XIX Quantitative Finance Workshop - QFW 2018

Rome 24-26 January 2018

Aims and Scope

The University of Roma Tre is pleased to host the XIX Workshop on Quantitative Finance QFW2018 from January 24 to January 26. The QFW2018 is an annual conference for academia and industry on theoretical and practical aspects of quantitative finance. The aim of the Workshop is to promote the exchange of ideas that are relevant to researchers and practitioners and cover topics in Mathematical Finance, Quantitative Risk Management, Portfolio Optimization, Financial Economics, Computational Finance, Econophysics, Financial Econometrics, Statistics of Financial Markets, Corporate Finance, and related fields. After the great success of the previous edition at the University of Milano-Bicocca, we repeat the same conference format, lasting two days and a half. We particularly encourage the participation of Italian and foreign PhD students and young researchers, either coming from industry or academia.

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Contents

REGULAR PAPERS

Wednesday, January 24^{th}, 2018

Session I: Miscellanea (Aula 7)

Semiparametric estimation of large variance-covariance and correlation matrices with an application to financial data

24 Jan
14:00
Aula 7

Claudio Morana

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This paper proposes a three-step estimation strategy for dynamic conditional correlation models. In the first step, conditional variances for individual and aggregate series are estimated by means of QML equation by equation. In the second step, conditional covariances are estimated by means of the polarization identity and consistent estimates of the conditional correlations are obtained by their usual normalization. In the third step, the two-step conditional covariance and correlation matrices are regularized by means of a new non-linear shrinkage procedure and used as starting value for the maximization of the joint likelihood of the model. This yields the final, third step smoothed estimate of the conditional covariance and correlation matrices. Due to its scant computational burden, the proposed strategy is suitable for the estimation of vast conditional variance-covariance and correlation matrices. An application to financial data is also provided.
Keywords: semiparametric dynamic conditional correlation model, time-varying parameter models, systemic risk.

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24 Jan
14:30
Aula 7

Is more data always better? Optimal data usage in non-stationary systems

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Past Financial Crisis have shown that contemporary risk management models provide an unjustified sense of security and fail miserably in situations in which they are needed the most. In this paper we start from the assumption that risk is a notion that changes over time and therefore past datapoints only have limited explanatory for the current situation. Our objective is to derive the optimal amount of representative information by optimizing between the two adverse forces of estimator convergence, incentivising us to use as much data as possible, and the aforementioned non representativeness doing the opposite. In this endeavour a corner stone assumption of probability theory is weakened, identically distributed random variables and substituted by the assumption that the law of the data generating process changes over time. Hence, in this paper we give a quantitative theory on how to perform statistical analysis in an optimal way for some specific non-ergodic systems. As an application we discuss the impact of a paragraph in the last iteration of proposals by the Basel Committee on Banking Regulation.
Keywords: Mathematical Finance, Non-Ergodicity, Semimartingale Modeling, Risk Management, Banking Regulation.

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24 Jan
15:00
Aula 7

The short-time behavior of VIX implied volatilities in a multifactor stochastic volatility framework

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We consider a modeling setup where the VIX index dynamics are explicitly computable as a smooth transformation of a purely diffusive, multidimensional Markov process. The framework is general enough to embed many popular stochastic volatility models. We develop closed-form expansions and sharp error bounds for VIX futures, options and implied volatilities. In particular, we derive exact asymptotic results for VIX implied volatilities, and their sensitivities, in the joint limit of short time-to-maturity and small log-moneyness. The obtained expansions are explicit, based on elementary functions and they neatly uncover how the VIX skew depends on the specific choice of the volatility and the vol-of-vol processes. Our results are based on perturbation techniques applied to the infinitesimal generator of the underlying process. This methodology has been previously adopted to derive approximations of equity (SPX) options. However, the generalizations needed to cover the case of VIX options are by no means straightforward as the dynamics of the underlying VIX futures are not explicitly known. To illustrate the accuracy of our

technique, we provide numerical implementations for a selection of model specifications.
Keywords: VIX options, multifactor stochastic volatility, asymptotic expansions.

An agent-based model for personal finance decisions

24 Jan
15:30
Aula 7

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In a group of individuals aiming for a collective decision, that decision is influenced by individual competences, but these are in turn subject to a reciprocal influence. Such an influence may lead to less competent agents exerting an unduly influence, a phenomenon known as equality bias. In this paper an agent-based model is proposed to investigate the evolution of competences under such a reciprocal influence. Through MonteCarlo simulation it is shown that: a) the average competence at steady state diminishes as the degree of interaction among the agents and/or the number of agents grow, both in the case of just positive influence (more competent agents increasing the competence of less competent one) and when both positive and negative influences are present; b) the convergence towards a steady state value is slow and characterized by oscillations.
Keywords: Agent-based models, Decision making processes, Competence evolution.

Session II: Volatility (Aula 8)

Consistency of local-stochastic volatility models with respect to spot inversion and multiplication

24 Jan
14:00
Aula 8

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We investigate the consistency of classes of local-stochastic volatility (LSV) models with respect to spot inversion and multiplication, and hence their applicability in the foreign exchange market. We consider two main classes, one based on the

Heston model and one based on the SABR model; then we embed them in a more general superclass of LSV models. We give general conditions that the models in the superclass must satisfy to be invariant with respect to inversion and check these conditions for a collection of popular LSV models. We also investigate affine diffusion processes, showing that the symmetry conditions for inversion are automatically fulfilled. We draw conclusions on the arbitrage opportunity in variance swaps for the Heston model. With respect to multiplication, we analyze the general superclass showing that in order for the consistency to be preserved only one common volatility process for all exchange rates must be considered and moreover a stochastic adjustment in the drift of the exchange rate dynamics is needed.
Keywords: local-stochastic volatility models, affine models, FX, consistency.

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24 Jan
14:30
Aula 8

Volatility Bursts: A discrete-time option model with multiple volatility components

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I propose an affine discrete-time model, called Vector Autoregressive Gamma with volatility Bursts (VARG-B) in which volatility experiences, in addition to frequent and small changes, periods of sudden and extreme movements generated by a latent factor which evolves according to the Autoregressive Gamma Zero process. A key advantage of the discrete-time specification is the possibility of estimating the model via the Extended Kalman Filter. Moreover, the VARG-B model leads to a fully analytic conditional Laplace transform which leads to a closed option pricing formula. When estimated on S&P500 index options and returns the new model provides more accurate option pricing and modelling of the IV surface with respect to some alternative models.
Keywords: Volatility Bursts, ARG-Zero, Option Pricing, Extended Kalman Filter, Realized Volatility.

Jumps or flatness?

24 Jan
15:00
Aula 8

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We show that flatness, that is the pervasive presence of zero returns in price data, has a strong impact on multipower variation which is heavily detrimental for jump inference. Even moderate levels of flatness, compatible with those observed in actual prices, imply a large number of false positives when detecting jumps, and a sizable negative bias in the measurement of the jump activity index. We provide limit theorems for multipower variation under flat trading which allow to quantify the bias and correct for it. We use the flatness-robust multipowers to reappraise the statistical features of jumps in empirical finance. Jumps appear to be much less frequent, much less contributing to price variation, and much less vibrant that what found by the empirical literature so far.
Keywords: Flat Trading; Multipower variation; Jump testing; Blumental-Getoor index.

HARK the SHARK: Realized volatility modelling with measurement errors and nonlinear dependencies

24 Jan
15:30
Aula 8

Giuseppe Buccheri[1] and Fulvio Corsi[2]

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Despite their effectiveness, linear models for realized variance neglect measurement errors on integrated variance and exhibit several evidences of misspecification due to the inherent nonlinear dynamics of volatility. We propose new extensions of the popular approximate long-memory HAR model apt to disentangle these effects and quantify their separate impact on volatility forecasts. By combining the asymptotic theory of the realized variance estimator with the Kalman filter and by introducing time-variations in the HAR parameters driven by the score of the predictive likelihood, we build new models that account for: (i) measurement errors (HARK), (ii) nonlinearity (SHAR) and (iii) both measurement errors and nonlinearity (SHARK). The proposed models are simply estimated through standard maximum likelihood methods, and are shown, both on simulated and real data, to provide better out-of-sample forecasts compared to standard HAR specifications and other competing approaches.
Keywords: Realized Volatility, Measurement errors, Nonlinear time-series, Kalman filter.

Session III: Derivative Pricing (Aula 7)

Predictability information criterion for selecting stochastic pricing models

24 Jan
16:30
Aula 7

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Pricing models of derivative instruments usually fail to provide reliable results when risks rise and financial crises occur. More advanced stochastic pricing models try to improve the fitting results adding risk factors and/or parameters to the models, incurring the risk of overfitted results. Drawing on these observations, it is proposed a generalisation of the Akaike Information Criterion (AIC) suitable to evaluate forecasting power of alternative stochastic pricing models for any fixed arbitrary forecasting time-horizon. The Predictability Information Criterion (PIC) differs from the classical criteria for evaluating statistical models as it assumes that the random variable to study can (or cannot) be partially predictable, which makes it particularly suitable for studying stochastic pricing models coherently with the semimartingale definition of the price process. On the basis of this assumption the criterion measures and compares the uncertainty of the predictions of two different alternative models when prices are (or are not) predictable. I conclude with a focus on the crude oil market by comparing GBM and OU stochastic processes that are commonly used for modeling West Texas Intermediate (WTI) oil spot price returns in derivative pricing models. .
Keywords: Model Selection, Information Theory, Predictability.

Quantization goes Polynomial

24 Jan
17:00
Aula 7

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Quantization algorithms have been recently successfully adopted in option pricing problems to speed up Monte Carlo simulations thanks to the high convergence rate of the numerical approximation. In particular, recursive marginal quantization has been proven to be a flexible and versatile tool when applied to stochastic volatility processes. In this paper we apply for the first time these techniques to the family of polynomial processes, by exploiting, whenever possible, their peculiar properties. We derive theoretical results to assess the approximation errors and we describe in numerical examples practical tools for fast exotic option pricing.
Keywords: Quantization, Polynomial Models, Stochastic Volatility, Option Pricing, Path-Dependent Options.

Smile Modelling in Commodity Markets

24 Jan
17:30
Aula 7

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We present a stochastic-local volatility model for derivative contracts on commodity futures able to describe forward-curve and smile dynamics with a fast calibration to liquid market quotes. A parsimonious parametrization is introduced to deal with the limited number of options quoted in the market. Cleared commodity markets for futures and options are analyzed to include in the pricing framework specific trading clauses and margining procedures. Numerical examples for calibration and pricing are provided for different commodity products.
Keywords: Commodity, Option Pricing, Margining Procedures, Collaterals, Local volatility, Stochastic Volatility.

Algorithmic differentiation for discontinuous payoffs

24 Jan
18:00
Aula 7

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We present a general technique to compute the sensitivities of the Monte Carlo price of discontinuous financial products. It is a natural extension of the pathwise adjoint method, which would require an almost-surely differentiable payoff; the efficiency of the latter method when many sensitivities must be calculated is preserved. Empirically, the new algorithm is competitive in terms of accuracy and execution time when compared to benchmarks obtained by smoothing of the payoff, which benchmarks are biased and require a non-obvious tuning of their parameters.
Keywords: Sensitivities, Greeks, algorithmic differentiation, pathwise differentiation, derivatives pricing, discontinuous payoffs, digital options.

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24 Jan
18:30
Aula 7

A Mellin transform approach to barrier option pricing

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A barrier option is an exotic path-dependent option contract that (depending on terms) automatically expires or can be exercised only if the underlying asset reaches a predetermined barrier price. Using a PDE approach, we provide an integral representation of the barrier option price based on the Mellin transform. In the case of knock-out barrier options, we obtain a decomposition of the barrier option price into the corresponding European option value minus a barrier premium. The integral representation formula can be expressed in terms of the solution to a system of coupled Volterra integral equations of the first kind. Moreover, we suggest some possible numerical approaches to the problem of barrier option pricing.

Keywords: Option pricing, barrier option, Volterra integral equations.

Session IV: Risk Management (Aula 8)

24 Jan
16:30
Aula 8

S&P 500 Index, an option-implied risk analysis

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The forward-looking nature of option prices allows one to derive model-free conditional risk measures. Naturally linked to the option market data, the option-implied VaR and CVaR are then economically-based flexible risk measures. Without relying on any distributional assumption, the option-implied methodology overcomes the CVaR elicitability issue, thus making possible a comparison based on the backtesting results. This paper derives and analyzes the performances of the 2005-2015 S&P 500 option-implied VaR and CVaR and compares them with different statistically-based (classical) risk measures. The option-implied estimates are superior to the proposed alternatives and deliver good results during the financial crisis, thus being a convenient alternative to the existing risk measures. The model-free nature of the estimates is an interesting tool both for regulators and companies in order to perform external or internal risk analysis without posing assumptions on the composition of the balance sheet of the companies.

Keywords: Option Prices, VaR and CVaR, Long and Short-term Risk Measures, Elicitability, SP 500 Index.

Allocation of risk capital in a cost cooperative game induced by a modified Expected Shortfall

24 Jan
17:00
Aula 8

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The standard theory of coherent risk measures fails to consider individual institutions as part of a system which might itself experience instability and spread new sources of risk to the market participants. This paper fills this gap and proposes a cooperative market game where agents and institutions play the same role. We take into account a multiple institutions framework where some institutions jointly experience distress, and evaluate their individual and collective impact on the remaining institutions in the market. To carry out the analysis, we define a new risk measure (SCoES) which is a generalization of the Expected Shortfall of Acerbi (2002), and we characterize the riskiness profile as the outcome of a cost cooperative game played by institutions in distress (a similar approach was adopted by Denault in 2001). Each institution's marginal contribution to the spread of riskiness towards the safe institutions in then evaluated by calculating suitable solution concepts of the game such as the Banzhaf-Coleman and the Shapley-Shubik values.

Keywords: Risk measures, systemic risk, cooperative market game, Shapley Value, Value-at-Risk, Expected Shortfall.

Conditional expectiles, time consistency and mixture convexity properties

24 Jan
17:30
Aula 8

Fabio Bellini[1], Valeria Bignozzi[1] and Giovanni Puccetti[2]

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We study conditional expectiles, defined as a natural generalisation of conditional expectations by means of the minimisation of an asymmetric quadratic loss function. We show that conditional expectiles can be equivalently characterised by a conditional first order condition and we derive their main properties. For possible applications as dynamic risk measures, we investigate their convexity properties with respect to mixtures. It turns out that expectiles are not in general neither mixture concave nor mixture convex, although we provide several sufficient conditions that we illustrate in various examples.

Keywords: Conditional expectiles, dynamic risk measures, mixture concavity, time-consistency, supermartingale property.

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24 Jan
18:00
Aula 8

Risk measures based on benchmark loss distributions

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We introduce a new class of quantile-based risk measures that generalize Value at Risk and, likewise Expected Shortfall, allows to take into account both the frequency and the severity of losses. The key ingredient is a benchmark loss distribution (BLD), i.e. a function that specifies for each loss level a probability threshold. The rationale is that losses exceeding a certain level should be tolerated if they occur with a sufficiently low probability which could, in principle, depend on the magnitude of the loss. When the BLD is the tail distribution of a prescribed random loss L, a position is acceptable if it dominates L, with respect to first order stochastic dominance. It follows that acceptability is not intended in absolute terms, but in comparison with a benchmark tail behavior. We define the corresponding cash-additive risk measures and provide a comprehensive study of their main properties with a view towards the most recent theoretical and practical developments. BLD risk measures contain Value at Risk as the special case of a constant loss profile. Merits and drawbacks of this new class are widely discussed and a variety of possible applications are presented.

Keywords: Risk measures, Benchmark Distribution, Robustness, Backtesting, Law Invariance.

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24 Jan
18:30
Aula 8

Static allocation with actively managed funds: Empirical analysis

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Herzel and Nicolosi (working paper, 2017) examines the impact of implicit incentives on mutual fund mangers' investment strategies, and consequently, on the portfolio allocation choices of the investors. First, they theoretically find the optimal wealth for manger with linear or convex incentives. Then, via a simulation approach, they compare the efficient frontier of portfolios controlled by manager with linear or convex incentives. Here, I examine a sample of US equity mutual funds over 1996-2006 providing a set of empirical tests that supports Herzel and Nicolosi (working paper, 2017) predictions.

Keywords: Mutual funds, Implicit Incentives, Relative Performance, Tracking Error Volatility, Flows.

Thursday, January 25^{th}, 2018

Session V: Financial Econometrics (Aula 7)

Decomposing and backtesting a flexible specification for CoVaR

25 Jan
9:00
Aula 7

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The Conditional Value-at-Risk (CoVaR) proposed by Adrian and Brunnermeier (2016)which quantifies the impact of a company in distress on the Value-at-Risk (VaR) of the financial systemhas established itself as a reference measure of systemic risk. In this study, we extend the CoVaR along two dimensions, which lead respectively to: i) the Conditional Autoregressive VaR (CoCaViaR), in which we include autoregressive components of conditional quantiles to explicitly capture volatility clustering and heteroskedasticity; ii) the Conditional Quantile-Located VaR (QL-CoVaR), which accentuates the degree of distress in the connections between the conditioning companies and the financial system, as the parameters are estimated by directly linking the left tails of their returns distributions. By combining the two new risk measures, we also build the Conditional Autoregressive Quantile-Located VaR (QL-CoCaViaR) and introduce a new backtesting method. A large empirical analysis highlights the validity of such approaches and critically discuss their pros and cons. In particular, including quantile-located relationships leads to relevant improvements in terms of predictive accuracy during stressed periods and, therefore, provides a valuable tool for regulators to assess systemic events.
Keywords: CoVaR, CaViaR, Quantile Regression, Quantile-Located, Extreme Risk.

Annual VaR from high frequency data

25 Jan
9:30
Aula 7

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We study the temporal aggregation of risk measures such as Value-at-Risk. For stock returns it is known that Realized Volatility from intraday data provides accurate measures of daily risk but it is not clear how these extend to risk over longer horizons like one year. For the temporal aggregation the most important issue is the persistence of the volatility process. As a simple rule of thumb we find that Value-at-Risk scales approximately as $\tau^{0.55}$ with horizon τ.
Keywords: Risk Management, Long Term Risk, Volatility, VaR.

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25 Jan
10:00
Aula 7

Statistical inference for price sluggishness

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Asset prices recorded at a high frequency are more sluggish than implied by the semi-martingale hypothesis. We propose a new general framework formalizing this phenomenon. A limit theory for Multi-Idle-Time (an economic indicator for price idleness) and related quantities is provided. This allows to quantify the level of idleness in an asset price adjustment and to develop nonparametric specification tests. We consider two different hypotheses. First, whether the extent of sluggishness is constant (and deterministic) or time-varying (and stochastic). Second, whether the sluggishness is persistent. The empirical application on US stocks provides the evidence that stock price flatness is both time-varying and persistent, especially during the crisis.
Keywords: Flatness, idle time, zero returns, stable convergence, liquidity.

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25 Jan
10:30
Aula 7

Modelling crypto–currencies financial time–series

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This paper studies the behavior of crypto–currencies financial time–series of which Bitcoin is the most prominent example. The dynamic of those series is quite complex displaying extreme observations, asymmetries and several nonlinear characteristics which are difficult to model. We develop a new dynamic model able to account for long–memory and asymmetries in the volatility process as well as for the presence of time–varying skewness and kurtosis. The empirical application, carried out on a large set of crypto–currencies, shows evidence of long memory and leverage effect that has a substantial contribution in the volatility dynamic. Going forward, as this new and unexplored market will develop, our results will be important for asset allocation, risk management and pricing of derivative securities.
Keywords: Crypto-currency, Bitcoin, Score–Driven model, Leverage effect, Long memory, Higher Order Moments.

Session VI: Portfolio Selection (Aula 8)

A Note on portfolio optimization under a quantile hedging constraint

25 Jan
9:00
Aula 8

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We suggest to focus on the case of a European quantile hedging constraint and to work on the problem of portfolio optimization under such a constraint. We thus consider a class of Markovian optimal stochastic control problems in which two controlled processes (X^ν, Y^ν) have to meet a probabilistic shortfall constraint $P[Y_T^\nu \geq g(T, X_T^\nu)] \geq p$ at some terminal date T with g a given function. We denote by V the corresponding value function. Following the arguments of Bouchard, Elie and Imbert (2010) we convert this initial problem into a state constraint one where the constraint is defined via an auxiliary value function v characterizing the reachable set $\mathcal{C} := \{(t, X_t^\nu, Y_t^\nu) \in [0,T] \times R^{d+1} : P[Y_T^\nu \geq g(T, X_T^\nu)] \geq p \text{ for some } \nu\}$. Therefore the domain $\mathcal{C}$ is not given a priori but is naturally integrated in the auxiliary value function v which solves, in a viscosity sense, a nonlinear parabolic PDE. Proceeding as in Bouchard, Elie and Imbert (2010) we can derive, in the interior of the domain, a Hamilton-Jacobi-Bellman characterization of V. However, the auxiliary value function v involves an additional controlled state variable coming from the diffusion of the probability of reaching the target and belonging to the compact set $[0, 1]$. This leads to non-trivial boundaries for V that need to be discussed. Our main result is thus the characterization of V at those boundaries. This answers a question raised in Section 5.1 in Bouchard, Elie and Imbert (2010).
Keywords: Viscosity Solutions, Optimal Control, Quantile Hedging Constraints, State Constraint Problems, Stochastic Target Problems.

Existence, uniqueness and stability of optimal portfolios of eligible assets

25 Jan
9:30
Aula 8

Michel Baes[1], Pablo Koch-Medina[2] and Cosimo Munari[2]

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In a capital adequacy framework, risk measures are used to determine the minimal amount of capital that a financial institution has to raise and invest in a portfolio of pre-specified eligible assets in order to pass a given capital adequacy test. From a capital efficiency perspective, it is important to identify the set of portfolios of eligible assets that allow to pass the test by raising the least amount of capital. We study the existence and uniqueness of such optimal portfolios as well as their sensitivity to changes in the underlying capital position. This naturally leads to

investigating the continuity properties of the set-valued map associating to each capital position the corresponding set of optimal portfolios. We pay special attention to lower semicontinuity, which is the key continuity property from a financial perspective. This "stability" property is always satisfied if the test is based on a polyhedral risk measure but it generally fails once we depart from polyhedrality even when the reference risk measure is convex. However, lower semicontinuity can be often achieved if one if one is willing to focuses on portfolios that are close to being optimal. Besides capital adequacy, our results have a variety of natural applications to pricing, hedging, and capital allocation problems.
Keywords: Risk measures, capital adequacy, pricing and hedging, capital allocation, optimal eligible assets.

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25 Jan
10:00
Aula 8

Portfolio optimization with expected shortfall in markets with contagion

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The cascade of negative shocks to financial markets experienced in 2008-2009 points to the interdependence of risks embedded in asset returns. In particular for portfolio allocation, neglecting to take this contagious behavior into account will underestimate the risk of realizing severe losses on the constituents of the portfolio over a short horizon. To address possible recurrence in the arrival of jump-related events, we consider a multidimensional jump-diffusion framework where classic Poisson jumps are equipped with long memory via past-weighted randomization of their intensity (Hawkes processes). Under this framework, we tackle the problem of minimum loss portfolio allocation, in terms of Expected Shortfall (ES). This is the optimization problem financial institutions face as capital requirements imposed by regulation are computed based on a tail risk measure. We use generalized method of moments (GMM) to estimate the model on three US stock indexes (XNG, MSH, BTK), representing three major sectors of the US economy. Given parameter estimates, we minimize, at a monthly frequency in the period 2001-2016, the ES of a portfolio consisting of the three indexes mentioned above. Finally, we perform an extensive out-of-sample back-test. We find that the Hawkes jump diffusion model outperforms two traditional models that are commonly implemented.
Keywords: Hawkes process, Contagion, Diversification, Expected shortfall, Backtesting, Portfolio allocation.

Understanding the momentum risk premium: An in-depth journey through trend-following strategies information

25 Jan
10:30
Aula 8

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Momentum risk premium is one of the most important alternative risk premia. Since it is considered a market anomaly, it is not always well understood. Many publications on this topic are therefore based on backtesting and empirical results. However, some academic studies have developed a theoretical framework that allows us to understand the behavior of such strategies. In this paper, we extend the model of Bruder and Gaussel (2011) to the multivariate case. We can find the main properties found in academic literature, and obtain new theoretical findings on the momentum risk premium. In particular, we revisit the payoff of trend-following strategies, and analyze the impact of the asset universe on the risk/return profile. We also compare empirical stylized facts with the theoretical results obtained from our model. Finally, we study the hedging properties of trend-following strategies.
Keywords: Momentum risk premium, trend-following strategy, cross-section momentum, time-series momentum, alternative risk premium, market anomaly, diversification, correlation, payoff, trading impact, hedging, skewness, Gaussian quadratic forms, Kalman filter, EWMA.

Session IX: Systemic Risk (Aula 7)

Modelling time-varying volatility interactions with an application to volatility contagion

25 Jan
14:30
Aula 7

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For modelling the dynamics of the volatility interactions over time, we propose an additive time-varying structure in which a time-dependent component is added to the extended vector GARCH process. In this setting, the structure and co-dependence of volatilities are allowed to smoothly change between two extreme volatility regimes and contagion identified through the crisis-contingent structural changes. An equation by equation estimator is proposed to estimate the time-varying vector GARCH process augmented with cross-market ARCH effects. A Lagrange multiplier (LM-)type test of volatility contagion is derived in which the constant co-dependence hypothesis is tested against a smoothly changing interdependence structure. To analyse the finite sample properties of the test we run simulation experiments. An empirical application of the modelling and testing procedures to

sovereign bond yields is also provided.
Keywords: Multivariate GARCH, Time-varying parameters, Volatility spillovers, LM testing, Volatility contagion.

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25 Jan
15:00
Aula 7

Common asset holdings and systemic vulnerability across multiple types of financial institutions

Paolo Barucca[1], Tahir Mahmood[2] and Laura Silvestri[2]

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One way systemic risk can crystallise is through fire sales of commonly held assets. This paper undertakes an in depth empirical analysis of the interconnections between European open-ended investment funds and UK regulated banks and insurance companies through their common asset holdings. This research is the first to combine regulatory holding-level asset data for banks and insurers with private data for open-ended investment funds. Our results show the existence of a significant overlap between the equity and debt portfolios of different types of financial institution. We characterise financial institutions of different types in terms of their diversification profile, portfolio similarity and vulnerability to fire sales, providing evidence for the existence of a price-mediated channel of contagion between banks, insurance companies and investments funds.
Keywords: Systemic risk, common asset holdings, fire sales, vulnerability, network analysis.

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25 Jan
15:30
Aula 7

Does economic policy uncertainty lead systemic risk? A comparative analysis of selected European countries

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We study lead-lag linkages between economic policy uncertainty and systemic risk for nine European countries in January 2010September 2016. In the research, conventional tools (linear and nonparametric Granger causality tests) and advanced techniques (wavelet analysis and Bayesian VARs) apply. The country-level analyses show that the lead-lag patterns vary considerably in the short and longer run as well as at different frequencies. Nonetheless, for most of the countries, the pivotal

role of uncertainty tends to strengthen over longer time horizons (at lower frequencies) and in the multivariate setting. Namely, in the BVAR framework, economic policy uncertainty leads systemic risk in the financially fragile economies (Ireland, Italy, Russia, Spain). The finding holds for the whole sample when a panel BVAR model is estimated. We also document a direct contractionary effect of uncertainty on economic activity for Ireland, Italy, the Netherlands, Russia and Spain. On the aggregate level, this effect is roundabout: uncertainty fuels systemic risk which in its turn causes an increase in unemployment.
Keywords: Bayesian VAR, dynamic factor model, economic policy uncertainty, systemic risk, wavelet coherence.

Session X: Derivatives (Aula 8)

Asset pricing in an imperfect world

25 Jan
14:30
Aula 8

Gianluca Cassese

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In a model with no given probability measure, we consider asset pricing in the presence of frictions and other imperfections and characterize the property of coherent pricing, a notion related to (but much weaker than) the no arbitrage property. We show that prices are coherent if and only if the set of pricing measures is non empty, i.e. if pricing by expectation is possible. We then obtain a decomposition of coherent prices highlighting the role of bubbles. Eventually we show that under very weak conditions the coherent pricing of options allows for a very clear representation which allows, as in Breeden and Litzenberger, to extract the implied probability.
Keywords: Arbitrage, Bid/Ask spreads, Bubbles, Coherence, Risk-neutral probability, Transaction costs.

Canonical Markovian representations of stochastic Volterra equations

25 Jan
15:00
Aula 8

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We introduce canonical Markovian representations of stochastic Volterra processes in terms of transport stochastic partial differential equations (SPDEs). Solution theories are equivalent but the Markovian representation allows for novel numerical techniques as well as solution concepts that are hard to guess from the Volterra equations' point of view. If the instantaneous characteristics of the Volterra process are affine or polynomial the Markovian lift is affine or polynomial as well, providing another explanation of certain affine or polynomial techniques present in

the Volterra world. Examples from rough volatility modeling are included.
Keywords: Stochastic Volterra processes, rough volatility, ambit processes, variation of constants formula, stochastic partial differential equations, affine processes, Szkefalvi-Nagy theorem.

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25 Jan
15:30
Aula 8

A consistent stochastic model of the term structure of interest rates for multiple tenors

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Explicitly taking into account the risk incurred when borrowing at a shorter tenor versus lending at a longer tenor ("roll-over risk"), we construct a stochastic model framework for the term structure of interest rates in which a frequency basis (i.e. a spread applied to one leg of a swap to exchange one floating interest rate for another of a different tenor in the same currency) arises endogenously. This roll-over risk consists of two components, a credit risk component due to the possibility of being downgraded and thus facing a higher credit spread when attempting to roll over short–term borrowing, and a component reflecting the (systemic) possibility of being unable to roll over short–term borrowing at the reference rate (e.g., LIBOR) due to an absence of liquidity in the market. The modelling framework is of "reduced form" in the sense that (similar to the credit risk literature) the *source* of credit risk is not modelled (nor is the source of liquidity risk). However, the framework has more structure than the literature seeking to simply model a different term structure of interest rates for each tenor frequency, since relationships between rates for all tenor frequencies are established based on the modelled roll-over risk. We proceed to consider a specific case within this framework, where the dynamics of interest rate and roll-over risk are driven by a multifactor Cox/Ingersoll/Ross–type process, show how such model can be calibrated to market data, and used for relative pricing of interest rate derivatives, including bespoke tenor frequencies not liquidly traded in the market.
Keywords: Tenor swap, basis, frequency basis, liquidity risk, swap market.

Session XI: Insurance (Aula 7)

Optimal proportional reinsurance and investment for stochastic factor models

25 Jan
16:30
Aula 7

Matteo Brachetta[1] and Claudia Ceci[1]

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In this work we investigate the optimal reinsurance-investment strategy of an insurer company which wishes to maximize the expected exponential utility of its terminal wealth in a finite time horizon. Our goal is to extend the classical Lundberg model introducing a stochastic factor which affects the intensity of the claims arrival process, described by a Cox process, as well as the insurance and reinsurance premia. Using the classical approach based on the Hamilton-Jacobi-Bellman equation we characterize the optimal strategy and provide a verification result for the value function via classical solution of two backward partial differential equations. Results under various premium calculation principles are discussed.
Keywords: Stochastic control, Hamilton-Jacobi-Bellman equation, Stochastic factor models, Optimal reinsurance, Optimal investment.

A market consistent framework for the fair evaluation of insurance contracts under Solvency II

25 Jan
17:00
Aula 7

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In the last years regulators introduced, with the Solvency II directive, a market consistent and risk neutral valuation framework for determining the fair value of asset and liabilities of insurance funds. In this work, we introduce an arbitrage free and market consistent economic scenario generator which allows for different stochastic sources of risk: interest rates, sovereign credit spread and liquidity basis, corporate rating transition and default process. In this model, the dependence between different sovereign issuers (or corporate sectors) is also considered. We give a wider perspective to our model specifying the dynamic of risk factors under both the real world and the risk neutral probability measures, making our model suitable for pricing and risk management, in particular, of the valuation risk due to correlation, basis and liquidity risk. Furthermore, we address valuation risk by proposing an invariant probabilistic sensitivity analysis for assessing the calibration risk, i.e. the impact that statistical uncertainty in the estimation of a model parameters can

have on the probability distribution of risk factors and hence on pricing. To the best of our knowledge, this kind of analysis is an innovation for ESG practice. Finally, we apply our model to the evaluation of minimum guaranteed options embedded in insurance life with-profit contracts.
Keywords: Solvency II, economic scenario generator, market consistent valuation, invariant probabilistic sensitivity analysis, minimum guaranteed option.

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25 Jan
17:30
Aula 7

Indifference pricing of pure endowment life insurance contracts under partial information

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In this paper we investigate the pricing problem of a pure endowment contract when the insurer has a limited information on the mortality intensity of the policyholder. The payoff of this kind of policies depends on the residual life time of the insured as well as the trend of a portfolio traded in the financial market, where investments in a riskless asset, a risky asset and a longevity bond are allowed. We propose a modeling framework that takes into account mutual dependence between the financial and the insurance markets via an observable stochastic process which affects the risky asset and the mortality index dynamics. Since the market is incomplete due to the presence of basis risk, in alternative to arbitrage pricing we use expected utility maximization under exponential preferences as evaluation approach, which leads to the so-called indifference price. Under partial information this methodology requires filtering techniques that can reduce the original control problem to an equivalent problem in complete information. Using stochastic dynamics techniques, we characterize the value function as well as the indifference price in terms of the solution to a quadratic-exponential backward stochastic differential equation. Finally, a duality relation is discussed.
Keywords: Unit-linked life insurance contract, partial information, backward stochastic differential equations, indifference pricing.

Geographical diversification in annuity portfolios

25 Jan
18:00
Aula 7

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This paper studies the problem of an insurance company that has to decide whether to expand her portfolio of policies selling contracts written on a foreign population. We propose a parsimonious continuous-time model for longevity risk, that captures the dependence across different ages in two populations and evaluate the diversification gains due to the international expansion. We present a calibrated example, based on annuity portfolios of UK and Italian males aged 65-75. We show that diversification gains, evaluated as the reduction in the portfolio risk margin following the international expansion, can be non-negligible, in particular when interest rates are low. We describe how the expansion can obtain through a swap, instead of opening a foreign affiliate.
Keywords: Geographical diversification, life insurance, risk management, multi-population mortality, longevity risk modeling.

Session XII: Portfolio Optimization (Aula 8)

Prudent valuation and market price uncertainty: an efficient capital allocation under EBA regulatory technical standards

25 Jan
16:30
Aula 8

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Prudent valuation rules included into the EU Capital Requirement Regulation (CRR) require to deduct from the Common Equity Tier 1 capital the Additional Valuation Adjustment (AVA), an amount aimed at mitigating the valuation risk arising from multiple valuation uncertainty sources. In this article, we focus on the AVA Market Price Uncertainty (MPU), taking into account the valuation uncertainty arising from uncertain valuation inputs, and we present an efficient calculation methodology in terms of both capital allocation and valuation risk mitigation. Indeed, the complex set of rules defined by regulators allows some discretionary choices, which may lead to remarkably different capital deductions. In particular, we exploit the possibility to reduce the number of parameters taken into account,

which allows institution to benefit from a lower AVA MPU, under specific conditions. We show that a Global Sensitivity Analysis based on the Kuiper's metric can be used to justify extreme reductions and drive the choice among the eligible reduced parameters sets. The results of our analysis provide institutions with theoretical foundations about the complex and partially still unexplored prudent valuation topic and with suggestions to reach a robust and efficient capital allocation. We provide a numerical example by presenting a case study considering a portfolio of interest rate derivatives and one-dimensional risk factors.
Keywords: Valuation, valuation uncertainty, fair valuation, prudent valuation, Additional Valuation Adjustments, Market Price Uncertainty, Global Sensitivity Analysis, CRR, EBA, AVA, MPU, GSA.

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25 Jan
17:00
Aula 8

Forward-looking portfolio selection with multivariate non-Gaussian models and the Esscher transform

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In this study we propose a portfolio selection framework based on option implied information and multivariate non-Gaussian models. The models incorporate skewness, kurtosis and more complex dependence structures among stocks log-returns than the simple correlation matrix. The two models considered are a multivariate extension of the normal tempered stable (NTS) model and the generalized hyperbolic (GH) model, respectively, and the connection between the historical measure P and the risk neutral measure Q is given by the Esscher transform. We consider an estimation method that simultaneously calibrate the time series of univariate log-returns and the univariate observed volatility smile. To calibrate the models, there is no need of liquid multivariate derivative quotes. The method is applied to fit a 50-dimensional series of stock returns, to evaluate widely known portfolio risk measures and to perform a portfolio selection analysis.
Keywords: Normal mean-variance mixture, time-changed Brownian motion, multivariate non-Gaussian processes, portfolio risk measures, portfolio optimization.

Optimal portfolio allocation with volatility and co-jump risk that Markowitz would like

25 Jan
17:30
Aula 8

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We study a continuous time optimal portfolio allocation problem with volatility and co-jump risk, allowing prices, variances and covariances to jump simultaneously. Differently from the traditional approach, we deviate from affine models by specifying a flexible Wishart jump-diffusion for the co-precision (the inverse of the covariance matrix). The optimal portfolio weights which solve the dynamic programming problem are proportional to the inverse covariance matrix, reconciling optimal dynamic allocation with the static Markowitz-type economic intuition. Numerical experiments show the accuracy of the proposed approximation and quantify the effect, based on a calibration on historical U.S. data, of price/volatility co-jumps on portfolio selection.
Keywords: Asset allocation, stochastic volatility, co-jumps, co-precision, Wishart process, dynamic programming, HJB equation.

Volatility and arbitrage

25 Jan
18:00
Aula 8

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The capitalization-weighted cumulative variation $\sum_{i=1}^{d} \int_0^{\cdot} \mu_i(t) d\langle \log \mu_i \rangle(t)$ in an equity market consisting of a fixed number d of assets with capitalization weights $\mu_i(\cdot)$ is an observable and a nondecreasing function of time. If this observable of the market is not just nondecreasing but actually grows at a rate bounded away from zero, then strong arbitrage can be constructed relative to the market over sufficiently long time horizons. It has been an open issue for more than ten years, whether such strong outperformance of the market is possible also over arbitrary time horizons under the stated condition. We show that this is not possible in general, thus settling this long-open question. We also show that, under appropriate additional conditions, outperformance over any time horizon indeed becomes possible, and exhibit investment strategies that effect it.
Keywords: Trading strategies, functional generation, relative arbitrage, short-term arbitrage, support of diffusions, diffusions on manifolds, nondegeneracy.

Friday, January 26^{th}, 2018

Session XIII: Credit and Operational Risk (Aula 7)

26 Jan
9:00
Aula 7

Operational risk assessment of a new product using AHP

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The risk assessment of a new product is one of the most critical activities performed by the Operational Risk Management (ORM) of a company operating in the financial sector. For a new product there are few reference points to assess its riskiness for ORM, due both to the lack of operational loss data and to the inexperience of the process owners in handling the new operation. To overcome these two limitations, we propose an operational risk methodological framework to identify and prioritize the most dangerous operational risk events with respect to the introduction of a new product in a financial institution. The methodology provides the use of a checklist based on risk factors (causes) to assess the operational riskiness of a new product before its launch. Then, after the launch and with particular reference to the management of a new product, we use the Analytic Hierarchy Process (AHP) approach to prioritize operational risk events, and the 80/20 rule to allocate them in appropriate risk rating classes. As a further element with respect to the aforementioned framework, we then develop an optimization model to minimize the total cost of investments required to cover all the important risks. Furthermore, we to study the relationship between the total cost of investments and the exposure coverage by means of another optimization model.

Keywords: Analytic Hierarchy Process, New product, Operational Risk Assessment, 80/20 rule.

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26 Jan
9:30
Aula 7

The relative pricing of sovereign credit risk after the eurozone crisis

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The paper investigates the relative pricing of the sovereign credit risk, by studying the relationship between sovereign CDS spreads and sovereign yields, for European countries, during and after the sovereign debt crisis. We show that after the launch of the Outright Monetary Transaction (OMT) Programme, by the European Central Bank, the relative mispricing of the sovereign credit risk has strongly reduced. We disentangle the effects of the ECB intervention on the sovereign credit

risk market in different ways. We offer empirical evidence on the theoretical relationship between CDS spreads and bond yields, before and after the ECB intervention, across Eurozone and No Eurozone countries. Then, we estimate a contingent claim model for sovereign credit risk, and we shed light on the relationship between risk and return for sovereign securities. Further, we test the profitability of arbitrage strategies that exploit deviations from the equilibrium condition. As result, we provide evidence that the consistent relationship between default risk and bond yields across the Eurozone countries was restored after the ECB intervention.
Keywords: Sovereign credit risk, OMT Programme, Arbitrage, Mispricing, Kalman filter.

CVA evaluation of defaultable claims in a multi-factor intensity model by correlation expansion

26 Jan
10:00
Aula 7

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In this paper we discuss the problem of CVA evaluation of contingent claims in presence of unilateral counterparty credit risk by considering the possibility of WWR (Wrong Way Risk) scenario.The pricing problem is modeled by using the intensity approach and risk-adjusted rates. The asset price and the intensity process are positive jump-diffusions driven by correlated factors. This rules our model out of the standard BAJD (Basic Affine Jump Diffusions) framework introduced by Duffie, Pan and Singleton. We therefore reconsider for this case the approach proposed by Antonelli-Scarlatti (for a general class of stochastic volatility models) and by Antonelli-Ramponi-Scarlatti (for Margrabe type options) to develop CVA in a power series of the correlation around the zero value. The coefficients of the series can be identified and a good approximation for the CVA can be obtained by computing just few of them. Numerical simulations are provided for the case of vulnerable option contracts.
Keywords: CVA, vulnerable options, intensity models.

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26 Jan
10:30
Aula 7

Enhanced equity-credit modeling for contingent convertibles

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Contingent convertible (CoCo) bonds are characterized by forced equity conversion under either accounting or regulatory trigger. Accounting trigger occurs when the capital ratio of the issuing bank falls below some contractual threshold. Under the regulatory trigger, sometimes called the point-of-non-viability (PONV) trigger, the regulatory authority may enforce equity conversion when the financial health of the bank deteriorates to certain distressed level. In this paper, we propose an equity-credit modeling of the joint process of the stock price and capital ratio that integrates both the structural approach of accounting trigger and reduced form approach of PONV trigger of equity conversion. We also construct effective Fortet algorithms and finite difference schemes for numerical pricing of CoCo bonds under various forms of equity conversion payoff. The pricing properties of the CoCo bonds under different assumptions of the state dependent intensity of PONV trigger, contractual specifications and market conditions are examined.
Keywords: Contingent convertibles, equity-credit modeling, Fortet algorithms.

Session XIV: Stochastic Control (Aula 8)

26 Jan
9:00
Aula 8

Portfolio optimization for a large investor controlling market sentiment under partial information

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We consider an investor faced with the utility maximization problem in which the risky asset price process has pure-jump dynamics affected by an unobservable continuous-time finite-state Markov chain, the intensity of which can also be controlled by actions of the investor. Using the classical filtering theory, we reduce this problem with partial information to one with full information and solve it for logarithmic and power utility functions. In particular, we apply control theory for piecewise deterministic Markov processes (PDMP) to our problem and derive the optimality equation for the value function and characterize the value function as the unique viscosity solution of the associated dynamic programming equation. Finally, we provide a toy example, where the unobservable state process is driven by a two-state Markov chain, and discuss how investors ability to control the intensity of the state process affects the optimal portfolio strategies as well as the optimal wealth

under both partial and full information cases.
Keywords: Utility maximization, regime switching, partial information, piecewise deterministic processes.

On a strategic model of pollution control

26 Jan
9:30
Aula 8

Giorgio Ferrari[1] and Torben Koch[1]

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This paper proposes a strategic model of pollution control. A firm, representative of the productive sector of a country, aims at maximizing its profits by expanding its production. Assuming that the output of production is proportional to the level of pollutants' emissions, the firm increases the level of pollution. The government of the country aims at minimizing the social costs due to the pollution, and introduces regulatory constraints on the emissions' level, which then effectively cap the output of production. Supposing that the firm and the government face both proportional and fixed costs in order to adopt their policies, we model the previous problem as a stochastic impulse two-person nonzero-sum game. The state variable of the game is the level of the output of production which evolves as a general linearly controlled one-dimensional Ito-diffusion. Following an educated guess, we first construct a pair of candidate equilibrium policies and of corresponding equilibrium values, and we then provide a set of sufficient conditions under which they indeed realize an equilibrium. Our results are complemented by a numerical study when the (uncontrolled) output of production evolves as a geometric Brownian motion, and the firm's operating profit and the government's running cost functions are of power type. An analysis of the dependency of the equilibrium policies and values on the model parameters yields interesting new behaviors that we explain as a consequence of the strategic interaction between the firm and the government.
Keywords: Pollution, stochastic impulse nonzero-sum game, verification theorem, diffusions.

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26 Jan
10:00
Aula 8

Singular stochastic control problems for reflected diffusions and applications

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Reflected diffusions naturally arise in many problems from applications ranging from economics and mathematical biology to queueing theory. In this paper we consider a class of infinite time-horizon singular stochastic control problems for a general one-dimensional diffusion that is reflected at zero. We assume that exerting control leads to a state-dependent instantaneous reward, whereas reflecting the diffusion at zero gives rise to a proportional cost with constant marginal value. The aim is to maximize the total expected reward, minus the total expected cost of reflection. We show that depending on the properties of the state-dependent instantaneous reward we can have qualitatively different kinds of optimal strategies. The techniques employed are those of stochastic control and of the theory of linear diffusions.
Keywords: Reflected one-dimensional diffusions, singular stochastic control, variational inequality, optimal stopping, optimal dividend, capital injection, optimal harvesting.

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26 Jan
10:30
Aula 8

Irreversible investment with fixed adjustment costs: a stochastic impulse control appraoch

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We consider an optimal stochastic impulse control problem over an infinite time horizon motivated by a model of irreversible investment choices with fixed adjustment costs. By employing techniques of viscosity solutions and relying on semiconvexity arguments, we prove that the value function is a classical solution to the associated quasi-variational inequality. This enables us to characterize the structure of the continuation and action regions and construct an optimal control. Finally, we focus on the linear case, discussing, by a numerical analysis, the sensitivity of the solution with respect to the relevant parameters of the problem.
Keywords: Impulse stochastic optimal control, Quasi-variational inequality, Viscosity solution, Irreversible investment, Fixed cost.

Session XVII: Corporate Finance (Aula 7)

Preemptive investment under uncertainty

26 Jan
14:30
Aula 7

Jan-Henrik Steg

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This paper provides a general characterization of subgame perfect equilibria for strategic timing problems, where two firms have the (real) option to make an irreversible investment. Profit streams are uncertain and depend on the market structure. The analysis is based directly on the inherent economic structure of the model. In particular, determining equilibria with preemptive investment is reduced to solving a single class of constrained optimal stopping problems. Further tools are derived for analysing Markovian state-space models. Applications to typical models from the literature complete commonly insufficient equilibrium arguments, show when uncertainty leads to qualitatively different behavior, and establish additional equilibria that are Pareto improvements.
Keywords: Preemption, real options, irreversible investment, subgame perfect equilibrium, optimal stopping.

The ebbing of accrual accounting

26 Jan
15:00
Aula 7

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This paper investigates the accruals ability to improve the information content of earnings over cash flows, as reflected in market prices. We find that, when the correlation between accruals and cash flows is less negative than -0.4, the association of the two performance measures to prices is statistically indistinguishable. This finding, together with the documented decrease over time in the magnitude of the negative correlation between the earnings components (Bushman et al. (2016)), implies a sharp reduction of the pertinence of accruals to valuation. The proportion of firms in the sample whose pricing significantly benefits from accrual accounting (with respect to cash flow accounting) decreased from around 95% in the beginning of the 70s' to roughly 65% in 2015.
Keywords: Expectation formation pertinence, Earnings, Accrual accounting, Nonparametric regression.

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26 Jan
15:30
Aula 7

Are contingent convertibles going-concern capital? Evidence from bank stock returns

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Contingent convertibles (CoCos) are intended to either convert to new equity or be written down prior to a banks insolvency while it is a going concern. Yet, the first test case of a CoCo led to a failure to convert before insolvency. We develop a model that predicts that CoCos lead to more extreme stock returns if they are not expected to convert or be written down prior to insolvency. However, if investors expect a conversion or write-down before failure, the issuing banks stock returns become less extreme. This prediction is tested using a sample of European banks during 2011 to 2015 when many CoCos were issued. We find evidence that CoCos reduce stock return variance and several other measures of downside risk, consistent with the perception that they are going-concern capital. These risk reduction effects occur mainly for equity conversion, rather than write-down, CoCos.
Keywords: Contingent Capital, Bank Risk, Bank Regulation.

Session XVIII: Asset Pricing (Aula 8)

26 Jan
14:30
Aula 8

Inefficient market bubbles

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Local martingales that are not uniformly integrable martingales have recently gained increased attention in the stochastic processes and mathematical finance literature, being linked to special cases in arbitrage pricing theory and to the occurrence of bubbles. We present a deterministic necessary and sufficient criterion to determine whether a single jump local martingale is a uniformly integrable martingale. Our class of processes is based on a general, possibly explosive homogenous diffusion and a state dependent jump hazard rate, extending both results on homogeneous diffusions and single jump processes with deterministic jump hazard. While to date, most of the research on local martingales that are not uniformly integrable martingales has been focused on deterministically bounded time, we provide natural examples of processes that live on a stochastically unbounded (yet finite) time window.

Keywords: Uniformly integrable martingales, Local martingales, Single jump, Explosive diffusion, Financial bubbles.

Comparing asset pricing models by the conditional Hansen-Jagannathan distance

26 Jan
15:00
Aula 8

Patrick Gagliardini[1] and Diego Ronchetti[2]

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We compare non-nested parametric specifications of the Stochastic Discount Factor (SDF) using the conditional Hansen-Jagannathan (HJ-)distance, which is defined as the discrepancy between an SDF family identifying an asset pricing model and the set of admissible SDFs satisfying the conditional no-arbitrage restrictions. This distance accounts for the models ability to match the dynamic pricing restrictions for the test assets, and not just the unconditional pricing restrictions for a specific choice of managed portfolios (instruments). We estimate the conditional HJ-distance by a kernel-based Generalized Method of Moments estimator and establish its large sample properties for model selection purposes. We demonstrate empirically the usefulness of our approach by comparing several SDF models including preference-based specifications and some recently proposed SDF models that are conditionally linear in the priced risk factors.

Keywords: Asset pricing model comparison, stochastic discount factor, Hansen-Jagannathan distance, Generalized Method of Moments, conditional moment restrictions, nonparametric estimation.

It only takes a few moments to hedge options

26 Jan
15:30
Aula 8

Andrea Barletta[1], Paolo Santucci de Magistris[1] and David Sloth[2]

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Traders offset the risks carried by options and other securities by using the so-called greeks as hedge ratios, with the delta and the vega being the most prominent examples. In this work, we propose a novel non-structural method to compute the delta and vega associated with European options, building on two results that are model-independent. First, under suitable regularity conditions on the risk-neutral density, an option price can be disentangled into a linear combination of risk-neutral moments. Second, there exists an explicit functional form linking the risk-neutral moments to the price of the underlying asset and the related variance swap contracts. We show that the variability of S&P 500 call prices is mostly explained by two

factors that relate to level and volatility of the underlying, which endorses delta-vega hedging. Based on this evidence, we devise and empirically compare the hedging performance of two strategies where the vega exposure is adjusted either by taking a direct position on variance swap contracts or, indirectly, through an ATM call option. While both strategies ensure effective immunization in periods of market turmoil, taking direct exposure on volatility might not be optimal during extended periods of subdued market volatility, which we relate to the phenomenon known as low VIX puzzle.
Keywords: Option greeks, hedging, risk-neutral moments, low VIX puzzle.

Session XIX: Energy Market (Aula 7)

Additive energy forward curves in a Heath-Jarrow-Morton framework

26 Jan
16:30
Aula 8

Fred Espen Benth[1], Marco Piccirilli[2] and Tiziano Vargiolu[2]

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One of the peculiarities of power and gas markets is the delivery mechanism of forward contracts. The seller of a futures contract commits to deliver, say, power, over a certain period, while the classical forward is a financial agreement settled on a maturity date. Our purpose is to design a Heath-Jarrow-Morton framework for an additive, mean-reverting, multicommodity market consisting of forward contracts of any delivery period. The main assumption is that forward prices can be represented as affine functions of a universal source of randomness. This allows us to completely characterize the models which prevent arbitrage opportunities: this boils down to find a density between a risk-neutral measure Q, such that the prices of traded assets like forward contracts are true Q-martingales, and the real world probability measure P, under which forward prices are mean-reverting. The Girsanov kernel for such a transformation turns out to be stochastic and unbounded in the diffusion part, while in the jump part the Girsanov kernel must be deterministic and bounded: thus, in this respect, we prove two results on the martingale property of stochastic exponentials. The first allows to validate measure changes made of two components: an Esscher-type density and a Girsanov transform with stochastic and unbounded kernel. The second uses a different approach and works for the case of continuous density. We apply this framework to two models: a generalized Lucia-Schwartz model and a cross-commodity cointegrated market.
Keywords: Energy markets, mean-reversion, Heath-Jarrow-Morton approach, forwards, martingale property.

The seasonality in the implied accumulated volatility of electricity options

26 Jan
17:00
Aula 7

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Seasonality is an important topic in electricity markets, as both supply and demand are dependent on the time of the year. Clearly the level of prices shows seasonal behaviour, and it is to expect that also the fluctuations are seasonal. We investigate empirically the seasonality in implied volatility of options on electricity futures. The implied volatility can be described very well with a combination of a linear and an exponential term, corresponding to a classical long term - short term two factor model. Moreover, we find clear seasonal patterns in the level of the volatility depending on the delivery month of the futures, and compare the performance of several implementations of seasonality in the theoretical two factor framework.
Keywords: Implied volatility, electricity options, seasonality, mean reversion, two-factor model.

Capacity markets and the pricing of reliability options

26 Jan
17:30
Aula 7

Luisa Andreis[1], Maria Flora[1], Fulvio Fontini[1] and Tiziano Vargiolu[1]

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The growing penetration of non-dispatchable renewable sources, like solar and wind, in the electricity market of many countries introduced in the latest years market uncertainties in the quantity of electricity produced, which can possibly originate price spikes. Capacity markets have exactly the purpose of providing new potential capacity when that present in the market is already allocated and there is a sudden drop in supply (due for example to unexpected adverse weather events). In this talk we will present the different capacity remuneration mechanisms, and analyze in more detail the so-called reliability option, which is a call option sold by producers to transmit system operators. This option has the important advantage of shaving possible price peaks, but its correct pricing require non-trivial techniques.
Keywords: Electricity markets, capacity markets, reliability option, peak-shaving.

Session XX: Stochastic Calculus (Aula 8)

26 Jan
16:30
Aula 8

Affine Volterra processes

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We introduce affine Volterra processes, defined as solutions of certain stochastic convolution equations with affine coefficients. Classical affine diffusions constitute a special case, but affine Volterra processes are neither semimartingales, nor Markov processes in general. We provide explicit exponential-affine representations of the Fourier-Laplace functional in terms of the solution of an associated system of deterministic integral equations, extending well-known formulas for classical affine diffusions. For specific state spaces, we prove existence, uniqueness, and invariance properties of solutions of the corresponding stochastic convolution equations. Our arguments avoid infinite-dimensional stochastic analysis as well as stochastic integration with respect to non-semimartingales, relying instead on tools from the theory of finite-dimensional deterministic convolution equations. Our findings generalize and clarify recent results in the literature on rough volatility models in finance.
Keywords: Stochastic Volterra equations, Riccati-Volterra equations, affine processes, rough volatility.

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26 Jan
17:00
Aula 8

A deterministic shift extension of the Black model

Stephane Dang-Nguyen[1] and Yves Rakotondratsimba[2]

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In this paper, the deterministic shift extension is applied to the Black model and its extensions. It consists in adding a deterministic function to the spot rate process, hence this approach is an alternative to the extensions of the Black model which use a time varying lower bound. As a consequence, the proposed model has a weaker economic interpretation but, it allows to capture the term structure perfectly in a simple manner or to correct pricing errors. This approach is applied, in a first time, to the extended Black model and some numerical applications are provided as illustration. In a second time, the extension is also used with multivariate shadow rate models, and is detailed for two of the most famous Gaussian models. Some actuarial applications for the pricing of basic Italian life policies are also discussed.

Keywords: Interest rates models, shadow rates models, deterministic shift extension, participating life policies.

Infinite-dimensional calculus under weak spatial regularity of the processes

26 Jan
17:30
Aula 8

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Two generalizations of Itô formula to infinite-dimensional spaces are given. The first one, in Hilbert spaces, extends the classical one by taking advantage of cancelations when they occur in examples and it is applied to the case of a group generator. The second one, based on the previous one and a limit procedure, is an Itô formula in a special class of Banach spaces having a product structure with the noise in a Hilbert component; again the key point is the extension due to a cancelation. This extension to Banach spaces and in particular the specific cancelation are motivated by path-dependent Itô calculus.
Keywords: Stochastic calculus in Hilbert (Banach) spaces, Itô formula.

SHORT TALKS

Thursday, January 25^{th}, 2018

Session VII: Short Talk I (Aula 7)

Minimum regularised covariance determinant estimators for equity selection

25 Jan
11:30
Aula 7

Maria Elena De Giuli[1], Marco Neffelli[2] and Marina Resta[2]

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One of the main flaws of Markowitz portfolio is the use of sample estimators for both the covariance matrix and the mean of assets returns. In particular, various scholars highlighted that the sample covariance matrix is bad conditioned and prone to amplify the outliers impact. This turns out in generating erroneous estimates that can drive Markowitzs optimization procedure towards sub-optimal allocations. To handle this issue, we propose to use the Minimum Regularised Covariance Determinant (MRCD) estimators class to improve the optimization procedure. The MRCD, in fact, always produces a well-conditioned covariance matrix which has been shown to be consistent, as well as location and scatter invariant. In fact, the MRCD regularises the estimation in presence of fat-tailed datasets; moreover, it includes the Minimum Covariance Determinant (MCD) estimator as special case, when the data are well behaved. The aim of this paper is to test the robustness of the MRCD estimators class against the sample covariance matrix for portfolio allocation. We focused on the Global Minimum Variance Portfolio (GMVP) problem. In this way, we were able to detach the estimation impact on the covariance matrix by that of the assets mean, as the GMVP problem does not require any derivation for the assets mean. Our sample was based on 300 constituents drawn from the S&P500 index: we considered monthly observations, from 01/01/1996 to 31/10/2017 for an overall number of 262 data points. In order to test the robustness of our approach for several covariance matrix sizes, we selected as investment universe the early most capitalised 30, 50, 100, 150, 200 and 300 assets from the original sample. We run the following investment strategy: at the beginning of each month, we estimate the covariance matrix with sample and MRCD techniques, allocating the wealth according to the GMVP. With the aid of a monthly rolling window, we repeated the process

for an overall number of 202 out-of-sample periods. Therefore, the investment performance is evaluated only out-of-sample by way of the average monthly turnover, the global variance and the deflated Sharpe ratio. Results show that the MRCD is a more efficient alternative to its sample counterpart: for the GMVP, in fact, out-of-sample performances exhibit reduced turnover and global variance, while the deflated Sharpe ratio is higher. The improvement is more evident when the sample size is large, since the MRCD estimator regularises the estimation procedure when the covariance matrix has high-dimension, estimating the MCD only in the case of 30 assets.

Keywords: Global Minimum Variance Portfolio, Minimum Regularised Covariance Determinant Estimator, Deflated Sharpe Ratio.

Learning the optimal risk - Advanced risk-based portfolio management with global optimization and machine learning algorithms

25 Jan
11:45
Aula 7

Marco Bianchetti[1] and Marco Scaringi[2]

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We consider the portfolio optimization problem from a trading and risk management point of view. Given a generic initial portfolio of financial instruments (e.g. stocks, derivatives and securities) with a given risk profile and subject to risk management limits, we aim to find optimal trading strategies, based on eligible tradable and liquid market instruments (i.e. quoted stocks and plain vanilla derivatives and securities), able to globally optimize the portfolio risk figures while respecting the required risk limits. We make use of an evolutionary approach based on genetic algorithms, where a population of candidate trading strategies is evolved using crossover, mutation and elitism, until optimal solutions are found as the best trading strategies that both minimize the selected risk measures and respect the risk limits. We apply our idea to different test cases based on real portfolios including linear and non-linear real financial instruments. We show that different optimal trading strategies may exist, depending on the combination of risk-based objective functions and limits. We also show that machine learning techniques can help to drive the population evolution according to the observed characteristics of past populations, thus effectively reducing the computational effort needed to reach convergence. Our approach is general with respect to initial portfolios, risk profiles, measures and limits, eligible optimization instruments and trading strategies, and optimization algorithms. It can be applied, in principle, to real portfolios of investors and financial institutions, provided that, in practice, a single operational framework and sufficient computational resources are available. Strong financial insight is needed both to select the optimization parameters, i.e. the eligible trading strategies, and to understand the financial soundness of the solutions proposed by the optimization

metaheuristic.
Keywords: Risk management, risk measures, risk limits, VaR, XVA, sensitivity, portfolio optimization, global optimization, metaheuristics, genetic algorithms, machine learning.

On the stability of portfolio selection models

25 Jan
12:00
Aula 7

Francesco Cesarone[1], Carlo Domenico Mottura[1], Jacopo Maria Ricci[1] and Fabio Tardella[2]

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One of the main issues in portfolio selection models consists in assessing the effect of the estimation errors of the parameters required by the models on the quality of the selected portfolios. Several studies have been devoted to this topic for the minimum variance and for several others minimum risk models. However, no sensitivity analysis seems to have been reported for the recent popular Risk Parity diversification approach, nor for other portfolio selection models requiring maximum gain-risk ratios. Based on a simulation approach, we provide here empirical evidence showing that the Risk Parity model is always the most stable one in all the cases analyzed. Furthermore, the minimum risk models are typically more stable than the maximum gain-risk models, with the minimum variance model being often the preferable one.
Keywords: Risk Parity, estimation errors, portfolio optimization, stability measures, gain-risk ratio.

Pricing methods for perpetual Bermudan and quantile options based on Spitzer identities

25 Jan
12:15
Aula 7

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We present results for pricing perpetual Bermudan and α-quantile options based on the Spitzer identities for general Lévy processes. We devise and implement new pricing methods for α-quantile and perpetual Bermudan options and implement for the first time a numerical scheme by Green (2009). In the case of perpetual Bermudan options we also present and compare two different methods for calculating the optimal exercise boundary. The pricing methods we present show excellent

error performance with grid size, having either exponential or at least fourth order polynomial convergence.
Keywords: Fourier transform, Spitzer identities, Hilbert transform, z-transform, hindsight options, perpetual Bermudan options.

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25 Jan
12:30
Aula 7

Variational formulation of American option prices in the Heston Model

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We give an analytical characterization of the price function of an American option in Heston-type models. Our approach is based on variational inequalities and extends recent results of Daskalopoulos and Feehan (2011). We study the existence and uniqueness of a weak solution of the associated degenerate parabolic obstacle problem. Then, we use suitable estimates on the joint distribution of the log-price process and the volatility process in order to characterize the analytical weak solution as the solution to the optimal stopping problem. We also rely on semi-group techniques and on the affine property of the model.
Keywords: American options, degenerate parabolic obstacle problem, optimal stopping problem.

Session VIII: Short Talk II (Aula 8)

25 Jan
11:30
Aula 8

A Malliavin calculus approach to credit valuation adjustments

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In this article we detail a Malliavin calculus approach to the calculation of credit valuation adjustments for derivatives whose underlyings are driven by a certain class of jump-diffusion processes. The path dependence of the credit valuation adjustment and the non-zero correlation between the default of a counterparty and relevant risk factors serve as the prime motivators behind this application; the tools of Malliavin calculus allow us to derive expressions for conditional expectations in terms of regular expectations without conditioning. Addressing current issues within the financial markets, we present a numerical example, wherein we price the credit valuation adjustment of a portfolio of total return swaps on a portfolio of additional tier 1 bonds.

Keywords: Malliavin calculus, credit valuation adjustment, Monte Carlo simulation, total return swap.

Affine processes and non-linear (partial) differential equations

25 Jan
11:45
Aula 8

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We present several novel stochastic representation formulas for ordinary and partial differential equations connecting classical results going back to, e.g., E. Dynkin or H. McKean, with recent results by, e.g., P. Henry-Labordere et al. In particular ordinary and partial differential equations beyond standard local Lipschitz assumptions can be treated. Several examples from mathematical Finance are considered and some aspects of machine learning of solutions of dynamical systems are discussed.

Keywords: Affine process, stochastic representation, branching process, Levy Khintchine form, machine learning.

State constrained stochastic optimal control problems via reachability approach

25 Jan
12:00
Aula 8

Olivier Bokanowski[1], Athena Picarelli[2] and Hasnaa Zidani[3]

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This paper deals with a class of stochastic optimal control problems in presence of state constraints. It is well known that for such problems the value function is, in general, discontinuous, and its characterization by a HamiltonJacobi equation requires additional assumptions involving an interplay between the boundary of the set of constraints and the dynamics of the controlled system. Here, we give a characterization of the epigraph of the value function without assuming the usual controllability assumptions. To this end, the stochastic optimal control problem is first translated into a state-constrained stochastic target problem. Then a level-set approach is used to describe the backward reachable sets of the new target problem. It turns out that these backward reachable sets describe the value function. The main advantage of our approach is that it allows us to easily handle the state constraints by an exact penalization. However, the target problem involves a new state variable and a new control variable that is unbounded.

Keywords: HamiltonJacobi equations, State constraints, Stochastic optimal control, Viscosity solutions.

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25 Jan
12:15
Aula 8

Optimal trading of imbalance options for power systems

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We study the problem of calculating the so called "real value" of an optimal trading strategy that smooths real-time fluctuations of a power system. The proposed trading strategy includes the offer of American-style put or call options and is managed by an operator who is the owner of an electricity storage facility. This means that this storage operator has the possibility to optimally decide which option to offer, with the restriction of having the storage device in the appropriate mode at any time. The system operator accepts these offers as possible long-term real-time balancing resorts. With the storage device, either electricity consumption or generated electricity can be increased in the network and in our work this happens accordingly via the exercise of the corresponding option. Using the relation with variational inequalities, we calculate the real value of the optimal trading strategy for the storage operator and at the same time we calculate the balancing cost of this resort compared to a so called "target cost" for the system operator. These results reveal that with proper parameter choices, mutual benefit is available, i.e. a financial profit for the storage operator whilst the balancing cost can also be reduced for the electricity system operator. Our results are illustrated via numerical calculations which are carried out after having the parameters of the model fit to real UK data. Optimal operational strategies are also described using our analysis.
Keywords: Optimal control, variational inequalities, OR in energy, real option, electricity balancing market.

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25 Jan
12:30
Aula 8

Interest rates term structure models and their impact on actuarial forecasting

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Interest rates term structures are of fundamental importance for pricing financial instruments and/or insurance contracts. The analyst must take into account how much these essential measures- together with the price of the instrument- can be affected by an inaccurate process of yield curve modeling. These discrepancies are mainly due to two factors: first, the different models and numerical techniques used to estimate the zero-coupon rates; second, as the information is generally retrieved from a database provider, the same maturity can match to different risk-free debt instruments quotes. The aim of this paper is to examine the discrepancies from using alternative interest rate databases, and to test the capabilities of different techniques in modelling the yield curve (DAmato et al., 2016).The paper is divided into three parts. In the first part, we consider the different bootstrapping methods used to obtain the yield form implied by the treasury bonds to assess the problem

of the discrepancies in pricing. In the second part, we compare the performance of conventional models used for deriving the calibration of the term-structure models. We have considered three approaches: the parametric models of Nelson-Siegel, Svensson and De Rezende-Ferreira; the interest rate structure methods based on the Vasicek and the Cox, Ingersoll and Ross stochastic processes; and a battery of Machine Learning models. As previously said, this issue has also already discussed in DAmato et al. (2016); however, our approach goes beyond, since we also fit the interest rate term structure by a set of models that allows a more robust analysis of the zero-rates curve and the discount factors. Finally, in the third part of the paper, we show how these discrepancies can impact on financial valuations. Thus, in this last part, we compare the impact of the two databases with respect to the calculation of annuity factors, issue that is of great importance in the insurance field. We choose this benchmark as it represents the pricing base of life-insurance contracts. To do so, we examine two popular yield curve datasets: the Daily Treasury Yield Curve2, and the time series posted in the Federal Reserve Board3. We calibrate all the models using panel methods. We apply this method to different maturities: 3- and 6-months and 1-, 2-, 3-, 5-, 7-, 10-, 20-, 30-years.Our results show that significant discrepancies on the estimation of temporary life annuities arise, due to both the difference between the different reference databases, and to the different calibration models.
Keywords: interest rate term structure modelling, annuity factors, machine learning techniques, nonlinear parametric models.

Friday, January 26^{th}, 2018

Session XV: Short Talk III (Aula 7)

26 Jan
11:30
Aula 7

A Portfolio Model for Minimizing Systemic Risk

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In this work we deal with a portfolio problem where the decision maker aims at minimizing the systemic risk of a set of interconnected countries. To this aim, given a set of countries, the economic agent optimally selects his exposure to sovereign and systemic risks. Systemic risk has gained increasing attention over the last years, since recent financial crisis made clear that it is of great relevance in this globalized and interconnected world. This type of financial risk is referred to the possibility that severe instability or collapse of one of the components of a financial system might lead to turmoils or the breakdown of the entire system. It is strongly related to the interconnectedness among individual elements. Indeed, recent financial crisis proved that the failure of a financial institution, even though not necessarily large in terms of total assets, can threaten the stability of the entire financial system, leading to serious negative effects on the real economy. Two different approaches have been proposed in the literature to face the issue of systemic risk. On one hand, market-based measures of systemic risk have been developed by Acharya (2016), Adrian and Brunnermeier (2016) and Tarashev et al. (2009). On the other hand, a large and fasting-growing literature focuses on the architecture of the financial system by using network analysis which plays a fundamental role for studying the instability properties of a system (see Acemoglu et al. (2015), Hale (2012), Upper (2011)). In this work, we follow the second approach. We estimate from daily time series of Sovereign CDSs spreads the daily default probabilities of the related countries. Data includes 13 European countries updated from June 2003 to June 2017. An empirical analysis has been developed in order to build a minimum systemic risk portfolio based on daily observations of sovereign CDSs quotes of the countries. We considered two different strategies: the long- and short-term ones. These two settings lead to different optimal portfolios. Since the onset of the financial crisis, the price of credit protection in the Euro area has increased substantially and systemic risks have grown more prominent. In late September 2008, the sovereign CDS market has attracted a considerable attention that, in May 2010, peaked in flight to safety episodes (Beber et al., 2008). Sovereign debt markets in several countries came under stress and massive sell-offs in government bonds were observed. For instance, CDSs spreads on Greek bonds jumped above 1,000 basis points. High CDSs quotes during

that period were interpreted not only as falling market liquidity, but also as concerns about an increasing number of credit rating downgrades (not necessarily as risk of principal losses on outstanding debt). Since the sovereign Euro crisis, CDSs spreads have been considered as warning signaling tools which may increase the perception of the governments credit riskiness and consequently systemic risk. Ang and Longstaff (2013) study the systemic risk component in sovereign credit spreads by comparing the CDSs issued in U.S.A. and those issued within the Eurozone. They find that the systemic component is larger among Eurozone sovereigns and is mainly determined by global financial variables. Caceres et al. (2010) assess that the relative weight of global risk aversion and country-specific risks changes with time. Whether local or global factors prevail mainly depends on the state of the economy. Augustin (2012) and Arghyrou and Kontonikas (2012) find that global factors prevail in good times and that local factors matter in bad times. Augustin and Tdongap (2016) confirm the existence of time-varying risk premia in sovereign spreads as a compensation for exposure to U.S. macroeconomic risk. The interconnections among countries are modelled through a network. In particular, we introduce the weighted clustering coefficient which is a network indicator measuring the level of cliquishness of the neighboring of a node, so it can be used as a good proxy of the risk level. In this regard, the clustering coefficient of the constructed network is taken as a proxy of the systemic risk of the network itself. Formally, a network is a graph, which is defined as a pair of sets, one collecting the nodes and the other containing the links (or edges). The links, eventually weighted, formalize the relationships among the nodes. The weight of an edge captures the "intensity"- defined by using a prefixed criterion - of the relationship among the nodes connected by the considered edge. The clustering coefficient is a local indicator of the network related to the single node and describes the structure of the neighbors around it. In fact, any non isolated node i is connected with other nodes of the network. In turn, such nodes are connected one with the others, so that there is the possibility of having one or more triangles around i. Hence, the maximum number of potential triangles around i depends on the number of nodes connected with i. As the number of existing triangles approaches the number of the theoretical ones, the neighboring around i becomes interconnected and, in some sense, stronger. Formally, the clustering coefficient of a node is defined as the ratio of the number of effective to the potential triangles, being then in [0; 1]. The definition has been also extended to weighted networks, where weights play a relevant role in assessing the structure around a node. We refers here to the clustering coefficient introduced by Onnela et al. (2003) and Onnela et al. (2005) and we extend it in a time-varying setting for the purposes of our analysis. In general, results reflect the financial and economic reality of the European countries in times of crisis, highlighting also the disparities among the members of European Union. In particular, the obtained results show that clustering coefficients as built here emphasize the main facts which characterize the European sovereign debt crisis and fly to safety episodes.
Keywords: Sovereign Risk, Systemic risk, Networks, Clustering Coefficient, Credit Default Swaps, Mean Absolute Deviation.

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26 Jan
11:45
Aula 7

Equal risk contribution portfolios for CVaR and CVaR-deviation risk measures

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Equal Risk Contribution (ERC), also called Risk Parity (RP), is a strategy for asset allocation that aims at equally sharing the risk among all the assets of the selected portfolio. In this paper we propose new developments of the ERC approach using Conditional Value-at-Risk (CVaR) and CVaR-Deviation as risk measures. Under appropriate conditions, we provide a way to ?nd CVaR and CVaR-Deviation ERC portfolios as solutions of a convex optimization problem. For asset allocation models, an important issue concerns the stability of the selected portfolios w.r.t. errors in the estimates of the input model parameters. This is a critical point, since the optimization phase in portfolio selection models tends to amplify these errors and thus cause instability of the optimal portfolio weights. We perform an analysis to examine the sensitivity to estimation errors of Minimum-Risk and ERC portfolios with CVaR and CVaR-Deviation, both on arti?cial and real investment universes. As expected, the estimation errors for the parameters needed to implement portfolio selection models, particularly those with CVaR, tend to rapidly increase with the number of assets in the market when the length of data is limited. Therefore, we also propose a way to tackle this issue representing the future assets returns by a simulation model called Historical Filtered Bootstrap. We then perform an empirical analysis to determine the best range for the number of simulated scenarios, taking into account the performances of the portfolios provided by the models, the sensitivity to input errors, and the computational burden.
Keywords: Portfolio Optimization, Risk Parity, Asset Allocation, Conditional Value-at-Risk, CVaR Deviation, Estimation Error.

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26 Jan
12:00
Aula 7

Estimation CARMA (p,q) model using financial data

Fabrizio Lilliu[1], Lorenzo Mercuri[2] and Andrea Perchiazzo[1]

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The aim of the paper is to present a new R Package for the estimation of a Lévy driven CARMA process. Referring to the literature of Brockwell (2001) and relying on the possibility to determine the characteristic function and consequently also the transition density of the process, the paper shows how it is possible to construct the Maximum Likelihood Estimation for a general Lévy CARMA (p,q) model and its package. In the case of a Gaussian CARMA, the transition density is itself Gaussian

and therefore mean and variance may be calculated easily through the property of a stochastic integral. While in the case of a general Lévy CARMA (p,q) model, the transition density can be determined through the Fourier transform. The paper shows the advantages that MLE should give in terms of reliability for a general Lévy driven CARMA process and for this reason, a new R package was developed. In addition, some cases of financial time series are taken into consideration for showing the potentiality of the package and its applications.
Keywords: CARMA model, MLE estimation, Transition density, Computational finance.

Copula-based study of the dependence structure between VIX and SP500

26 Jan
12:15
Aula 7

Fabio Bellini[1], Lorenzo Mercuri[2] and Edit Rroji[1]

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Copula-GARCH models are employed in the presence of multivariate time series as an alternative to the standard multivariate GARCH. In practice, for the univariate time series ARMA-GARCH models are used while the dependence structure of univariate innovation terms is described by means of a copula function. We compare the fitting of different copula-GARCH models that describe the dependence structure of S&P 500 logreturns with the changes in the levels of Volatility Implied Index (VIX). Starting from findings in the financial literature, we require that the candidate copula functions to be all able to reproduce two features: strong negative dependence and radial asymmetry. We replicate the analysis in three subsequent time interval in order to investigate temporal stability of results. We repeat the same analysis considering as implied risk index the interexpectile difference, computed from option prices and defined as a difference of two expectiles of the risk neutral distribution of the market index.
Keywords: Copula, Implied risk, Interexpectile difference.

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26 Jan
12:30
Aula 7

Asian options pricing under OrnsteinUhlenbeck dynamic

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Asian options are derivative contracts written on an average price. More precisely, the prices of an underlying security (or index) are recorded on a set of dates during the whole or part of the lifetime of the contract. These are popular among commodity derivative traders and risk managers. For example, Eydeland and Wolyniec [2003] explain how Asian options can play an important role in price risk management performed by local delivery companies in the gas market. In this paper, we implement pricing procedures for the case of a continuously monitored Asian call option with fixed strike when the underlying follows an exponential mean-reverting Ornstein-Uhlenbeck dynamics. This assumption is more realistic than the basic geometric Brownian motion, for example, in commodity markets where mean-reversion represents a stylized feature (see for example Bessembinder et al. [1995]). From a mathematical perspective, the problem turns out to be related to the sum of correlated lognormal random variables whose distribution in unknown and very complicated (see, for example, Dothan [1978] and Privault and Yu [2016], and references therein). Nevertheless, the moments of this distribution are known. We exploit this to first solve the pricing problem by implementing a moment matching procedure assuming a distribution for the sum of correlated lognormal random variables and, hence, estimating its parameters. In principle, every distribution that is unimodal and with a positive support can be considered; in this paper, we consider first some approximations previously introduced in the literature, i.e., lognormal (see Turnbull and Wakeman [1991]), gamma (see Milevsky and Posner [1998] and Chang and Tsao [2011]) and reciprocal gamma (see Milevsky and Posner [1998] and Lo, Palmer and Yu [2014]). We then investigate for the first time, to the best of our knowledge, the use of the Birnbaum-Saunders distribution as an alternative approximation. In all these cases, we consider both two and three parameter settings. The second approximation we propose is a lower bound based on approximating the exercise region with the more tractable geometric average. In particular, we retrieve the results of Rogers and Shi [1992] and Thompson [1998] when the underlying follows an Ornstein-Uhlenbeck process. In order to assess the accuracy of our proposed pricing procedures, we implement Monte Carlo strategies using the proposed approximations as control variates. Although the use of the lower bound as a control variate turns out to be straightforward, the implementation of a moment matched control variate is less trivial; we are currently working in this direction. Hitherto, numerical experiments show that our pricing procedures are accurate. The introduction of a third parameter allows increasing precision, but requires a larger computational effort as multiple numerical integration is required. The lower bound technique turns out to be the best trade-off between accuracy and computational effort. We conclude the paper by considering some extensions, in particular, augmenting the Ornstein-Uhlenbeck dynamics by jumps of normal sizes (Merton [1976]) and double

exponential sizes (Kou [2002]). We derive formulae for the first 3 moments and use the abovementioned distributional assumptions. Our numerical experiments suggest that the use of a third parameter is essential for higher accuracy as two-parameter approximations are unable to capture fat tails. Among the approximations considered, a shifted reciprocal gamma appears to be best-performing.
Keywords: Asian options, Pricing, Mean-reversion, Moment Matching, Lower bound, Jumps.

Session XVI: Short Talk IV (Aula 8)

Beating the market? A mathematical puzzle to market efficiency

26 Jan
11:30
Aula 8

Michael Heinrich Baumann

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The efficient market hypothesis is highly discussed - supported and criticized - in economic literature. In its weakest form it states that there are no price trends. When weakening the no-trending assumption only a little to arbitrary short and small and fully unknown trends, by use of control techniques it is very easy to construct trading strategies with zero initial investment and positive expected gain. Since even the trend's sign may be unknown, a possible trader does not have to think about predictable patterns etc. Even if compared to buy-and-hold strategies and adjusted for risk, the control-based strategies are preferable.
Keywords: Technical Analysis, Efficient Market Hypothesis, Robust Positive Expectation, Simultaneously Long Short Trading, Control-based Trading Strategies.

Risk aversion connectedness in five European countries

26 Jan
12:00
Aula 8

Andrea Cipollini[1], Iolanda Lo Cascio[1] and Silvia Muzzioli[2]

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In this paper we compute an aggregate index of risk aversion and indices of vulnerability and the contribution to systemic risk aversion for five European countries. The variance risk premium proxies risk aversion. The contribution to the literature is twofold. First, this is the first study estimating not only the common component, but also indices of directional connectedness among variance risk premia. Second, it is the first to estimate the interconnections by means of a FIVAR model, in order to account for long memory. Our analysis indicates measures of total and directional connectedness unlike those that would be obtained with the use of a short memory VAR. These differences arise when the focus is on market turmoil periods and on forecast horizons of thirty days. Future research evaluating spillovers among long memory series can benefit from our results. Policy-makers should take these interconnections into account when adopting effective macroeconomic policies.
Keywords: Variance risk premium, systemic risk aversion, long memory, Diebold and Yilmaz (2012), international spillovers, FIVAR.

Weak dependence and GMM estimation for supOU and mixed moving average processes

26 Jan
12:15
Aula 8

Imma Valentina Curato[1] and Robert Stelzer[1]

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We consider a mixed moving average process X driven by a Lévy basis and prove that is a weakly dependent process. Using this property, we show that sample mean and autocovariances of X have a limiting normal distribution. As an application, we can then use a Generalized Method of Moments estimation for the supOU process and the supOU stochastic volatility model after choosing a suitable distribution for the mean reverting parameter. For these estimators, we analyze the asymptotic behavior in detail.
Keywords: Weak dependence, Lévy Basis, Generalized method of moments, Ornstein-Uhlenbeck type process, Stochastic volatility.

On the consistency of real-world and risk-neutral probabilities: inversion in the risk ranking of investment portfolios

26 Jan
12:30
Aula 8

Annalisa Molino

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Risk-neutral probabilities are a powerful computational tool because they make possible to calculate every asset price by simply discounting its expected payoff at the risk-free rate. However their use turns out to be questionable in risk management. This paper deals with the problem of the consistency of real-world and risk-neutral measures in quantifying the risk of an investment portfolio. Under the assumption that the risk is measured by the variance of portfolio return, it is proved that it is almost always possible to get an inversion in the risk ranking, that is to find one portfolio that is more risky than a second one under the real-world measure but less risky under the risk-neutral one. Thus, the risk neutral measure may deliver not only misleading misleading, but even conflicting information with the real-world one. As an empirical application, efficient equity portfolios for which the risk-neutral probability inverts the risk ranking are estimated from options market prices and underlying returns.
Keywords: Risk neutral measure, efficient frontier, probabilistic scenarios.

POSTER SESSIONS

Thursday and Friday, January $25^{th} - 26^{th}$, 2018

Session 14:00-14:30, Aula 7 and Aula 8

Large deviations for method-of-quantiles estimators of one-dimensional parameters

25-26 Jan
14:00-14:30
Aula 7 and 8

Valeria Bignozzi[1], Claudio Macci[2] and Lea Petrella[3]

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We consider method-of-quantiles estimators of unknown parameters, namely the analogue of method-of-moments estimators obtained by matching empirical and theoretical quantiles at some probability level $\lambda \in (0, 1)$. The aim is to present large deviation results for these estimators as the sample size tends to infinity. We study in detail several examples; for specific models we discuss the choice of the optimal value of λ and we compare the convergence of the method-of-quantiles and method-of-moments estimators.

Keywords: Location parameter, methods of moments, order statistics, scale parameter, skewness parameter.

25-26 Jan
14:00-14:30
Aula 7 and 8

A dominance maximization approach to portfolio selection

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Portfolio selection is a typical decision problem under uncertainty, where the drivers of uncertainty are the asset returns. Generally, the aim is to choose the fractions of a given capital invested in each asset, such that the resulting portfolio return satisfies specific criteria. Starting with the seminal work of Markowitz [1952, 1959], the key problem in asset allocation is to select a portfolio with appropriate features in terms of gain and risk. Among academics and practitioners, different measures of gain (expected return, median return, absolute or relative wealth, etc.) and risk (variance, semivariance, MAD, CVaR, etc.) have been proposed. From a mathematical viewpoint, the synthetic indices that represent gain and risk (or other features) are modeled by functions of n real variables to be optimized simultaneously. This optimization phase represents the first step of the gain-risk analysis [see, e.g., Blay and Markowitz, 2013, Elton et al, 2009, Markowitz, 1959], where the efficient portfolios, namely the Pareto optimal solutions, are detected. Multiobjective optimization problems arise naturally when the decision process involves several (potentially) conflicting goals that must be taken into account simultaneously. Solving multiobjective programs usually consists in computing the Pareto optimal solution that best suites the decision maker; this is in general carried out by scalarization. Just with respect to the latter approach, it is hardly possible here to even summarize the huge amount of solution methods that have been proposed for multiobjective optimization. We only mention that solution methods are commonly grouped into four main categories: no-preference, a posteriori, a priori and interactive methods. We refer the interested reader to the fundamental Miettinen [2012] for both theoretical bases and review of the literature on multiobjective optimization. Among the Pareto optimal portfolios, one can adopt preference criteria with respect to risk (or gain). Generally, these criteria are introduced in the second step of the gain-risk analysis, where the risk aversion characteristics of the decision maker are specified and by which the optimal choice between efficient portfolios is made. Once the preferences of a decision maker has been modeled by a utility function $u(\cdot)$, the optimal portfolio must be the efficient portfolio with (exact or approximate) maximum expected utility [see Blay and Markowitz, 2013, Carleo et al, 2017, Markowitz, 2014, and references therein]. One of the main limitations of expected utility maximization is the subjective specification of a utility function. A way to overcome this issue is to use exact and approximate stochastic dominance (SD) relations [see Bruni et al, 2012, 2015, Roman and Mitra, 2009, and references therein]. Similarly to Ballestero and Romero [1996], in this paper we provide an alternative framework to the expected utility approach, resulting in a no-preference strategy that requires the solution of a nonlinear nonconvex single-objective reformulation of the original multiobjective problem. More precisely, we develop here

a portfolio selection method based only on the probabilistic features of the asset returns. To easily describe the rationale behind this no-preference approach, let us consider a portfolio selection problem with two objectives, a (convex) measure of risk $\rho_P(x)$ and one (concave) that represents gain $\gamma_P(x)$, where $x \in R^n$ is the vector of portfolio weights. Each feasible solution x identifies, in the objectives space (in this case the risk-gain plane), a rectangle defined by a reference point (e.g., the so-called nadir vector or the worst values of the objectives on the feasible region) and the point $(\rho_P(x), \gamma_P(x))$. Clearly, x dominates all the feasible points whose objective values belong to the rectangle. In the light of this consideration, we aim at computing a Pareto optimal solution that maximizes the area of the corresponding rectangle. This simple idea draws inspiration from the hypervolume paradigm (see, e.g., Auger et al [2009], Fleischer [2003] and Zitzler and Thiele [1998]), shares some conceptual similarities with other approaches (e.g., GUESS Buchanan [1997] and the method of the global criterion, see Miettinen [2012]), and can be classified as a particular instance of the single-objective approach that consists in maximizing the (weighted) geometric mean of the difference between the objective functions and the components of the reference point (see Audet et al [2008] and Lootsma et al [1995]). The distinctive and significant features of the resulting approach are further investigated: computing a (global) solution of the reformulation is not sensitive to the scaling of the objective functions and provides one with a (global) Pareto optimum of the original problem that *dominates the most* (in the sense of the area of the induced rectangle) with respect to the objectives space. Interestingly, this Pareto optimum has the nice property that any other feasible point (including all the other Pareto optima), for which any objective is improved (e.g., entailing a larger gain or a smaller risk w.r.t. the ones provided by our approach) by a factor, is such that the other objective must worsen by at least the same factor. As for the solvability issue, in general, one can not expect to solve globally a nonconvex single-objective program (like the one arising in our framework) in order to recover global Pareto optimal solutions. Surprisingly, as for our reformulation, any stationary point with a nontrivial positive value of the corresponding area turns out to be global optimal. Hence, one can employ any standard nonlinear algorithm, such as the projected gradient one, in order to make our approach practically viable. We provide some numerical results showing the significance of the computed Pareto optima also with respect to the solutions provided by other classical approaches. Moreover, as further development, we envisage that the peculiar nature of the approach makes it fit particularly well into the noncooperative scenario of multi-portfolio selection.
Keywords: Asset allocation, Portfolio (multiobjective) Optimization, Gain-risk analysis, No-preference methods, Nonlinear Programming.

25-26 Jan
14:00-14:30
Aula 7 and 8

Ostensible financial stability caused by wealth inequality: A preliminary report

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This article investigates ostensible financial stability of an economic sector caused by wealth inequality. When a sector is decomposed into two subsectors that possess a severe wealth inequality the sector in entirety can look financially stable while the two subsectors have opposite extreme financially instability, one from excessive equity the other from lack thereof. The unstable subsector can result in further financial distress and even trigger a financial crisis. The market instability indicator, an early warning system derived from dynamical systems is used to analyze the subsectoral financial instability of the system. An extreme case analysis is provided to explain what financial instabilities can arise amid seemingly stable economy and positive outcomes.
Keywords: Nonlinear dynamical system, agent-based model, financial instability contagion, wealth inequality.

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Housing market shocks in Italy: A GVAR approach

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In this paper, we use a Global Vector Autoregression (GVAR) model to assess the spatio-temporal mechanism of house price spillovers, also known as *ripple effect*, among 93 Italian provincial housing markets, over the period 2004-2016. To better capture the local housing market dynamics, we use data on both house prices and transactions volume. In particular, we focus on estimating to what extent exogenous shocks (e.g. negative housing demand shocks) arising from 10 Italian chief towns impact on their house prices and sales and how this shock spills over the housing market aggregates of neighbouring provinces. The negative structural housing market shocks are identified by using theory driven sign restrictions. The results show that the effects of the exogenous shocks to sales are much larger than the ones to house prices. Furthermore, the results from impulse response functions reveal evidence of a ripple effect on transactions volumes for almost all Italian provinces, while the house price spillovers show low magnitude, with the exception of Roma.
Keywords: House prices spillovers, ripple effect, housing market shock, Global VAR, sign restrictions.

Stability of calibration procedures: fractals in the Black-Scholes model

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Usually, in the Black-Scholes pricing theory the volatility is a positive real parameter. Here we explore what happens if it is allowed to be a complex number. The function for pricing a European option with a complex volatility has essential singularities at zero and infinity. The singularity at zero reflects the putcall parity. Solving for the implied volatility that reproduces a given market price yields not only a real root, but also infinitely many complex roots in a neighbourhood of the origin. The Newton-Raphson calculation of the complex implied volatility has a chaotic nature described by fractals.

Keywords: Black-Scholes, model calibration, Newton-Raphson method, implied volatility, fractal, Julia set.

BitCoin price and cross-exchange dependence

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The BitCoin is the first decentralised digital currency, which provides a solution to the problem of trust in a currency system (Tasca, 2015). It is based on an open source software which generates a peer to peer network. This network includes a high number of computers connected to each other through the Internet and complex mathematical procedures are implemented both to check the truthfulness of the transaction and to generate new BitCoins. Opposite to traditional transactions, which are based on the trust in financial intermediaries, this system relies on the network, on the fixed rules and on cryptography. The entire system is based on an open source software created in 2009 by a computer scientist known under the pseudonym Satoshi Nakamoto, whose identity is still unknown. The key innovation in BitCoin is its decentralized core technologies (Böhme et al., 2015). This system allows to have an independent currency, not subject to the control of central authority and without inflation. Recent literature claims BitCoin as a volatile stock and prove price changes are affected by sentiment/eagerness factors, Yermack (2013); Kristoufek (2015). Motivated by the evidences in the above quoted papers and the increasing interest in BitCoin derivatives, in Cretarola et al. (2017) the authors introduce a model in continuous time to describe both the dynamics of a BitCoin sentiment indicator and of the corresponding BitCoin price. An important issue

about BitCoin prices is that it is traded on different web-exchanges for different prices. In this paper we analyze the inter-dependence among prices in different exchanges in order to distinguish if there are leaders and followers exchanges; besides, we investigate whether statistical arbitrage strategies such as pair-trading are indeed possible by trading in different BitCoin exchanges.
Keywords: BitCoin, Asset price dynamics, dependence structure.

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Fuzzy Volatility Indices

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The measurement of volatility is of fundamental importance in finance. Standard market practice adopted for volatility estimation from option prices leads to a considerable loss of information and the introduction of an element of arbitrariness in the volatility index computation. We propose to resort to fuzzy regression methods in order to include all the available information from option prices and obtain an informative volatility index. In fact, the obtained fuzzy volatility indices do not only offer a most possible value, but also a lower and an upper bound for the interval of possible values, providing investors with an additional source of information. We also propose a defuzzification method in order to select a representative value within this interval. Moreover, we investigate the occurrence of truncation and discretization errors in the volatility index computation by resorting to an interpolation-extrapolation methodology. We also test the forecasting power of each volatility index on future realized volatility.
Keywords: Fuzzy volatility index, fuzzy regression methods, defuzzification method, volatility forecasting, implied volatility.

The maximum acceptable correlation for a defaultable guarantee: some numerical results

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The subject of this paper is the valuation of a defaultable guarantee. In this type of guarantee all the entities involved are exposed to default risk and these risks are correlated. Then, for pricing this kind of contract, it is necessary to model the dependence structure of the defaut times of the guarantor and of the borrower. As for the portfolio credit derivatives framework, we model the dependence by the copula functions. We highlight here some critical issues using the Gaussian and Student-T copulas when the marginals are exponential pdf with constant intensities of default. We show that, for some levels of the default intensities of the parties, we obtain that the up-front value of the guarantee is not monotonically decreasing when the default dependence between the guarantor and the borrower increases. In these cases, we detected a maximum acceptable correlation parameter, for which the Gaussian and Student-T copulas work appropriately, by varying the default intensities of the entities. Furthermore, in order to cover the entire range of default correlations, we propose to consider jumps in the dynamics of the default intensities, figured by the maximum acceptable correlation.
Keywords: Defaultable Guarantees, Counterparty Risk, Default Correlation, Copula Functions.

Hybrid statistical agent based model for financial market

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We intend to build hybrid statistical agent based model, which can be interchangeably used as statistical or agent based model. The interchanging between models solves the problem of validation, calibration, parameter estimation and simulation complexity, as they are only used when required. The empirically grounded agent based model, cluster the agents based on trading strategies using dynamic machine-learning method called smooth plaid clustering technique. The novel methodology maps trading strategies of all traders in a highly liquid, anonymous electronic market to find certain common strategies belonging to a particular cluster. This in turn describes behavior of agents who inhabit the new ecosystem of an anonymous electronic financial market. Then, In our empirically grounded hybrid statistical agent based model we examine the price dynamics by knocking out agent one by one.
Keywords: High Frequency Trading, Agent Based Model, Machine leaning, Mathematical Finance.

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Numerical solutions of integral equations: a weighted mean-value theorem approach

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Fredholm and Volterra integral equations, both of first and second kind, have practical application in many fields like as biology, medicine, and finance. Although there are various methods available in the literature for the search for analytical solutions, in most cases finding a solution in closed form is impractical and, for this purpose, several numerical methods have been proposed. Many papers in the literature have considered equations of the second kind. Indeed, it is usually the case that one can reduce integral equations of the first kind to those of second kind by means of the regularization method (see for example [5]). In recent years, several numerical methods have been proposed: Aziz et al. [3] proposed new algorithms based on Haar wavelets for the numerical solution of nonlinear Fredholm and Volterra integral equations of second kind; Doucet et al. [4] who considered the standard Von Neuman expansion of the solution of a Fredholm integral equation of second kind and approximate it by using a Markov chain Monte Carlo methods; a mean-value theorem approach has been recently proposed by Alturk [2] for the numerical solutions of linear and nonlinear Fredholm integral equations, Fredholm integro-differential equations, systems of linear and nonlinear equations. In this work, starting from the observation that an application of the mean-value theorem to Volterra integral equations produces a time-dependent quantity, we apply the mean-value theorem approach to solve linear and nonlinear Volterra integral equation both of first and second kind. Usually, a first application of this method does not produce a good approximation of the solution. We show that one obtains a not negligible error by applying one time the mean value approach to the second example (a Fredholm integral equation) in [6]. In order to obtain an accurate solution approximation, we propose successive trapezoidal numerical integrations. In order to test our method, we apply it to some examples in literature with known solution: one-dimensional and multi-dimensional settings are investigated. We observe that, after few iterations, a more accurate aproximate solution is obtained: the error between the exact and the approximate solution decreases rapidly. Furthermore, in order to show the flexibility of our method we test it on: (i) Voterra-renewal integral equations with space maps, and we show that our results are in line with those obtained by Annunziato et al. in [1]; (ii) Fredholm integral equations arising in asset-pricing problems. Also in this case our results are in line with the ones shown in [4].

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Keywords: Linear and nonlinear Fredholm integral equations, Linear and nonlinear Volterra integral equations, Weighted mean value theorem.

One dimensional time homogeneous stochastic differential equation with discontinuous coefficients

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How important are GSI banks for the financial distress in the Eurozone? An analysis based on MIDAS VAR

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In this paper, we examine the role of the Globally Systemic Important Banks, GSIB, located in Europe as a possible source of financial distress in eurozone. For this purpose we fit a MIDAS VAR to daily observation of individual bank CDS spread changes (a proxy of individual bank distress) and to the weekly observations of the CISS index constructed by ECB to proxy financial distress in the eurozone. Our findings show that, overall, GSIBs distress shocks account for 8.5% of the EZ financial stress variation at 4-week horizon, by averaging across different regimes, and, during the financial turmoil period, their impact raises above 10%. Moreover, the shocks in MIDAS VAR model explain a much larger part of the FEVD than those obtained by a traditional VAR model.
Keywords: Credit Default Swaps, Financial Stress Index, MIDAS VAR.

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Bounds for extreme risk taking in mean reverting and long memory interest rates

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Most market practitioners expect that when the interest rates level jumps due to a rare event it will eventually return to its average level once the situation restores. Practitioners' expectation is supported by the observations of the rates behaviour. The concept of mean reversion is not new and mean reverting property has been widely documented and applied in finance, especially to interest rates (see, e.g. Vasicek (1977)). One the one hand, there is vast economic literature that provides evidence of a strong link between the behaviour of interest rates and changes in macroeconomic variables (see e.g., Barro (2006), Colacito and Croce (2011), Gourio (2012)) suggesting how the rates movements affect the probability of default of the entire economy (see e.g., Divino (2013)). On the other hand, recent financial disasters emphasized the need for a deep investigation of the quantitative properties of long-run risks and related models. In particular, Farhi and Gabaix (2016) show that the probability of world disasters, as well as each countrys exposure to the possibility of rare but extreme events, creates joint fluctuations in exchange rates, interest rates, options, and stock markets. Central banks as well as most of the agents operating in the financial market are more and more interested in having information on the maximum (minimum) value that interest rates can reach. A main task is then to look for bounds of interest rates within defined tolerance thresholds, without being over controlled or forgoing desirable opportunities. Recently, Embrechts and Puccetti (2006a, 2006b) provide bounds on the distribution function of the sum of risks, when no information on the structure of dependence of the random vector is available. Bounds on risk measures for risk aggregation with dependence uncertainty are also studied in Bernard et al.(2014), Bernard and Vanduffel (2015) and Kou and Peng (2016). However, bounds for mean reverting processes have not been investigated in literature. The purpose of this paper is to provide bounds for interest rates processes with the attempt to contribute to give a quantitative explanation of risk exposures that affect the economy. This paper studies interest rates by means of Vasiceck processes, a class of processes that posses a suitable feature: the mean reversion. We derive the explicit density function for the supremum of the Vasiceck process. Then, we discuss the fractional Vasiceck process, a Gaussian process that allows for a realistic feature in interest rates: the long range dependence. We compute the variance of such process and derive bounds for the supremum of both Vasicek and fractional Vasicek interest rates processes.
Keywords: Interest rates, Vasicek, fractional Vasicek, extreme events, financial disasters long-run risks.

A revised approach to CIR short-term interest rates model: The CIR# Model

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It is well known that the Cox-Ingersoll-Ross (CIR) stochastic model to study the term structure of interest rates, as introduced in 1985, is inadequate for modelling the current market environment with negative short interest rates. Moreover, the diffusion term in the rate dynamics goes to zero when short rates are small; both volatility and long-run mean do not change with time; they do not fit with the skewed (fat tails) distribution of the interest rates, etc. The aim of the present work is to suggest a new framework, which we call the CIR# model, that fits well the term structure of short interest rates such that the market volatility structure is preserved as well as the analytical tractability of the original CIR model. It is worth noting that in the CIR# model the standard Brownian motion process is replaced with normally distributed standardized residuals of optimal ARIMA models suitably chosen.

Keywords: Interest rates forecasting, volatility, ARIMA models, simulation, jumps fitting, translation.

Selection of value at risk models for energy commodities

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The understanding of energy commodities price dynamics is crucial for producers, consumers and financial institutions. Short term fluctuations come from picks and drops in demand or supply causing time frame of high volatility and clustering. In the long run, their prices evolution sheds light on the health state of the world economy, revealing possible bubbles and stagnation periods. The matter is relevant also to the policy maker who adjusts his targets depending on their prices as energy is a major component in inflation rate indices. Besides being used in industrial applications, energy commodities are extensively traded in the markets for hedging strategies. Trading and financial firms widely use futures and options contract to offset their position against bear markets. Over the past decades a rich literature has flourished to propose techniques for measuring and quantify market risk. The most employed risk measure is the Value at Risk (VaR), defined as the

worst expected loss of an asset or a portfolio given a certain confidence level and over a specific time period. In this paper we investigate different VaR forecasts for daily energy commodities returns using GARCH [1], Generalized Autoregressive Score (GAS) [2] and the Conditional Autoregressive Value at Risk (CaViaR) [3] models. We further develop a Dynamic Quantile Regression (DQR) one where the parameters evolve over time following a first order stochastic process. All the models considered are selected employing the Model Confidence Set procedure proposed by [4] which provides a superior set of models by testing the null hypothesis of Equal Predictive Ability. Successively information coming from each model selected by the procedure is pooled together using a weighted average approach. The empirical analysis is performed on seven common energy commodities traded in the NYMEX such as, West Texas Intermediate crude oil (WTI), Brent crude oil, Heating oil #2, Propane, New York Harbor Conventional Gasoline Regular (NYHCGR), Ultra-Low-Sulfur #2 Diesel Fuel and Kerosene-Type Jet Fuel covering the period from November 07, 2002 to July 10, 2017. From the results obtained by applying the whole procedure we found, without claiming to be complete, that the quantile models approach i.e. the CaViaR representations and the DQR model outperform the others for all commodities time series considered both at 95% and 99% confidence level. This result is valid both for the models considered individually and for their combination. Moreover we show that pooling together the GARCH and the GAS models we achieve an improvement of the performances compared to each single model in terms of backtesting procedure.

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Keywords: Energy Commodities, Model Selection, GARCH, GAS, Quantile Regression.

The use of CVAR in statistical arbitrage pairs trading: An application to the Italian Banks' sector

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In this paper the focus is on the statistical arbitrage pairs trading, which makes use of the cointegration viewpoint. In the equity markets the trading consists in buying undervalued stocks and selling overvalued stocks in order to make a profit. However the true prices of stocks are hard to assess and forecast as there are a huge amount of random factors which influence them. The pairs trading overcomes this difficulty by using the idea of relative prices. The basis of relative prices are found in the financial Arbitrage Pricing Theory where a pair of stocks with similar characteristics should have the same prices. Whenever the prices of this pair are different, it means that one stock is overpriced and the other stock is underpriced. The hypothesis is that this pair is cointegrated and driven by a common stochastic trend. When modelling several unit root non-stationary time series jointly, the Error Correction Model or CVAR model is the main framework to describe the problem.
Keywords: Pairs trading, Error Correction Model, Italian banks' market.

A lattice based model for evaluating bonds and interest sensitive claims under stochastic volatility

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We propose a flexible lattice model for pricing bonds and interest sensitive claims under stochastic volatility, which is able to accommodate different dynamics specifications, and permits correlation between the interest rate and volatility diffusion. The model is based on the forward shooting grid method where the volatility process, as the primary state variable, is discretized by means of a recombining binomial tree. Then, the interest rate, as the auxiliary state variable, is discretized by attaching a subset of representative realizations to each node of the volatility lattice to cover the range of possible interest rates at each time slice. Finally, we develop a bivariate lattice presenting four branches for each node, where the joint probabilities for the possible jumps embed the correlation. Since the model works on representative interest rate values, a linear interpolation technique is used when solving backward through the lattice to compute the bond present value or the interest sensitive claim price.
Keywords: Interest sensitive claims, Stochastic volatility, Binomial algorithms.

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An entropic approach for risk neutral probabilities

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We study the application of entropy in finance. In probability and statistics quantities such as entropy and relative entropy are used to identify the behavior of the long sequence of random variables. Most of the theoretical and empirical studies in finance are aimed to improve the performance of the underlying model. The use of entropy for non-extensive systems based on a parametric generalization of the Boltzmann–Gibbs entropy. The parametric approach assumes a model for a risk-neutral distribution with a distribution free model, seeking an empirical risk-neutral distribution concurrent with properties of risk neutrality. When markets are complete the underlying asset prices are assumed to define a unique martingale. In the field of econophysics forecasting is a central problem and provides useful advance techniques for prediction of the future. In the theory of finance risk neutral probabilities plays very important role. In this article we consider the Hunt-Devolde semi-Markov regime switching interest rate model, and based on new entropy. We obtain risk-neutral probabilities using Lambert function and a new type of approach.
Keywords: Binomial Pricing, Black-Scholes Model, Risk Neutral Probability, Entropy Measures, semi-Markov Processes.

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Stocastic systemic LCOE with time varying-pricing schedule

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A methodological scheme to diversify the portfolio of generating technologies, through a Levelized Cost of Electricity (LCOE) analysis is explored in this research work, in order to minimize the cost and risk involved in the production of electricity. We investigate the cost effect of the time-varying pricing schedule when the intermittent renewable energy source is integrated into a dispatchable resourced based power system, under a stochastic systemic framework. The unpredictability of fossil fuel prices and the uncertainty in the environmental policies constitute the financial risk in the purely thermal technology portfolio. The fossil fuel is modeled using the mean-reverting Levy models, which captures the complicated behaviour in the observed dynamics of market prices; this ensured a more accurate computation of LCOE. The Conditional Value at Risk Deviation (CVaRD) measure is used to capture the tail risk in the systemic LCOE portfolio for the assessment of worst-case scenario. We observe that the inclusion of solar and wind components, which represent the riskless asset of the portfolio, shows a combined effect of extra cost and risk

reduction in the systemic frontier produced through the mean-CVaRD optimization approach. This research is useful for a policymaker in measuring the overall competitiveness of an energy system.
Keywords: LCOE, renewable energy, Conditional Value at Risk Deviation.

Volatility targeting using delayed diffusions

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A target volatility strategy (TVS) is a risky asset-riskless bond dynamic portfolio allocation which makes use of the risky asset historical volatility as an allocation rule with the aim of maintaining the instantaneous volatility of the investment constant at a target level. In a market with stochastic volatility, we consider a diffusion model for the value of a target volatility fund (TVF) which employs a system of stochastic delayed differential equations (SDDEs) involving the asset realized variance. Firstly we prove that, under some technical assumptions, contingent claim valuation on a TVF is approximately of Black-Scholes type, which is consistent with and supports the standing market practice. In second place, we develop a computational framework using recent results on Markovian approximations of SDDEs systems, which we then implement in the Heston variance model using an ad hoc Euler scheme. Our framework allows for efficient numerical valuation of derivatives on TVFs, whose typical purpose is the assessment of the guarantee costs of such funds for insurers.
Keywords: Target volatility, portfolio strategy, stochastic delayed differential equations, finite dimensional Markovian representation, stochastic volatility, guarantee costs, Euler scheme.

Can volatility models explain extreme events?

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This paper revisits several existing volatility models by the light of extremal dependence, i.e. serial dependence in extreme returns. First, we investigate the extremal properties of different high-frequency based volatility processes and show that only a subset of them can generate dependence in the extremes. Second, we corroborate the empirical evidence on extremal dependence in financial returns, showing that extreme returns present strong and persistent correlation and that extreme negative returns are much more correlated than positive ones. Finally, a large empirical analysis suggests that only models exhibiting extremal dependence and endowed with a leverage component can appropriately explain extreme events.
Keywords: Extremal dependence, Return predictability, Tail risk, Volatility models, Realized volatility.

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