

XVII Workshop on Quantitative Finance

Abstracts

Thursday, 28, January 2016.

9:00-10:30 PARALLEL SESSIONS

Mathematical Finance I (Sala Stemmi)

Peter Markowich, Panagiotis Souganidis, **Josef Teichmann** and Marie-Therese Wolfram.

Parabolic free boundary price formation models under market size fluctuations.

In this paper we propose an extension of the Lasry & Lions price formation which includes fluctuations of the numbers of buyers and vendors. We analyze the model in the case of deterministic and stochastic market size fluctuations and present results on the long time asymptotic behavior. Numerical simulations support and extend the theoretical statements and give further insights into price formation dynamics.

Matteo Burzoni, Marco Frittelli and Marco Maggis.

Model-free superhedging duality.

In a model free discrete time financial market, we prove the superhedging duality theorem, where trading is allowed with dynamic and semi-static strategies. We also show that the initial cost of the cheapest portfolio that dominates a contingent claim on every possible path, might be strictly greater than the upper bound of the no-arbitrage prices. We therefore characterize the subset of trajectories on which this duality gap disappears and prove that it is an analytic set.

Katia Colaneri, Claudia Ceci and Alessandra Cretarola.

The Föllmer-Schweizer decomposition under incomplete information.

In this paper we study the Föllmer-Schweizer decomposition of a square integrable random variable with respect to a given semimartingale S under restricted information. Thanks to the relationship between this decomposition and that of the projection of the random variable with respect to the given information flow, we characterize the integrand appearing in the Föllmer-Schweizer decomposition under partial information in the general case where the random variable is not necessarily adapted to the available information level. For partially observable Markovian models where the dynamics of S depends on an unobservable stochastic factor X , we show how to compute the decomposition by means of filtering problems involving functions defined on an infinite-dimensional space. Moreover, in the case of a partially observed jump-diffusion model where X is described by a pure jump process taking values in a finite dimensional space, we compute explicitly the integrand in the Föllmer-Schweizer decomposition by working with finite dimensional filters.

Risk I (Sala Azzurra)

Elisa Luciano and Antonella Tolomeo.

Information effects in longevity-linked vs purely financial portfolios.

Whenever a new financial product is offered by the financial industry, rational investors face a trade off between diversification benefits and costs of "getting to know" the newly introduced asset. A paramount example is offered by longevity-linked bonds. This paper considers investors who can decide either to pay a fee and separate the information on different risks affecting their asset value, or to remain uninformed and receive a non-separating signal. Uninformed investors optimally filter their pooled signal. The paper provides conditions under which diversification benefits are exploited, both when the investor decides to remain uninformed and when he does not. It also provides conditions under which investors diversify when fees are low, after having acquired information,

and remain undiversified when information fees are too high: they rationally prefer to remain undiversified, but to avoid information costs.

Wouter Heynderickx, Jessica Cariboni, Wim Schoutens and Bert Smits.

The Relationship between Risk-Neutral and Actual Default Probabilities: the Credit Risk Premium.

The relationship between the risk-neutral measure Q and the actual or real-world measure P , and the corresponding credit risk premium, are investigated in this paper. Quantifying and understanding the long-term average risk premium is important for a variety of financial applications and investment decision-making. This study develops an empirical analysis of this relationship, using CDS spreads of European corporates for estimating risk-neutral probabilities, and Moody's historical transition matrices to derive the corresponding actual values. Special attention is given to the recent financial crises and our study allows us to quantify its impact on risk premia. In line with some research based on pre-crisis data, we find that the ratio between the risk-neutral and actual default intensities, which we call the coverage ratio, is a convex and decreasing function of the actual default intensities. We are able to further differentiate between different time-horizons and conclude that current risk premia levels are still above their initial levels and this could indicate a permanent upward shift in risk premia. Finally, we link our results with the concept of Real Economic Value and its role in the bail-out of several European financial institutions.

Roberto Baviera, Gaetano La Bua and **Paolo Pellicoli**.

A note on CVA and Wrong Way Risk.

Hull and White approach to Wrong Way Risk in the computation of Credit Value Adjustment is considered the most straightforward generalization of the standard Basel approach. The model is financially intuitive and it can be implemented by a slight modification of existing algorithms for CVA calculation. However, path dependency in the key quantities has non elementary consequences in the calibration of model parameters. We propose a simple and fast approach for computing these quantities via a recursion formula. We show calibration methodology on market data and CVA computations in two relevant cases: a FX forward and an interest rate swap.

11:00-13:00 PARALLEL SESSIONS

Portfolio Selection (Sala Stemmi)

Francesco Cesarone, Renato Bruni, Andrea Scozzari and Fabio Tardella.

On Exact and Approximate Stochastic Dominance Strategies for Portfolio Selection.

Enhanced Indexation is the selection of a portfolio that should produce a return in excess to that of a given benchmark index. One recent and promising strategy for this task is the selection of portfolios that stochastically dominate the benchmark. Several types of stochastic dominance relations are known, but their practical application can be troublesome. We propose here a new type of approximate stochastic dominance relation that is more suitable for portfolio selection problems. We show that this relation is stronger than other existing approximate stochastic dominance relations, and we use it to find the portfolio that approximately stochastically dominates a given benchmark with the best possible approximation. Our model is formulated as an LP with exponentially many constraints. Nonetheless, we show that it has a theoretical polynomial time complexity through the equivalence of optimization and separation, and we propose an efficient constraint generation algorithm for its solution. We present some further improvements of stochastic dominance approaches. We evaluate the practical behavior of the selected portfolios with extensive empirical analyses on real and publicly available datasets, obtaining very good out-of-sample performances.

Flavio Angelini, Stefano Herzel and **Marco Nicolosi**.

Optimal Asset Allocation In Money Management Under Mean-Reverting Returns.

We find the optimal strategy for a performance related compensation in the presence of mean reverting returns. Our solution is determined by solving a system of Riccati equations and is based on a Laplace transform approach. We put together, and extend, the results by Basak et al. (2007), who solved our same problem under constant returns and by Watcher (2002), who determined the optimal portfolio choice for an investor with utility over consumption under mean-reverting returns.

Attilio Meucci, **Alberto Santangelo** and Romain Deguest.

Risk budgeting and diversification based on optimized uncorrelated factors.

We measure the contributions to risk of a set of factors, strategies, or investments, based on "Minimum-Torsion Bets", namely a set of uncorrelated factors, optimized to closely track the factors used to allocate the portfolio. We then introduce a novel definition of contributions to risk, which generalizes the "marginal contributions to risk", traditionally used in banks for risk budgeting and in asset management to build risk parity strategies. The Minimum-Torsion Bets allow us to also introduce a natural diversification score, the Effective Number of Minimum-Torsion Bets, which we use to measure and manage diversification. We discuss the advantages of the Minimum-Torsion Bets over the traditional approach to diversification based on marginal contributions to risk. We present two case studies, a security-based investment in the stocks of the S&P 500, and a factor-based investment in the five Fama-French factors.

Ambrogio Dalò, Rocco Ciciretti and Leonardo Becchetti.

Fishing the Corporate Social Responsibility Risk Factors.

Corporate Social Responsibility (CSR) is an increasingly relevant aspect in the current economic and financial scenario. It can be seen as supply side response to a growing demand from stakeholders who ask corporations to internalize externalities, even in absence of domestic and transnational regulation. A typical argument in the literature is that CSR reduces the risk of conflicts with stakeholders. In this paper we test the following hypothesis: i) are dimension specific CSR risk factors (WMB) independent from those traditionally considered in the asset pricing literature? ii) does exist a pricing anomaly related to a responsible behavior of the firm?, iii) the inclusion of a CSR risk factor in standard multifactor asset pricing models does eliminate the eventual pricing anomalies related to a socially responsible behavior? and, iv) does a multifactor model that include a CSR risk factor better able in explaining the cross section of expected returns? Our findings document that CSR represents an independent source of risk to which portfolios are exposed. We find that large stocks are more exposed than small stocks to this source of risk, and that a multifactor asset pricing model augmented with a CSR risk factor performs better in explaining the cross section of stock returns.

Interest Rates and Foreign Exchange (Sala Azzurra)

Anna Maria Gambaro, Laura Ballotta and Gianluca Fusai.

HJM multiple-curve model with time-changed Levy processes.

We propose a multiple-curve model, set in the Heath-Jarrow-Morton framework (Heath, Jarrow and Morton (1992)), with time-changed Levy processes. This paper is inspired by the work of Eberlein and Raible (1999) on Levy models, generalized in Crepey et al. (2014) to a multiple curve setting. To the best of our knowledge, no previous work presents a theoretically consistent no-arbitrage framework for pricing interest rate derivatives with time-changed Levy process. Moreover we apply these processes to a multiple-curve post crisis set-up. First of all, we build a term structure for zero coupon bonds and Libor FRA rates and we derive sufficient conditions to ensure the absence of arbitrage. The pricing of interest rate derivatives, as caps and swaptions, is developed using the Fourier transform method. Finally different choices for the construction of the driving process are examined and compared.

Stephane Dang-Nguyen and Yves Rakontondratsimba.

Generation of scenarios for the interest rates under the Arbitrage Free Dynamic Nelson-Siegel model.

The affine Arbitrage-Free Dynamic Nelson-Siegel (AFDNS) model introduced by Christensen, Diebold and Rudebusch (2007) provides a new interesting alternative framework for pricing and risk managing, as it both maintains the theoretical arbitrage-free restrictions of affine models and provides remarkably empirical properties. Our purpose in this paper is to provide the analysis and formulas required in the generation of scenarios for the interest rates at future time-horizons, under this mentioned AFDNS model.

Nicola Moreni and **Andrea Pallavicini**.

FX Modelling in Collateralized Markets: foreign measures, basis curves, and pricing formulae.

We present a general derivation of the arbitrage-free pricing framework for multiple-currency collateralized products. We include the impact on option pricing of the policy adopted to fund in foreign currency, so that we are able to price contracts with cash flows and/or collateral accounts expressed in foreign currencies inclusive of funding costs originating from dislocations in the FX market. Then, we apply these results to price cross-currency swaps under different market situations, to understand how to implement a feasible curve bootstrap procedure. We present the main practical problems arising from the way the market is quoting liquid instruments: uncertainties about collateral currencies and renotioning features. We discuss the theoretical requirements to implement curve bootstrapping and the approximations usually taken to practically implement the procedure. We also provide numerical examples based on real market data.

Elena Dumitrescu, Peter Hansen and Janine Balter.

Exchange Rate Volatility Forecasting: a Multivariate Realized-GARCH Approach.

We propose a model of exchange rates that jointly models associated realized measures of volatility and covariances within the Realized GARCH framework. The proposed model exploits identities arising from no arbitrage conditions, that facilitates a relatively parsimonious modeling of a panel of exchange rates. The model shares the simplicity of GARCH models while taking advantage of realized volatility measures that are computed from high-frequency (intraday) data. The latter leads to a better modeling of the variances and covariances, by providing a flexible modeling of their dynamic properties. The model easily produce forecasts at any horizon. The model is illustrated with an empirical application for exchange rates between the currencies: EUR, USD and JPY. An out-of-sample comparison shows that the proposed model dominates conventional benchmark models, in particular at shorter horizons.

14:00-15:00 POSTER SESSION

Leoni Eleni Oikonomikou.

Modeling Financial Market Volatility in Transition Markets: A multivariate case.

This paper presents evidence of linkages across equity markets in the following transition economies: Russia, Ukraine, Poland and Czech Republic from beginning of January 2005 till the end of December 2014. We apply a multivariate asymmetric EGARCH model. Empirical results indicate significant return and volatility spillover effects during the full sample and the Russian Great Recession and Ukrainian crisis episodes. These confirm that the equity markets in question became highly correlated during crises periods. Further, over the full sample period, there is evidence of return co-movements, and strong volatility persistence. During the Russian Great Recession sub sample, the own-return effects of the markets are stronger than the cross-market effects and their correlations have increased. Finally, the Ukrainian political crisis indicated no clear information producer, whereas, evidence of returns co-movement still exists. The markets in question are mainly partially integrated and the volatility transmission linkages across them are not that strong in crises periods, thus confirming previous literature on the particularities of emerging and frontier markets.

Stephane Dang-Nguyen and **Yves Rakotondratsimba**.

Control of price acceptability under the univariate Vasicek model.

The valuation of the probability of a financial contract to be lower or higher of a given price under the univariate Vasicek model is discussed in this paper. This price restriction can be justified by consistency reasons, since some prices may not be coherent on a financial point of view, e.g. they imply negative yields, or thought as unreachable by the asset manager. At first, assuming that the pricing functions is monotone, the price constraints are formulated in terms of a threshold on the value of the spot rate process. Since this process is Gaussian, these limits are reformulated in terms of a barrier of the Gaussian increments. Next, once the thresholds are identified, the probability to satisfy the price restriction after the generation of the spot rate at one future date can be computed. Then, assuming that the bounds on the spot rate are constant during a Monte-Carlo simulation, the probability of generating a path of this process that does not satisfy the constraint is valued using some results related to the hitting times. Lastly, the proposed approach is applied to various interest rates sensitive contracts and is illustrated by some numerical examples.

Gianluca Farina and Rosella Giacometti,

A model of infectious defaults with immunization.

This paper introduces a new model that takes inspiration from the approach of Davis and Lo (2001) but differentiates from it by relaxing the homogeneous assumption and by introducing few restrictions on the shape of the infection mechanism that allow for a good level of tractability. In particular, the contagion mechanism proposed is the result of two independent components: an infection attempt generated by defaulting firms and a failed defense from healthy ones. We provide an efficient recursive algorithm for the portfolio loss distribution similar, in spirit, to the one commonly used for CID (conditionally independent) models. A version of the model with a simplified parameter structure is then applied to the problem of pricing and hedging CDO instruments and its performance is compared to the standard one factor Gaussian model.

Domenico Di Gangi, Fabrizio Lillo and Davide Pirino,

Assessing Systemic Risk Due to Fire Sales Spillover Through Maximum Entropy Network Reconstruction.

Assessing systemic risk in financial markets is of great importance but it often requires data that are unavailable or available at a very low frequency. For this reason, systemic risk assessment with partial information is potentially very useful for regulators and other stakeholders. In this paper we consider systemic risk due to fire sales spillover and portfolio rebalancing by using the risk metrics defined by Greenwood et al. (2015). By using the Maximum Entropy principle we propose a method to assess aggregated and single bank's systemicness and vulnerability and to statistically test for a change in these variables when only the information on the size of each bank and the capitalization of the investment assets are available. We prove the effectiveness of our method on 2001-2013 quarterly data of US banks for which portfolio composition is available.

Immacolata Oliva,

Arbitrage-Free Pricing of American Contingent Claims in Uncertain Volatility Market Models.

In this paper we establish an explicit expression for the endpoints of an arbitrage-free prices interval for American contingent claims in financial markets characterized by uncertain volatility. We exploit the notion of G-expectation and the related Itô stochastic calculus on suitable stopping time intervals.

Piero Mazzarisi, Fabrizio Lillo and Stefano Marmi,

When panic makes you blind: a chaotic route to systemic risk.

Systemic risk refers to an instability involving the whole or a large component of the financial system, typically caused by a stochastic shock and exacerbated by interrelations between financial intermediaries. Systemic risk and systemic financial stability represent a problem of renewed interest after the financial crisis of 2007-2009. In recent years, several works have focused on different aspects of the same problem. Our contribution is to propose a dynamical systems approach to a challenging issue concerning the fact that financial markets are expectations feedback systems. Expectations about the future state of the financial system are part of the law of motion of the financial system itself, that is the expectations of future prices and risks influence today the agents' decisions and their portfolio choices. When a rational investor can correctly anticipate future volatility and correctly estimate portfolio adjustments according to its strategy, a financial market populated by such investors will be in a fixed point equilibrium. However, several recent publications have stressed how financial agents populating a financial market tend to be boundedly rational. Bounded rationality in portfolio choices may have crucial consequences on the aggregate behavior of all market participants and lead to the breaking of the fixed point equilibrium of the financial system. We investigate the role of the bounded rationality in financial markets in terms of systemic risk and systemic financial stability.

Elisa Mastrogiacomo and **Asmerilda Hitaj**,

Jump diffusions and portfolio optimization with state dependent risk aversion.

The main aim of this paper is to describe a portfolio optimization problem under state-dependent expected utility. Inspired by the recent results in Bjork, Murgoci and Zhou (2014), we analyze the mean-variance portfolio selection problem with state-dependent risk aversion. We consider a continuous time Lévy model consisting of two assets, one stock price with dynamics of jump-type and a bank account with constant risk-free rate. Since this problem is time inconsistent we approach it within a game theoretic setting and look for subgame perfect Nash equilibrium strategies. Under this approach an extension of the standard dynamic programming equation to a system of nonlinear PDEs is needed. More precisely, using comparison theorems for BSDEs with jumps we arrive at tractable

criteria for the solution of such games, in the form of a kind of non-Markovian analogue of the Hamilton-Jacobi-Bellman-Isaacs (HJBI) equation.

Michael Schneider, Fabrizio Lillo and Loriana Pellizzon,

Liquidity Dynamics and Illiquidity Cascades in the European Sovereign Bond Market.

We study the European sovereign bond market and the liquidity dynamics on its most important inter-dealer platform. We construct a condensed measure of liquidity at high frequencies and identify jumps in liquidity directly. Using Hawkes processes we estimate and describe the dynamics of illiquidity shocks to the market. This allows us to evaluate the impact of central bank interventions on market liquidity.

15:00-17:00 PARALLEL SESSIONS

Optimization (Aula Bianchi)

Salvatore Federico, René Aid, Huyen Pham and Bertrand Villeneuve.

Explicit investment rules with time-to-build and uncertainty.

We establish explicit socially optimal rules for an irreversible investment decision with time-to-build and uncertainty. Assuming a price sensitive demand function with a random intercept, we provide comparative statics and economic interpretations for three models of demand (arithmetic Brownian, geometric Brownian, and the Cox-Ingersoll-Ross). Committed capacity, that is, the installed capacity plus the investment in the pipeline, must never drop below the best predictor of future demand, minus two biases. The discounting bias takes into account the fact that investment is paid upfront for future use; the precautionary bias multiplies a type of risk aversion index by the local volatility. Relying on the analytical forms, we discuss in detail the economic effects. For example, the impact of volatility on the optimal investment is negligible in some cases. It vanishes in the CIR model for long delays, and in the GBM model for high discount rates.

Paolo Guasoni and **Antonella Tolomeo**.

Disentangling Overlapping Shocks in Portfolio Choice.

In a market where price shocks result from the sum of several mean-reverting shocks, this paper finds the optimal trading policies and their welfare for informed investors, who observe all individual shocks, and uninformed investors, who estimate them from the aggregate shock alone. All investors have constant relative risk aversion. When at least three shocks are present, uninformed investors ascribe more of the price change to shocks with lower frequency. Shocks that are uncorrelated for the informed are rationally perceived as negatively correlated by the uninformed, and their correlation weakens as the difference of their frequencies increases.

Claudio Fontana, Huy N. Chau, Andrea Cosso and Oleksii Mostovyi.

Optimal investment with intermediate consumption under no unbounded profits with bounded risk.

We consider the problem of optimal investment with intermediate consumption in a general semimartingale model of an incomplete market, with preferences being represented by utility stochastic fields. By building on the results of Mostovyi (2015), we show that the key duality relations of the utility maximization theory hold under the minimal assumptions of no unbounded profit with bounded risk (NUPBR) and of the finiteness of both primal and dual value functions.

Giorgia Callegaro, Mhamed Gaigi, Simone Scotti and **Carlo Sgarra**.

Optimal Investment in Markets with Over and Under-Reaction to Information.

In this paper we introduce a jump-diffusion model of shot-noise type for stock prices, taking into account over and under-reaction of the market to incoming news. We focus on the expected (logarithmic) utility maximization problem by providing the optimal investment strategy in explicit form, both under full (i.e., from the insider point of view, aware of the right kind of reaction at any time) and under partial information (i.e., from the standard investor viewpoint, who needs to infer the kind of reaction from data). We test our results on market data relative to Enron and Ahold. The three main contributions of this paper are: the introduction of a new market model dealing with over and under-reaction to news, the explicit computation of the optimal filter dynamics using an original

approach based on enlargement of filtrations and the application of the optimal portfolio allocation rule to market data.

Liquidity, Volatility and Trading I (Sala Azzurra)

Kim Christensen and **Roberto Renò**.

The Drift Burst Hypothesis.

The usual tenet that volatility dominates over the drift over short time intervals is not necessarily true when the drift term is locally explosive. The Drift Burst Hypothesis postulates the existence of such locally explosive drifts in the price dynamics. After describing the mathematical setting, embedded in the paradigm of traditional continuous-time finance, we introduce a nonparametric test for the presence of drift bursts. We propose a simple data generating process which is able to generate drift bursts endogenously, due to the presence of feedback traders. The empirical analysis shows that drift burst can usually be associated to “flash crashes”, and their occurrence rate is significantly large, and that drift bursts can be associated to higher volume, higher volatility and lower price impact.

Marcello Rambaldi, Emmanuel Bacry and Fabrizio Lillo.

The role of volume in order book dynamics: a multivariate Hawkes process analysis.

We show that multivariate Hawkes processes coupled with the nonparametric estimation procedure first proposed in Bacry and Muzy (2014) can be successfully employed to study complex interactions such as those observed in a limit order book. We demonstrate how this approach is amenable not only to analyze interplay between different order types (market orders, limit orders, cancellations) but also to include other relevant quantities such as the order size into the analysis. We apply this methodology to high-frequency order book data from the EUREX exchange. We first explore the interplay between different trade sizes and we then extend our model to the whole first level of the order book. We are able to identify several interesting features of this market at very short time scales.

Matthias Saerens, Cynthia Van Hulle and Gunther Wuyts.

Commonality in High-Frequency Trading.

High-frequency trading (HFT) accounts for an important percentage of trading volume in equity markets. In this paper, we focus on HFT in the cross-section of assets. In particular, we study whether it induces commonality across stocks. Using a sample of NASDAQ-listed stocks, we examine if there is a common factor in the intraday trading activity for this class of traders. Our findings indicate that there is indeed commonality in HFT across stocks, but that this is also true for non-HFT. A more detailed analysis shows that the exact difference between both groups of traders is complex and depends on the measure considered. Volume-based measures of HFT co-move more relative to non-HFT, while the reverse is true for imbalance-based measures. We interpret these results as consistent with the market making role of HFT, as well as with the fast taking and unwinding of positions resulting from other proprietary trading strategies.

Claudio Tebaldi, Fabio Trojani and Peter Gruber.

The Price of the Smile and Variance Risk Premia.

In a tractable stochastic volatility model, we identify the price of the smile as the price of the unspanned risks traded in SPX option markets. The price of the smile reflects two persistent volatility and skewness risks, which imply a downward sloping term structure of low-frequency variance risk premia in normal times. In periods of distress, the term structure is upward sloping and dominated by a high-frequency premium for jump variance. This dichotomy is consistent with the puzzling skew sensitivities of option markets with credit-constrained intermediaries and it builds a challenge for many reduced-form and structural models of stochastic volatility.

17:30-19:00 PARALLEL SESSIONS

Finance (Aula Bianchi)

Daniele Marazzina, Emilio Barucci and Gaetano La Bua.

Flow of funds, High Water Mark and asset allocation.

The effect of fund inflow/outflow on asset management is a hot research topic. In a path breaking contribution, Basak and co-authors show that inflows/outflows related to the performance of the fund with respect to that of a benchmark generate a risk shifting incentives in a finite range. This talk is based on two contributions. In the first one, we analyze the asset manager's portfolio problem when he is remunerated through a High Water Mark incentive fee and a management fee and the assets under management are characterized by in/outflow of funds. The presence of a flow fund induces risk in excess in case of a High Water Mark defined on the pure performance of the fund. Instead a High Water Mark defined on the assets under management leads to a more prudent investment strategy. In the second one, we study the case in which the manager's salary is based on the relative performance of the fund with respect to the benchmark. The dynamic of the fund is again affected by the presence of inflows and outflows: in fact, a positive performance induces an inflow to the fund, a negative performance causes an outflow. We provide analytical solutions, and we test how different levels of relative performance with respect to the benchmark affect the managers' risk-shifting incentives.

Marianna Brunetti, Rocco Ciciretti and Ljubica Djordjevic.

Till Mortgage Do Us Part: Refinancing Costs and Mortgage Shopping.

We show that the mortgage refinancing costs, which serve as a "lock-in" for mortgage holders, play an important role for mortgage shopping. Using a unique household panel dataset that enables us to infer individual bank switching, in conjunction with a legal reform that exogenously slashed down the refinancing costs, we find that the households responded to this change by increasingly shopping both for a mortgage (switching to take out a mortgage), and with a mortgage (switching to refinance an existing loan). Dissecting these results, we show that the effect of the reform was not uniform across households, with more educated individuals and those residing in less competitive markets being at the forefront of the wave of mortgage shopping.

Annalisa Fabretti, Tommy Garling, Martin Holmen and Stefano Herzel.

Convex Incentives in Financial Markets: an Agent-Based Analysis.

What is the influence of convex incentives, e.g. option-like compensation, on financial markets? We use agent-based simulations to replicate and extend the results of a laboratory experiment performed by Holmen et al. (2014). By replicating the experiment we identify some behaviors among participants which deviate from expected utility maximization and point out how they affected the outcomes of the experiment. By extending the simulations to a more general setting we show that convex incentives produces higher prices, lower liquidity and higher volatility. We also show that the influence of convex incentives on the decisions of the traders is much stronger than that of their risk preferences and that increasing the number of agents with convex incentives has a similar effect as that of increasing the inequality between agents' endowments.

Volatility (Sala Azzurra)

Elyas Elyasiani, Luca Gambarelli and **Silvia Muzzioli**.

Towards a skewness index for the Italian stock market.

The aim of this paper is twofold. First, to compare and contrast different measures of asymmetry of the Italian index options return distribution including the CBOE SKEW index formula adapted to the Italian market and a model-free measure based on the Faff and Liu (2014). Second, to investigate the sources of profitability of portfolio strategies (named skewness assets) based on the difference between the implied and realized third moment. This is in line with Bali and Murray (2013), who create three different portfolios (a PUT asset, a CALL asset, and a PUTCALL asset) in order to disentangle the contribution to the profitability of differences between the physical and the risk-neutral distribution that can be attributed to the left part, the right part or both sides of the distribution. The data set consists of FTSE MIB daily index options data and covers the time period January 2011-November 2014. We divide the sample into volatile (January 2011 - July 2012) and stable periods (August 2012 - November 2014): this allows us to contrast the pattern of skewness in the Italian stock index in different volatility periods.

Several results are obtained. First, the Italian SKEW index presents many advantages with respect to other asymmetry measures: it has a significant contemporaneous relation with market index returns and model-free implied volatility and is still a significant factor in explanation of market index returns, even after having controlled for model-free implied volatility. Second, there is a negative relationship between model-free implied volatility changes and changes in the Italian SKEW index indicating that an increase in model-free implied volatility is associated with a decrease in the Italian SKEW index (less negative risk neutral distribution). Third, in the Italian market, the SKEW index acts as a measure of market greed (the opposite of market fear), since returns react positively to an increase in the SKEW index; however the effect is asymmetric: returns react more negatively to a decrease in the SKEW index (increase in risk neutral skewness) than they react positively to an increase of the latter (decrease in risk neutral skewness). The results show that in the Italian market there exist a negative skewness risk premium: selling out-of-the-money puts and buying out-of-the-money calls is on average profitable. The skewness risk premium is higher in the low volatility period: in bullish market periods investors expect a more negatively skewed risk-neutral distribution than it is subsequently realized.

Claudio Pacati, **Gabriele Pompa** and Roberto Renò.

Smiling twice: The Heston++ model.

We recommend the addition of a deterministic displacement to multi-factor affine models to calibrate vanilla options on S&P500 and VIX derivatives jointly. The proposed model, labeled Heston++, calibrates both markets with an average relative error (on quoted implied volatilities over two years of data) of 2%, and a maximum relative error of 4%, without additional computational costs with respect to traditional affine benchmarks. Our empirical results also provide strong support for the presence of both price/volatility negatively correlated co-jumps and idiosyncratic jumps in the volatility dynamics.

Gaetano La Bua.

A Hybrid SLV model with Multifactor Stochastic Volatility.

The need for more satisfactory pricing models has brought the attention of researchers and practitioners on Stochastic Local Volatility models. Despite the growing interest on the topic, however, it seems that no particular attention has been paid to the use of multifactor specifications for the stochastic volatility part. The additional flexibility given by this kind of approach in describing the skew dynamics becomes extremely important when we deal with the pricing of forward volatility sensitive contracts like forward start or cliquet options. This paper tries to fill the gap: we introduce the Wishart Stochastic Local Volatility model that describes the stochastic volatility by means of a Wishart process as proposed in [11]. The goal of the new framework is twofold: adding a realistic volatility dynamics to Local Volatility models without the limitations of standard 1-factor Stochastic Volatility approaches, and improving European claims pricing performance of pure Wishart Stochastic Volatility model. The latter is quite relevant since we need to introduce stringent parameters restrictions to satisfy existence and uniqueness conditions for the solution of Wishart SDE. These conditions are required when we want to properly simulate the variance process in order to price more exotic derivatives. However such conditions are not usually met when market calibration is performed and so the resulting constrained parameters set is not able to reproduce accurately the market implied volatility surface. The additional Local Volatility component acts then as compensator. We further present an innovative simulation scheme for the asset path in the pure stochastic volatility specification based on the approach in [2]. The simulation scheme is also used to tackle the calibration of the so-called leverage function and price derivatives in the new hybrid framework.

Friday, 29, January 2016.

9:00-10:30 PARALLEL SESSIONS

Pricing (Sala Stemmi)

Lucio Fiorin, Giorgia Callegaro and Martino Grasselli.

Pricing via Quantization in Stochastic Volatility Models.

We provide the first recursive quantization based approach for pricing options in the presence of stochastic volatility. This method can be applied to any model for which an Euler scheme is available for the underlying price process and it allows to price vanillas, as well as exotics, thanks to the knowledge of the transition probabilities for the discretized stock process. We apply the methodology to some celebrated stochastic volatility models, including the Stein and Stein (1991) model and the SABR model introduced in Hagan and Woodward (2002). A numerical exercise shows that the pricing of vanillas turns out to be accurate; in addition, when applied to some exotics like equity-volatility options, the quantization-based method overperforms by far the Monte Carlo simulation.

Emanuele Nastasi and Roberto Baviera.

The relevance of geometry in optimal basket option bounds.

Optimal lower and upper bounds show interesting features even in the "elementary" Black-Scholes framework of n assets, whose log-prices are correlated via a correlation matrix ρ . These bounds can be obtained via a conditioning random variable Λ and, in general, are functions of the vector of correlations x between this variable and log-prices. This vector x belongs to a n -dimensional ellipsoid, a quadratic form determined by the inverse of the correlation matrix ρ . The identification of optimal x is crucial in numerical applications and in analytic approximations; in this paper we focus on non-negative ρ , a financially relevant case that characterizes some liquid option classes (as Asian options) and most baskets with equity stocks. We show how optimal bounds are related to some characteristics in the geometry of the problem and in particular to $\{\rho_i\}_{i=1,\dots,n}$, the column vectors of ρ . In a nutshell the main results are: i) for the lower bound we prove the existence of an optimal solution on the part of the ellipsoid delimited by the positive linear span of $\{\rho_i\}$; we also show some sufficient conditions for uniqueness of the global maximum ii) for the ICUB upper bound, $\{\rho_i\}$ are the only points where the bound has an angular point. In n dimensions for a ρ with a simple shape we prove that these points are local minima for the ICUB and this result looks to hold for a more general ρ . Furthermore for these points it is always possible to show that the associated partially exact comonotonic upper bound (PECUB) equals the ICUB.

Giulia Livieri, Giacomo Bormetti, Giorgia Callegaro and Andrea Pallavicini.

A backward Monte Carlo approach to exotic option pricing.

We propose a novel algorithm which allows to sample paths from an underlying price process in a local volatility model and to achieve a substantial variance reduction when pricing exotic options. The new algorithm relies on the construction of a discrete multinomial tree. The crucial feature of our approach is that – in a similar spirit to the Brownian Bridge – each random path runs backward from a terminal fixed point to the initial spot price. We characterize the tree in two alternative ways: in terms of the optimal grids originating from the Recursive Marginal Quantization algorithm and following an approach inspired by the finite difference approximation of the diffusion's infinitesimal generator. We assess the reliability of the new methodology comparing the performance of both approaches and benchmarking them with competitor Monte Carlo methods.

Liquidity, Volatility and Trading II (Sala Azzurra)

Michael Heinrich Baumann and Lars Grüne.

Positive Expected Feedback Trading Gain for all Essentially Linearly Representable Prices.

We study the simultaneous long short (SLS) feed-back trading strategy. This strategy is known to yield expected positive gain for zero start investment if the underlying stock returns are governed by a geometric Brownian motion or by Merton's jump diffusion model. In this paper, we generalize these results to a set of price models

called essentially linearly representable prices. Particularly, we show that the SLS trader's expected gain does not depend on the chosen price model but only on the risk-free interest rate and that it is always positive.

Damian Eduardo Taranto, Giacomo Bormetti, Jean-Philippe Bouchaud, Fabrizio Lillo and Bence Toth.

The Mixture Transition Distribution model for market impact and price dynamics.

Market impact is a key measure in the study of financial markets. For this reason several models have been proposed in literature. In this paper we review the linear models for the impact of order flow on prices, in particular the transient and the history dependent impact models. These models posit that the price at high frequency time scales is a linear combination of past realization of the order flow, weighted by propagator functions. The propagator function is the impact of past trades on the present price. Clearly, however, prices are influenced not only by the past order flow, but also by the past realization of returns. This is particularly evident in the case of large tick stocks, where the events of price change are very rare and very informative. In the first part of the paper we extend the transient impact model in order to take into account this effect, with the introduction of two propagator functions. This extension introduces a four states discrete random variable, which is the generalization of the order signs to the case of many events. We then propose the Mixture Transition Distribution framework, introduced originally by Raftery (1985), in order to model the joint dynamics of price and trades. This model represents a parsimonious approximation of a full high-order Markov chain. We propose two versions of the model: The first one has a small number of parameters and can be estimated via Maximum Likelihood. The second one has a large number of parameters and can be estimated by the Generalized Method of Moments and we prove that the optimization problem related to this estimation is convex. We show the results of the out-of-sample prediction of the previous models, and we conclude that the second version of model, despite the higher number of parameters, is able to better capture the dynamics of the markets without overfitting of the data.

Cecilia Mancini.

Truncated Realized Covariance when prices have infinite variation jumps.

The speed of convergence of the Truncated Realized Covariance (TRC) to the Integrated Covariation between the Brownian parts of two semimartingales is heavily influenced by the presence of infinite activity jumps with infinite variation (iV), through both the degree of dependence and the jump activity indices of the two small jumps processes. To show this, marginal stable-like small jumps with a parametric dependence structure are considered. The estimator is efficient in only some cases of iV jumps. The result of this paper is relevant in financial economics, since by the TRC it is possible to separately estimate the common jumps among two assets, which has important implications in risk management and contagion modeling.

11:00-13:00 PARALLEL SESSIONS

Risk II (Sala Stemmi)

Cagin Ararat and Birgit Rudloff.

Dual representations for systemic risk measures.

In the event of a financial crisis, it becomes important to measure and allocate the risk of a network of financial institutions. Such risk which takes into account the interconnectedness of the financial institutions is usually referred to as "systemic risk." This paper is concerned with a recent multivariate approach for measuring systemic risk where the state of the financial network is modeled as a random vector of individual equities/losses. Then, the systemic risk measure is defined as the set of all capital allocation vectors that make the "impact of the system to the society" acceptable. We present a dual representation theorem for the systemic risk measure and provide economic interpretations of the dual variables. As a special case, we consider a financial system with exponential aggregation mechanism, where the distances of the financial institutions with respect to the society are measured in terms of relative entropies.

Tommaso Colozza.

Synthetic and cash sovereign credit market: heading towards a unified European framework.

This paper investigates the price formation of credit risk premia across European sovereign countries. A metric of such premia is retrieved under the statistical measure using bootstrap techniques on hedging portfolios. This latter is retrieved in the cash-synthetic market by means of comparison to standard credit spreads vis-à-vis Germany. Price discovery is then analyzed in a VECM setting by means of lead-lag analysis. Discrepancies between the two credit metrics induces the CDS-bond basis, here defined as the spread of a benchmark rate on target hedged position. The basis is explained across a panel of four core and four non-core countries using idiosyncratic and common regressors. The retrieved unobserved fixed effects are then used as a metric for liquidity premia.

Jacopo Corbetta and **Ilaria Peri.**

Backtesting Lambda Value at Risk.

A new risk measure, the lambda value at risk (Λ VaR), has been recently proposed from a theoretical point of view as an immediate generalization of the value at risk (VaR). The Λ VaR appears to be attractive for its potential ability to solve several problems of the VaR. In this paper we propose three nonparametric backtesting methodologies for the Λ VaR which exploit different features. Two of these tests directly assess the correctness of the level of coverage predicted by the model. One of these tests is bilateral and provides an asymptotic result. A third test assesses the accuracy of the Λ VaR that depends on the choice of the P&L distribution. However, this test requires the storage of more information. Finally, we perform a backtesting exercise and we compare our results with the ones from Hitaj and Peri (2015).

Stefano Colucci and **Francesco Cesarone.**

A Quick Tool to forecast VaR using Implied and Realized Volatilities.

We propose here a naive model to forecast ex-ante Value-at-Risk (VaR) using a shrinkage estimator between realized volatility estimated on past return time series, and implied volatility extracted from option pricing data. Implied volatility is often indicated as the operators expectation about future risk, while the historical volatility straightforwardly represents the realized risk prior to the estimation point, which by definition is backward looking. In a nutshell, our prediction strategy for VaR uses information both on the expected future risk and on the past estimated risk. We examine our model, called Shrinked Volatility VaR, both in the univariate and in the multivariate cases, empirically comparing its forecasting power with that of two benchmark VaR estimation models based on the Historical Filtered Bootstrap and on the RiskMetrics approaches. The performance of all VaR models analyzed is evaluated using both statistical accuracy tests and efficiency evaluation tests, according to the Basel II and ESMA regulatory frameworks, on several major markets around the world over an out-of-sample period that covers different financial crises. Our results confirm the efficacy of the implied volatility indexes as inputs for a VaR model, but combined together with realized volatilities. Furthermore, due to its ease of implementation, our prediction strategy to forecast VaR could be used as a tool for portfolio managers to quickly monitor investment decisions before employing more sophisticated risk management systems.

Mathematical Finance II (Sala Azzurra)

Jiatu Cai, **Mathieu Rosenbaum** and **Peter Tankov.**

Asymptotic Lower Bounds for Optimal Tracking.

We consider the problem of tracking a target whose dynamics is modeled by a continuous Itô semi-martingale. The aim is to minimize both deviation from the target and tracking efforts. We establish the existence of asymptotic lower bounds for this problem, depending on the cost structure. These lower bounds can be related to the time-average control of Brownian motion, which is characterized as a deterministic linear programming problem. A comprehensive list of examples with explicit expressions for the lower bounds is provided.

Matteo Ludovico Bedini, **Rainer Buckdahn** and **Hans-Juergen Engelbert.**

Brownian Bridges on Random Intervals.

The issue of giving an explicit description of the flow of information concerning the time of bankruptcy of a company (or a state) arriving on the market is tackled by defining a bridge process starting from zero and conditioned to be equal to zero when the default occurs. This enables to catch some empirical facts on the behavior of financial markets: When the bridge process is away from zero, investors can be relatively sure that the default

will not happen immediately. However, when the information process is close to zero, market agents should be aware of the risk of an imminent default. In this sense the bridge process leaks information concerning the default before it occurs. The objective of this first paper on Brownian bridges on stochastic intervals is to provide the basic properties of these processes.

Giorgio Ferrari, Tiziano De Angelis and John Moriarty.

A solvable two-dimensional degenerate singular stochastic control problem with non convex costs.

In this paper we provide a complete theoretical analysis of a two-dimensional degenerate non convex singular stochastic control problem. The optimisation is motivated by a storage-consumption model in an electricity market, and features a stochastic real-valued spot price modelled by Brownian motion. We find analytical expressions for the value function, the optimal control and the boundaries of the action and inaction regions. The optimal policy is characterised in terms of two monotone and discontinuous repelling free boundaries, although part of one boundary is constant and the smooth fit condition holds there.

Asmerilda Hitaj, Lorenzo Mercuri and Edit Rroji.

Multivariate Mixed Tempered Stable Distribution.

The multivariate version of the Mixed Tempered Stable is proposed. It is a generalization of the Normal Variance Mean Mixtures. Characteristics of this new distribution and its capacity in capturing fat tails are discussed. This is an important feature, in particular, if we work with financial data. We introduce estimation and random-number generating procedures. The advantages of this new distribution are discussed and illustrated via simulation studies.

14:00-15:30 PARALLEL SESSIONS

Energy (Sala Stemmi)

Roberto Baviera and Teodoro Mainetti.

Going hybrid: a joint model for temperature and natural gas.

Natural gas spot prices and temperatures have been studied in detail in the literature as separate processes. We propose a simple joint model that, in spite of its parsimony, describes accurately many stylized facts of the two time series: in particular we show the role played by a time-delay parameter in order to take into account the impact of temperature forecast in cross-dependency. We discuss in detail a stepwise procedure in order to calibrate model parameters, describing the elementary estimation techniques involved and the statistical accuracy achieved. In the analysis we focus on the benchmark market in the U.S.A. (Henry Hub) and the temperatures in the Northeast and Midwest regions; we observe a negative, statistically significant, gas-temperature correlation in the cold season.

Marco Gallana, Enrico Edoli and **Tiziano Vargiolu**.

Optimal intra-day power trading with a Gaussian additive process.

The trading activity in Intra-Day (ID) electricity market has increased significantly over the last years. We study the problem of a financial agent wishing to maximize the expected utility of his/her terminal wealth when he/she operates in the ID market. Assuming that the price of traded hours follow an additive Ornstein-Uhlenbeck process, we derive the optimal strategy via the Hamilton-Jacobi-Bellman equation. In order to implement it, it is necessary to estimate the model parameters, and one cannot resort to known results, as the typical time series is unevenly time-spaced, with more and more transactions as the maturity approaches. We thus present an estimation procedure for unevenly spaced observations, based on maximum likelihood and a bootstrap bias correction to compensate the few observations at the beginning of the observation frame. Finally, we present a backtest and conclude.

Maren Schmeck.

Pricing options on forwards in energy markets: the role of mean reversion's speed.

Consider the problem of pricing options on forwards in energy markets. In Benthand Schmeck [3] an underlying spot price has been considered that highly fluctuates but also quickly mean reverts to its original level. In such a case, they found that fast mean reverting spikes do not matter in option pricing and that the Black 76 formula gives therefore a good approximation to options' prices. In this paper we study the impact of slowly mean reverting components in the spot price dynamics. We find both upper and lower error bounds for the option's price and hedging strategy. As a consequence, we show how mean reversion contributes to the option price.

Mathematical Finance III (Sala Azzurra)

Christa Cuchiero.

Polynomial processes in stochastic portfolio theory.

Inspired by volatility stabilized market models introduced by Robert Fernholz and Ioannis Karatzas [4], we characterize the class of polynomial diffusion models for the asset price process whose market weights process is again a polynomial diffusion process on the unit simplex. Explicit parameter conditions assuring the existence of relative arbitrages with respect to the market portfolio are given and the connection to non-attainment of the boundary is discussed. We also consider extensions to models with jumps and the computation of optimal relative arbitrage strategies.

Filippo Macaluso, Antonietta Mira and Paul Schneider.

How to sample from a distribution when only the moments are known with an application to affine financial model.

We develop a novel efficient simulation-based procedure to sample from a multivariate distribution when only its characteristic function is known, as often happens in financial applications. To achieve this goal, we combine two strands of the statistical literature: The first one is concerned with the approximation of the density ratio of the original target to an auxiliary measure by orthonormal polynomial series in weighted L_2 spaces, the second relates to simulation-based methods where the target density is not available and thus an approximation is used.)

Paolo Di Tella.

On the Chaotic Representation Property of Compensated-Covariation Stable Families of Martingales.

In the present paper, we study the chaotic representation property for certain families X of square integrable martingales on a finite time interval $[0, T]$. For this purpose, we introduce the notion of compensated-covariation stability of such families. The chaotic representation property will be defined using iterated integrals with respect to a given family X of square integrable martingales having deterministic mutual predictable covariation $\langle X, Y \rangle$ for all $X, Y \in X$. The main result of the present paper is stated in Theorem 5.8 below: If X is a compensated-covariation stable family of square integrable martingales such that $\langle X, Y \rangle$ is deterministic for all $X, Y \in X$ and, furthermore, the system of monomials generated by X is total in $L_2(\Omega, \mathcal{F}_T^X, \mathbb{P})$, then X possesses the chaotic representation property with respect to the σ -field \mathcal{F}_T^X . We shall apply this result to the case of Lévy processes. Relative to the filtration \mathcal{F}_L generated by a Lévy process L , we construct families of martingales which possess the chaotic representation property. As an illustration of the general results, we will also discuss applications to continuous Gaussian families of martingales and independent families of compensated Poisson processes. We conclude the paper by giving, for the case of Lévy processes, several examples of concrete families X of martingales including Teugels martingales.

16:00-17:30 PARALLEL SESSIONS

Pricing II (Sala Stemmi)

Andrea Romeo, Marina Marena and Patrizia Semeraro.

Pricing multivariate barrier reverse convertible with factor-based subordinators.

In this paper we study factor-based subordinated Lévy processes in their VG and NIG specifications, and focus on their ability to price multivariate exotic derivatives. Different model specifications, calibrated to a dataset of multivariate Barrier Reverse Convertibles listed at the Swiss market, show diverse ability in capturing smile patterns and recovering empirical correlations. We show how the range of the correlation spanned by the model is linked to the process marginal distributions. Our analysis finds that there exists a trade-off between marginal and correlation fit. A sensitivity analysis is performed, showing how the product's characteristics and the model's features affect Multi Barrier Reverse Convertible prices. Market and model prices are analyzed, highlighting and explaining discrepancies.

Cecilia Prosdocimi, Enrico Biffis and Benjamin Goldys.

A pricing formula for delayed claims: Appreciating the past to value the future.

We consider the valuation of contingent claims with delayed dynamics in a Black & Scholes complete market model. We find a pricing formula that can be decomposed into terms reflecting the market values of the past and the present, showing how the valuation of future cashflows cannot abstract away from the contribution of the past. As a practical application, we provide an explicit expression for the market value of human capital in a setting with wage rigidity.

Zorana Grbac, Laura Meneghello and Wolfgang Runggaldier.

Derivative pricing for a multi-curve extension of the Gaussian exponentially quadratic short rate model.

The recent financial crisis has led to so-called multi-curve models for the term structure. Here we study a multi-curve extension of short rate models where, in addition to the short rate itself, we introduce short rate spreads. In particular, we consider a Gaussian factor model where the short rate and the spreads are second order polynomials of Gaussian factor processes. This leads to an exponentially quadratic model class that is less well known than the exponentially affine class. In the latter class the factors enter linearly and for positivity one considers square root factor processes. While the square root factors in the affine class have more involved distributions, in the quadratic class the factors remain Gaussian and this leads to various advantages, in particular for derivative pricing. After some preliminaries on martingale modeling in the multi-curve setup, we concentrate on pricing of linear and optional derivatives. For linear derivatives, we exhibit an adjustment factor that allows one to pass from pre-crisis single curve values to the corresponding post-crisis multi-curve values.

Finance II (Sala Azzurra)

Carlo Sala and Giovanni Barone-Adesi.

Sentiment Lost: the Effect of Projecting the Empirical Pricing Kernel onto a Smaller Filtration Set.

Supported by empirical examples, this paper provides a theoretical analysis to show the impact of an improper calibration of the physical measure on the estimation of the empirical pricing kernel. While extracting the risk-neutral measure from option data provides a naturally forward looking measure, extracting the real-world probability from a stream of historical returns is only partially informative, thus suboptimal with respect to investors' future beliefs. In virtue of this disalignment, most of papers present in literature are then affected by the a homogeneity bias. From a probabilistic viewpoints, the missing beliefs are totally inaccessible stopping times on the coarser filtration set. As a consequence, an absolutely continuous local or strict local martingale, once projected on it, becomes continuous with jumps. As a result of a non fully informative physical measure, the proposed empirical pricing kernel is no longer a true martingale, as required by the classical theory, but a strict local martingale with consequences on the probabilistic nature of the relative risk-neutral measure. Finally we show how the implied options' moments help in reducing the degree of inaccessibility and shorten the distance between what is theoretically required and empirically accessible.

Maria Cristina Recchioni, Gabriele Tedeschi and Thomas Lux.

From bond yield to macroeconomic instability: a parsimonious affine model.

We present a hybrid Heston model with a local stochastic volatility to describe government bond yield dynamics. The model is analytically tractable and, therefore, can be efficiently estimated using the maximum likelihood approach. The contribution of the model is twofold. First, it captures changes in the yield volatility and predicts future yield values of Germany, France, Italy and Spain. This provides an early-warning indicator of instability phases in the countries investigated. Second, the model describes convergence/divergence phenomena among European government bond yields and investigate the countries' reaction to a common monetary policy dictated by the EONIA interbank rate.

Matteo Formenti, Luca Spadafora, Marcello Terraneo and Fabio Ramponi.

The efficiency of Anderson-Darling test with limited sample size size: an application to Backtesting CCR internal model.

This work presents a theoretical and empirical evaluation of Anderson-Darling test when the sample size is limited. The test can be applied in order to backtest the risk factors dynamics in the context of Counterparty Credit Risk modelling. We show the limits of such test when backtesting the distributions of an interest rate model over long time horizons and we propose a modified version of the test that is able to detect more efficiently an underestimation of the model's volatility. Finally we provide an empirical application.