empirical case analyzed. Finally, as a generalisation, we present an extension of the probability model, allowing different sizes of groups.

Martingale model risk sensitivity (Nizar Touzi)

This is a joint work with N. Sauldubois

Money and taxes implement optimal dynamic contracts (Stephane Villeneuve)

We analyse capital allocation and risk-sharing between a principal and many agents who privately observe their output. The optimal mechanism can be implemented by a market equilibrium with money and taxes.

This is a join work with B. Biais, H. Gersbach, J.C. Rochet and E.L. von Thadden.

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