### Scientific Committee

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## Organizing Committee

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Welcome

Welcome to the Third edition of the International Congress on Actuarial Science and Quantitative Finance. This year ICASQF is taking place in Manizales, Colombia on June 19—22, 2019. This event is organized by Sociedad Latinoamericana de Ciencias Actuariales y Finanzas Cuantitativas (SOLACFIN), Universidad Nacional de Colombia, Universidad EAFIT, Universidad del Rosario, Universidad Externado de Colombia, Universidad de Los Andes, and Asociación Colombiana de Actuarios (ACA) and sponsored by ADDACTIS Latina, Protección, Prectia and ICETEX. This third edition consolidates this biannual series of events as the referent in Actuarial Science and Quantitative Finance in Colombia, the Andean Region (Peru, Colombia, Venezuela, Ecuador and Bolivia) and the Caribbean Region with researchers from different parts of the world. This meeting is becoming the place to enhance relations between academic and industrial communities from Colombia and the Andean Region with the communities from North America and the rest of the world. Also, it is a fundamental objective of ICASQF to help as the meeting point for researchers and students to stimulate the growing interest in Actuarial Science and Quantitative Finance in Colombia, the Andean region and the Caribbean. SOLACFIN is the scientific and professional society created to administer ICASQF and increase relations between academic and industrial communities from Latin America.

The emphasis of the event is equally distributed between finance and actuarial science, and we take advantage of the opportunity for debates in these areas and related topics such as teaching, research, technical regulation and business practice in Andean and Caribbean regions, and its interrelation with the rest of the world.

The Congress will cover a variety of topics in Actuarial Science and Quantitative Finance, such as statistics and data mining techniques in Finance and Actuarial Science, numerical techniques in Finance, Portfolio Management, Derivative Valuation, Risk theory, Financial Mathematics and Life and Pension Insurance Mathematics, Non-Life Insurance Mathematics, and Economics of Insurance among others.

We are particularly proud to have with us recognized leaders in the areas of Actuarial Science and Finance. Invited speakers include Torben Andersen from Northwestern University, Soren Asmussen from Aarhus University, Peter Carr from New York University, Jacksa Cvitanic from Caltech, Bruno Dupire from Bloomberg LP, Morgens Steffensen from, University of
Copenhagen, Greg Taylor from University of New South Wales, Nizar Touzi from École Polytechnique, and Ruodu Wang from University of Waterloo.

Besides the plenary talks given by invited speakers, we include three short courses in Actuarial Science taught by Emiliano Valdez, Arthur Charpentier and Edward (Jed) Frees; we also include three short courses in Finance prepared by Julien Guyon, Mathieu Rosenbaum and Viktor Todorov and a contributed course by Javier Sandoval. We also include 32 contributed oral talks and 39 oral contributions presented in invited oral sessions and 13 poster presentations. Authors come from different corners of the world, and countries of origin include Australia, Austria, Brazil, Canada, China, Chile, Colombia, Denmark, France, Greece, Germany, India, Italy, Mexico, Peru, UK, USA, Spain and Switzerland. We received 78 contributions and 40 invited contributions. The selection process was the result of careful deliberations and 35 oral contributed presentations and 20 posters were accepted.

There are four oral presentations on Actuarial Science and five oral presentations on Quantitative Finance. We have made an important effort in including in the talks and course the point of view of practitioners; we hope that the impact of practitioners would become more relevant in future editions of ICASQF, and that this space would be important to discuss problems that arise in the industry with an academic perspective.

The complete review process was managed using the Conference Management Toolkit (CMT), sponsor by Microsoft Research. We are grateful to the professional team of Microsoft for its support.

We look forward to welcoming you at the third edition of ICASQF in Manizales.

Jaime A. Londoño
Chair Scientific Committee
ICASQF 2019
Short Courses
1.1 Advanced Predictive Models for Actuaries

Arthur Charpentier, Université du Québec à Montréal
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Abstract

We will spend some time here on the algorithmic side of machine learning techniques (LASSO and Ridge, Neural Network, Boosting, Bagging and Random Forests). We will also discuss the difference between GLMs and machine learning algorithms. Some specific techniques, important for actuarial applications, will also be discussed, such as classification in the context of unbalanced sampled some case studies will be discussed using R, with applications on insurance data.
1.2 Applied Financial Machine Learning Using Quantopian

Javier Sandoval, Universidad Externado de Colombia

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Abstract

This short course is based on the book Advances in Financial Machine Learning by Marcos López de Prado. The presentation will be divided into two sessions. The first session will emphasize on modern advances in the application of ML models to predict financial prices. We will cover statistical properties of financial data and stationarity transformations that avoid losing valuable information. The first part will also cover labeling for learning, Meta-Labeling and other methods to filter out false positives cases and scale our true positive predictions. Bagged classifiers and Random Forest will be used as the main ML techniques during the presentation. After covering all necessary theory, the second part will use Quantopian, a python-based IDE to apply and manipulate a specific trading strategy. This second part will focus on feature importance analysis to improve the algorithm’s performance and cross-validation in order to assess the generalization ability of the selected algorithm.

Target Audience: This course is intended to practitioners interested in applying machine learning techniques to trading. An intermediate or higher level of statistical learning and/or coding (Python) is desired.
1.3 Data Mining Techniques for Actuaries

Emiliano Valdez, University of Connecticut
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Abstract

Data mining involves the computational process of exploring and analyzing large amounts of data to uncover hidden and useful information. Such information is useful to process and efficiently reduce data into a more summarized, analytical representation. The ultimate goal of data mining is to be able to deliver predictive models applicable to new data. Predictive modeling is increasingly becoming an important function of an actuary in all areas of insurance: life, health, pensions, property and casualty. In this short course, we explore and describe the data mining tasks associated with supervised and unsupervised learning. There are generally four primary data mining tasks: association rule learning, clustering, classification, and regression. With each data mining task, we illustrate, using real data whenever available, its potential applications in actuarial science and in different areas of insurance. We further demonstrate the usefulness of these data mining techniques for actuaries to perform predictive analytics. Additionally, we briefly describe the emerging development of a new class of machine learning algorithms called deep structured learning. Some case studies will be discussed using R.

Keywords: data mining, statistical learning, supervised learning, unsupervised learning, deep learning, insurance applications.

Main reference:
1.4 Insurance Analytics and Ratemaking

Edward W. (Jed) Frees, Wisconsin School of Business,
University of Wisconsin
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Abstract

Analysts enjoy searching for patterns in data. But, without an identified goal, data analysis is just fun. This short course reviews the foundations of insurance data analysis with the purpose of setting insurance premiums, also known as ratemaking, as the target goal. Naturally, the techniques introduced can be used for many other business applications that will be described in the course.

This short course provides a fast-paced introduction to three components of insurance analytics: (i) statistical theory, (ii) data and data analysis, and (iii) the practice of ratemaking. The focus is on the linkages between these three. (1) Theoreticians want their approaches to be important and so their models should be calibrated with data and used in practice. (2) Data analysts want to take advantage of information in data, and so need strong foundations and real business problems they can solve. (3) Practical insurance managers need to mine the information available in modern large datasets but have some assurance that the methods being developed have strong foundations that will stand the test of time.

Participants may listen to lecture and see the demonstrations that will be given using the statistical package ‘R’. Moreover, with their own laptops, they may follow along interactively. Illustrative data, code, and links to other resources will be made available at the course website: https://sites.google.com/a/wisc.edu/insurance-analytics-and-ratemaking/

Target Audience: Practicing actuaries, students, and educators, interested in exposure to the foundations of insurance analytics.

Keywords: Insurance analytics, ratemaking, statistical distributions, estimation and model selection, regression analysis.
1.5 Nonparametric Inference Methods for Short-Dated Options

Viktor Todorov, Northwestern University
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Abstract

Options with short time to maturity, written on various underlying assets, are now actively traded on derivatives exchanges. The short time to maturity allows for deriving asymptotic expansions of the option prices as time approaches zero which can be readily applied to existing derivatives data. These expansions can be used to recover nonparametrically the spot characteristics of the underlying semi-martingale process, i.e., the stochastic volatility and the jump compensator/intensity.

In this talk, I present the main existing results on the topic and further discuss current open problems. I further illustrate various applications of the developed techniques for constructing “fear index” from options, volatility modeling and forecasting as well as for event study analysis.

Keywords: Asymptotic Expansions, Jumps, Nonparametric Inference, Options, Semimartingale, Stable convergence, Stochastic Volatility.
1.6 Rough Volatility: From Theory to Practice

Mathieu Rosenbaum, École Polytechnique

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Abstract

Rough volatility is now considered a stylized fact of financial data, both in the historical and the risk-neutral world. This means that the (log-)volatility process behaves as a fractional Brownian motion with very small Hurst parameter.

However, these non-Markovian models lead to some new technical challenges in practice. In these lectures, we aim at presenting various aspects of rough volatility modeling: Pricing, hedging, microstructural foundations, arbitrage issues and simulations.
1.7 The Particle Method for Smile Calibration

Julien Guyon, Bloomberg LP

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Abstract

The calibration of models to market smiles is a crucial issue for risk management in finance. This used to be done by running time-consuming optimization routines. In this short course we will show how particle methods very efficiently solve a wide variety of smile calibration problems, without resorting to any optimization:

- Calibration of the local volatility model with stochastic interest rates
- Calibration of stochastic local volatility models, possibly with stochastic interest rates and stochastic dividend yield
- Calibration to the smile of a basket of multi-asset local volatility-local correlation models, possibly with stochastic volatility, stochastic interest rates, and stochastic dividend yields
- Calibration of path-dependent volatility models and path-dependent correlation models
- Calibration of cross-dependent volatility models

The particle method is a Monte Carlo method where the simulated asset paths interact with each other so as to ensure that a given market smile (or several of them) is fitted. PDE methods typically do not work for these high-dimensional models. The particle method is not only the first available exact simulation-based method for smile calibration. It is also robust, easy to implement, and fast (as fast as a standard Monte Carlo algorithm), as many numerical examples will show. As of today, it is the most powerful tool for solving smile calibration problems. Icing on the cake: there are nice mathematics behind the scenes, namely the theory of McKean stochastic differential equations, propagation of chaos, and a new Malliavin « disintegration by parts » formula.
**Keywords:** smile calibration, Monte Carlo, particle method, stochastic local volatility, stochastic interest rates, stochastic dividends, local correlation, path-dependent volatility, cross-dependent volatility, McKean stochastic differential equations, propagation of chaos.
Plenary Talks
2.1 Adding Optionality

Peter Carr, NYU

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Abstract

Optionality arises when an investor is able to choose between the more valuable of two alternatives in the future. We present a new way to value optionality via change of arithmetic. We illustrate with both European and Bermudan optionality.

Keywords: Option Pricing, Bermudan options.
2.2 An Axiomatic for the Expected Shortfall

Ruodu Wang, University of Waterloo

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Abstract

The Value-at-Risk (VaR) and the Expected Shortfall (ES) are the two most popular risk measures used in banking and insurance regulation. In particular, according to the recent Basel Accords, ES replaces VaR as the standard risk measure for market risk in the banking sector. The class of VaR as quantile functions has been characterized in the literature with several different sets of economic axioms, whereas the class of ES, although being coherent risk measures, does not have an axiomatic foundation yet. We propose four simple and intuitive economic axioms to uniquely characterize an ES. In particular, the novel notion of (weak) comonotonicity play a significant role in the formulation of the axioms. Our results provide the economic foundation for using the risk measure Expected Shortfall as the globally dominating regulatory risk measure currently employed in Basel III/IV.

Keywords: axioms, value-at-risk, expected shortfall, Basel, regulation.
2.3 Characterization of Attainable Contingent Claims as an Application of the Functional Ito Calculus

Bruno Dupire, Bloomberg LP

Abstract

Attainable claims have the property that their price does not depend on a model as they can be replicated. We briefly review the Functional Ito Calculus and show how it can be used to identify the contingent claims that can be written as a) a stochastic integral of the stock price, b) a static position in European options, c) a combination of the two. It provides an algorithm that gives the decomposition and we apply it to a variety of cases. Even if a claim is not attainable we can use the approach to ascertain how hedgeable it is.
2.4 Claim Models: Granular and Machine Learning Forms

Greg Taylor, School of Risk and Actuarial Studies, University of New South Wales

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Abstract

The purpose of the presentation is to survey recent developments in granular models (“GMs”) and machine learning models (“MLMs”) for loss reserving, and to compare the two families with a view to assessment of their potential for future development. The history of these types of model is briefly discussed. The general basis for assessment of a predictive model is considered and applied to GMs and MLMs. Thus, the relative merits of these two categories discussed, as are the factors governing the choice between them and the older, more primitive models. Concluding sections briefly consider the possible further development of these models in the future.
2.5 Continuous Time Principal Agent and Optimal Planning

Nizar Touzi, Ecole Polytechnique

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Abstract

Using representation results from second order backward SDEs, we provide a general solution approach to continuous time Principal Agent problems, thus extending the line of argument in Sannikov. The main result reduces the last Stackelberg stochastic differential game to a standard stochastic control problem. The same technique allows also to formulate the optimal planning problem in mean field games as an optimal transport problem along controlled McKean-Vlasov dynamics.

Keywords: contract theory, principal-agent problem, stochastic control of path-dependent systems.
Abstract

A standard model in non-life insurance is that the Poisson rates at which customers in a portfolio generate claims form an i.i.d. sample from some distribution. Based on this, we determine the portfolio size for a given premium in a market with only one company when customers use a utility-based criterion for choosing whether to insure or not. This is then applied to ruin probability minimization. Similar ideas are used for the competition between two companies and applied to determine Nash- or Stackelberg equilibrium premium strategies. The market may either be frictional with Bayesian preferences or involve product differentiation.

The talk is based on joint work with Bent Jesper Christensen, Michael Taksar and Julie Thøgersen.
2.7 Optimal Fund Menus

Jaksa Cvitanic and Julien Hugonnier, Caltech

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Abstract

We study the optimal design of a menu of funds by a manager who is required to use linear pricing and does not observe the beliefs of investors regarding one of the risky assets. The optimal menu involves bundling of assets and can be explicitly constructed from the solution to a calculus of variations problem that optimizes over the indirect utility that each type of investor receives. We provide a complete characterization of the optimal menu and show that the need to maintain incentive compatibility leads the manager to offer funds that are inefficiently tilted towards the asset that is not subject to the information friction.

Keywords: Mutual fund menus, screening, linear pricing, closet indexing
2.8 Option-Bases Tail Risk Measures and Return Predictability in Global Equity Markets

Torben Andersen, Northwestern University

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Abstract

We explore the pricing of tail risk as manifest in equity-index options across international markets. We develop fully parametric as well as nonparametric option-based tail measures, without imposing strong assumptions on the underlying objective equity return dynamics. We document that the risk premium associated with negative tail events displays persistent shifts, unrelated to volatility. This tail risk premium is a potent predictor of future equity returns, while option-implied volatility only forecasts the future return variation. Hence, compensation for negative jump risk is the primary driver of the equity premium across all indices, whereas the reward for pure diffusive variance risk is largely unrelated to future equity returns. We also document pronounced commonalities, suggesting a high degree of integration among the major global equity markets.

Keywords: Equity Risk Premium, International Option Markets, Return Predictability, Tail Risk, Variance Risk Premium, Market Integration
2.9 Three Small Epiphanies

Mogens Steffensen, University of Copenhagen

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Abstract

We discuss, on a principle rather than a technical ground, three instances where things are perhaps not the way you thought they were – with potential impact, theoretically or practically. 

a) In life-cycle portfolio choice, does one really need to take realized capital gains into account, or are age-based investment rules doing the job? b) In time-consistent mean-variance portfolio optimization, is normalization of the variance by current wealth really the ‘right’ thing to do, or is there a ‘better’ normalization? c) In multi-state models frequently used in life insurance and credit risk, does there exist such a thing as a set of forward transition rates?

Keywords: Deterministic investment profiles; normalization of variance; forward rates and forward transition rates
Invited Sessions
Inhomogeneous Phase-Type Distributions and Heavy Tails

Hansjoerg Albrecher, Universite de Lausanne, Morgens Bladt, University of Copenhagen

Abstract

We extend the construction principle of phase-type (PH) distributions to allow for inhomogeneous transition rates and show that this naturally leads to direct probabilistic descriptions of certain transformations of PH distributions. In particular, the resulting matrix distributions enable to carry over fitting properties of PH distributions to distributions with heavy tails, providing a general modelling framework for heavy-tail phenomena. We also illustrate the versatility and parsimony of the proposed approach for the modelling of a real-world heavy-tailed fire insurance data set.
A Rationale for Benchmarking in Money Management

Fernando Zapatero, University of Southern California, Juan Sotes-Paladino, University of Melbourne

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Abstract

We analyze the optimal linear compensation of a privately informed fund manager absent moral hazard considerations. Contrary to previous research, we show that including a benchmark-adjusted component benefits investors when the parties exhibit different risk preferences. Linear benchmarking aligns the manager’s and investors’ optimal portfolios without altering the manager’s desired payoff profile. Since managers do not have to be compensated for choosing an undesired level of risk, the optimal benchmark allows investors to realize almost the full value of the manager’s private information at low cost. The optimal benchmark portfolio differs substantially from the unconditionally optimal portfolio that investors would choose under self-management. Under certain conditions, including a benchmarking component in a linear contract is not only optimal but necessary for active management to add value over passive alternatives. Our findings hold for simple passive benchmarks even in the absence of trading restrictions.

Keywords: Portfolio delegation, benchmarking, fulcrum fees, asymmetric information.
Linking Dividends and Capital Injections
A Probabilistic Approach

Jevgenijs Ivanovs, Aarhus University
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Abstract

In the context of collective risk theory, we give a sample path identity relating capital injections in the original model and dividend payments in the time-reversed counterpart. We exploit this duality to provide an alternative view on some of the known results on the expected discounted capital injections and dividend payments for risk models driven by spectrally negative Lévy processes. Furthermore, we present a probabilistic analysis and simple resulting expressions for a model with two dividend barriers, which was recently shown by Schmidli to be optimal in various Lévy risk models when maximizing the difference of dividend payments and injections in the presence of tax exemptions.

Keywords: Lévy processes; two-sided reflection; dividend strategies.
The Optimal Control of Government Stabilization Funds

Abel Cadenillas, University of Alberta

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Abstract

We study the optimal control of a government stabilization fund, which is a mechanism to save money in the good economic times to be used in the bad economic times. We obtain the optimal band for the government stabilization fund.

Keywords: Government stabilization fund, stochastic control.
3.2 Organized by Alexander Aue

On Scaling in High Dimensions

Gustavo Didier, Tulane University; Patrice Abry, ENS Lyon; B.C. Boniece, Tulane;
Herwig Wendt, University of Toulouse

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Abstract

Scaling relationships have been found in a wide range of phenomena that includes coastal landscapes, hydrodynamic turbulence, the metabolic rates of animals, Internet traffic and finance. For scale invariant systems, also called fractals, a continuum of time scales contributes to the observed dynamics, and the analyst’s focus is on identifying mechanisms that relate the scales, often in the form of exponents. In this talk, we will look into the little explored topic of scale invariance in high dimensions, which is especially important in the modern era of “Big Data”. We will discuss the role played by wavelets in the analysis of self-similar stochastic processes and visit recent contributions to the wavelet modeling of high- and multidimensional scaling systems. Connections with fractional cointegration will also be considered.

Keywords: High dimensions; wavelets; scale invariance; fractals.
Abstract

Estimation of the asymptotic variance of a time-average, which is known as the time-average variance constant (TAVC), or long run variance, is important for many statistical procedures involving dependent data. However, the estimation of TAVC is difficult as its performance relies heavily on the choice of a bandwidth parameter. Specifically, the optimal choices of bandwidth of all existing estimators depend on the TAVC itself and another unknown parameters which is very difficult to estimate. Thus, the optimal estimation of TAVC is not achievable. In this paper, by introducing a novel concept of converging kernel, we develop a new class of TAVC estimators in which the optimal bandwidth is free of unknown parameters and hence can be computed easily. Moreover, we prove that the new estimator has a constant risk asymptotically, in contrast to the exploding risk in the existing estimators.

Keywords: Asymptotic variance; bandwidth selection; kernel estimator; locally asymptotically minimax; long-run variance; tuning-free
The Short-Run and Long-Run Components of Financial Market Volatility

Giovanni Motta, Pontificia Universidad Catolica de Chile; Norbert Metiu, Bundesbank

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Abstract

We introduce a novel semi-parametric model which captures the volatility common to a large panel of financial variables by a small number of common volatilities. Each common volatility is decomposed into the product of two distinct components which display different degrees of persistence. The first component, modeled as a latent-factor GARCH-process, reflects short-run volatility dynamics. The second component modeled as an “evolutionary” slowly evolving function of time reflects long-run volatility dynamics. The long-run component, which we call the financial cycle, captures persistent movements in volatility associated with changes in long-run risks. We develop a semi-parametric estimation theory, and the finite-sample performance of our estimators is investigated considering a variety of simulation scenarios. Our empirical illustration shows that the bulk of the variation in 157 monthly U.S. financial variables is captured by a single common factor. The short-run volatility of this factor gauges widely used proxies of risk and uncertainty in financial markets, such as credit spreads and the VIX index, while its long-run volatility reaches elevated levels around major financial crises.

Keywords: Heteroskedastic factor models; Local Stationarity; International Equity Markets; International portfolio diversification; Financial cycle.
Optimal Investment, Derivative Demand and Arbitrage under Price Impact

Scott Robertson, Questrom School of Business, Boston University; Michalis Anthropelos, Department of Banking and Financial Management, University of Piraeus; Konstantinos Spiliopoulos, Department of Mathematics and Statistics, Boston University

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Abstract

We study the optimal investment problem with random endowment in an inventory-based price impact model with competitive market makers. Our goal is to analyze how price impact affects optimal policies, as well as both pricing rules and demand schedules for contingent claims. For exponential market makers preferences, we establish two effects due to price impact: constrained trading, and non-linear hedging costs. To the former, wealth processes in the impact model are identified with those in a model without impact, but with constrained trading, where the (random) constraint set is generically neither closed nor convex. Regarding hedging, non-linear hedging costs motivate the study of arbitrage free prices for the claim. We provide three such notions, which coincide in the frictionless case, but which dramatically differ in the presence of price impact. Additionally, we show arbitrage opportunities, should they arise from claim prices, can be exploited only for limited position sizes, and may be ignored if outweighed by hedging considerations. We also show that arbitrage inducing prices may arise endogenously in equilibrium, and that equilibrium positions are inversely proportional to the market makers’ representative risk aversion. Therefore, large positions endogenously arise in the limit of either market maker risk neutrality, or a large number of market makers.

Keywords: Optimal Investment; Price Impact; Equilibrium; Constrained Trading; Demand Schedules
Random Concave Functions

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Abstract

Spaces of convex and concave functions appear naturally in applications. For example, convex regression and log-concave density are important in statistics. In stochastic portfolio theory concave functions measure the concentration of capital, and their gradient maps define novel investment strategies. The gradient map may also be regarded as an optimal transport map. In this work we construct and study probability measures supported on spaces of concave functions. These measures may serve as prior distributions in Bayesian statistics and Cover’s universal portfolio, and as distributions over distributions. The random concave functions are constructed on the unit simplex by taking a suitably scaled (mollified, or soft) minimum of random hyperplanes. Depending on the regime of the parameters, we show that as the number of hyperplanes tends to infinity there are several possible limiting behaviors. In particular, there is a transition from a deterministic almost sure limit to a non-trivial limiting distribution that can be characterized using convex duality and Poisson point processes.
Bayesian Learning with Wasserstein Barycenters

Julio Backhoff-Veraguas, University of Vienna; Joaquín Fontbona, Universidad de Chile; Gonzalo Ríos, Universidad de Chile; Felipe Tobar, Universidad de Chile

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Abstract

We propose the Wasserstein barycenter as a model selection criterion when a posterior distribution on measures is available. The advantages of this criterion with respect to both the ‘maximum aposteriori method’ and the ‘Bayesian model averages’ are highlighted. Finally, we propose a numerical method for the computation of Wasserstein barycenters which can be thought of as a stochastic gradient descent algorithm on the space of measures.

Keywords: Bayesian learning, Wasserstein barycenter, model selection, stochastic gradient descent
Stochastic Volterra equations

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Abstract

In this presentation I will give a brief summary of the theory of Stochastic Volterra Equations (SVEs). I will concentrate on the questions of existence and uniqueness of weak solutions. The motivation to study SVEs comes from the literature on rough volatility models.

Keywords: Stochastic Volterra equations, weak existence, convolution equations, rough volatility.
3.4 Organized by Christa Cuchiero

Affine Processes Under Parameter Uncertainty

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Abstract

We develop a one-dimensional notion of affine processes under parameter uncertainty, which we call non-linear affine processes. This is done as follows: given a set of parameters for the process, we construct a corresponding non-linear expectation on the path space of continuous processes. By a general dynamic programming principle we link this non-linear expectation to a variational form of the Kolmogorov equation, where the generator of a single affine process is replaced by the supremum over all corresponding generators of affine processes with parameters in the parameter set. This non-linear affine process yields a tractable model for Knightian uncertainty, especially for modelling interest rates under ambiguity. We then develop an appropriate Ito-formula, the respective term-structure equations and study the non-linear versions of the Vasicek and the Cox-Ingersoll-Ross (CIR) model. Thereafter we introduce the non-linear Vasicek-CIR model. This model is particularly suitable for modelling interest rates when one does not want to restrict the state space a priori and hence the approach solves this modelling issue arising with negative interest rates.

Keywords: affine processes, Knightian uncertainty, Riccati equation, Vasicek model, Cox-Ingersoll-Ross model, non-linear Vasicek/CIR model, Heston model, Ito-formula, Kolmogorov equation, fully nonlinear PDE, semimartingale.
Modeling Rough Covariance Processes

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Abstract

The rough volatility paradigm asserts that the trajectories of assets’ volatility are rougher than Brownian motion, a revolutionary perspective that has changed certain persistent views of volatility. It provides via stochastic Volterra processes a universal approach to capture important features of time series and option price data as well as microstructural foundations of markets. We provide an infinite dimensional point of view on stochastic Volterra processes, which allows to dissolve a generic non-Markovanity of the at first sight naturally low dimensional volatility process. This approach enables to go beyond the univariate case considered so far and to treat the challenging problem of multivariate rough covariance models, in particular of affine type, for more than one asset.

Keywords: rough volatility, Volterra processes, infinite dimensional processes, affine covariance processes
Infinite Dimensional Polynomial Jump-Diffusions

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Abstract

We introduce polynomial jump-diffusions taking values in an arbitrary Banach space via their infinitesimal generator. We obtain two representations of the (conditional) moments in terms of solution of systems of ODEs. These representations generalize the well-known moment formulas for finite dimensional polynomial jump-diffusions. We illustrate the practical relevance of these formulas by several applications. In particular, we consider (potentially rough) forward variance polynomial models and we illustrate how to use the moment formulas to compute prices of VIX options.

Keywords: Infinite dimensional processes, VIX, polynomial process, moment formula
Deep Simulation

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Abstract

Random dynamical systems provide us with expressive regression bases to approximate generic dynamics. This provable insight is used to construct econometric models for high dimensional problems from finance in very efficient ways.

Keywords: econometric models, signature, random signatures, machine learning, reservoir computing.
Random Optimal periodic replenishment policies for spectrally positive Lévy demand processes.

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Abstract

In this talk, we revisit solve the stochastic inventory problem for a spectrally positive Lévy process in which the inventory can only be replenished at the jump times of an independent Poisson process. We will show the optimality of a periodic barrier replenishment policy that pushes the inventory up to a certain level at Poissonian dividend-decision times, if and only if the inventory is below some level. The optimal strategies and value functions are concisely written in terms of the scale functions. This is joint work with Alain Bensoussan and Kazutoshi Yamazaki.
On Optimal Periodic Execution Problem with Multiplicative Price Impact

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Abstract

We will talk about the optimal periodic execution problem with multiplicative price impact in algorithmic trading when an agent holds an initial position of shares of a financial asset. The inter-selling-decision times are modelled by the arrival times of a Poisson process. We prove that an optimal strategy has a barrier form, depending only on the number of shares left and the level of the asset price.
Abstract

We consider families $Q$ of equivalent probability measures which are time consistent. We prove under weak-compactness of the densities that all semimartingales have an additive decomposition as the sum of a predictable nondecreasing process and a universal local-supermartingale, by this we mean a process that is a local supermartingale with respect to each element of $Q$. We do this in a general setting and then illustrate the optimality of our weak-compactness condition in a specific model. We also show that processes having a supermartingale property with respect to nonlinear operators associated to the family of probability measures are always semimartingales under weak-compactness. This last result is relevant in the theory of optimal stopping under model uncertainty.
On de Finetti’s Problem with Non-Linear Taxes

Mauricio Junca, Universidad de los Andes

Abstract

We consider de Finetti’s problem when the insurance company pays taxes over the each dividend payment according to a non-linear function. We first study the diffusion and classical Cramér-Lundberg cases which shed some light on more general processes. This is ongoing joint work with Harold Moreno and José Luis Pérez.
3.6 Organized by Dylan Possamai

A General Theory of Non Markovian Time Inconsistent Stochastic Control in Continuous Time: A BSDEs Approach

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Abstract

In this work we develop a theory for continuous time non Markovian stochastic control problems which are time inconsistent. The distinguishing feature of these problems is that the classical Bellman optimality principle no longer holds. We adopt a game theoretic framework to study such problems meaning that we seek for subgame perfect Nash equilibrium points. As a first novelty of this work, we introduce and motivate a new definition of equilibrium that excludes pathological cases allowed in the current literature. Our problem is cast within the framework of a controlled non Markovian forward SDE and a general objective functional setting. In the same spirit as in the classical theory we establish an extended Dynamic Programming Principle. We use this to make an infinitesimal analysis of the game which is used to prove the necessity of a system of BSDEs analogous to the classic HJB equation. We can prove well-posedness of such system. As a final step we provide a verification theorem. Finally we present some conclusions and ongoing extensions.

Keywords: time-inconsistency; BSDEs; non-exponential discounting; mean-variance.
Mean–Field Moral Hazard for Optimal Energy Demand Response Management

Emma Hubert, Université Paris-Est Marne-la-Vallée; Romuald Élie, Université Paris-Est Marne-la-Vallée; Thibaut Mastrolia, École Polytechnique; Dylan Possamaï, Columbia University

Abstract

We extend the problem of demand response contracts in electricity markets set in Aïd, Possamaï, Touzi (2018) by considering a mean–field of consumers, whose consumption is impacted by a common noise. We formulate the problem as a Principal-Agent problem with moral hazard in which the Principal – she – is a producer observing in continuously the consumption of a continuum of risk-averse consumers and designs contracts to reduce her production costs. More precisely, the producer incentives them in reducing their consumption and the volatility of their consumption in the different usages, without observing the efforts they make. We prove that the producer can benefit from considering the mean–field of consumers by indexing contracts on the consumption of one Agent and the law of others. In the case of linear energy valuation discrepancy, we provide closed-form expression for this new type of optimal contracts that maximizes the utility of the producer. In most cases, we show that this new type of contracts allows her to choose the risk she wants to bear and to reduce the problem to an uncorrelated one.

Keywords: contract theory; principal-agent problem; second order backward SDEs; mean-field games; demand response; moral hazard
Regulation of the Exploitation of a Natural Resource.

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Abstract

We investigate the impact of a regulation policy imposed on an agent exploiting a renewable natural resource. We adopt a principal/agent model in which the principal looks for a contract, i.e. taxes/compensations, leading the agent to a given level of exploitation. For a given contract, we first describe the agent’s optimal effort using the BSDE theory. Under regularity assumptions on the coefficients, we then express the optimal contract as the solution to an HJB equation. We then extend the result to coefficients with less regularity by providing almost optimal strategies using an approximation result for the regulator’s value function. We end by numerical examples to illustrate the impact of the regulation in our model. Joint work with Idris Kharroubi (Sorbonne Univ.) and Thomas Lim (ENSIIE)

Keywords: environmental and resource economics; sustainability; stochastic control; contract theory; stochastic population dynamics
FBSDEs with Discontinuous Coefficients

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Abstract

In this talk we consider well-posedness of systems of forward and backward stochastic differential equations when (at least some of) the coefficients are merely assumed to be measurable. Since such systems cannot be tackled with classical fixed point theory, we device new methods based on “domination arguments” and Malliavin calculus techniques.

Keywords: Backward SDEs; Malliavin’s calculus; singular PDE; domination condition
3.7 Organized by Edward Frees

Analytics and Strategic Risk

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Abstract

In this presentation, we are going to review the use of analytics for a better understanding of Strategic Risk, its assessment, control, and mitigation. There are different approaches in defining what strategic risk is about and the way to deal with it. According to the work of Collins and Ruefli (1992, p.1709) who pointed out that “Strategic risk for an individual firm can be defined in terms of the probability of losing rank position vis-à-vis the other firms in the reference set.” This view gives us one of the main points to start in the evaluation of strategic risk. However, other authors such as Gates (2006) and Young and Hasler (2010) indicated that strategic risk could take different forms such as reputation, industry margin reductions, economic efficiency, environmental issues, energy issues, geographical hazards, threats and terrorism, citizen-customer dissatisfaction, and distribution of justice. Nowadays, the ERM frameworks and research in the field are in evolution (as it is the case of COSO updated 2017) to emphasize the use of data analytics in identifying factors affecting strategic risk and supporting to the decision-making process. Nevertheless, the answer to the need for measuring and monitoring strategic risk as a priority in today’s organizations is not fully clear yet. There is a great need for a firm-wide understanding of risk exposure and its risk control. In strategy formulation and its implementation, the understanding and dealing with strategic risk faces important challenges, such as data management, data analytics, sharing risk knowledge among different individuals, modeling process, embedding the analytics solutions in the core business information systems, standards and metrics building process, evaluation process, and communication among stakeholders. Based on the challenges of dealing with strategic risk, this presentation has been designed and concentrated on two aspects: first, understanding the variation of metrics of business performance. Second, reviewing how to integrate Key Risk Indicators (KRI) with Strategy Key Performance Indicators (KPI). The presentation exposes quantitative and qualitative methods that include the use of analytics tools (statistical and machine learning, and optimization) based on appropriate data management for the quantification and interpretation of

**Keywords:** Data analytics, strategic management
Classification Models for Understanding Policyholder Lapse

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Abstract

It has been studied in Jeong et al. (2018) that there is an association between the lapse behavior of a policyholder and characteristics of the policyholder such as the size of the claim made and the level of premium change. As a follow-up to this work, in this paper, we examine different classification models to help us identify observed characteristics that are important indicators of lapse behavior. Text mining is also utilized as a way of extracting features which are used in the model construction. For benchmark models, we will consider GLM-based models such as logistic and probit regression models. However, there has been a recent interest on the use of machine learning algorithms that include Neural network, classification and regression tree (CART), and ensemble methods such as boosting or random forest. We will explore these alternative algorithms that potentially can enable us to cope with covariates that have a substantial proportion of missing data. For model calibration, we use data obtained from the Singapore automobile insurance market with nine years of policy and claims information. The predictive accuracy of candidate models are evaluated using various out-of-sample validation measures.

Keywords: Policyholder lapse; auto insurance; classification; machine learning; text mining
On the Application of a Hierarchical Credibility Quantile Regression Model to Insurance and Finance

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Abstract

In actuarial (or in finance) practice there are cases where the claim (or P/L returns) distribution is not normal and other cases where the set of data is contaminated due to outlier events. Moreover, insurance or bank regulations (Solvency II or Basile II) may require the calculation of value at risk (VaR) for some prescribed confidence level p in (0,1) or the examination of some changes over time occurring across the claim (or P/L returns) distribution. In such cases the classical credibility regression models lead to an unsatisfactory behavior of credibility estimators, and it is more appropriate to use quantile regression instead of the ordinary least squares estimation. However, these quantile credibility models cannot perform effectively when the set of data has nested (hierarchical) structure. This paper develops credibility models for regression quantiles with nested classification as an alternative to Norberg’s (1986) approach of random coefficient regression model with multi-stage nested classification. In addition, nested quantile credibility estimators are established and numerical illustrations are herein presented.

Keywords: Nested Classification; Quantile Regression; Credibility.
Predictive Analytics of Insurance Claims Using Multivariate Decision Trees

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Abstract

Because of its many advantages, the use of decision trees has become an increasingly popular alternative predictive tool for building classification and regression models. Its origins date back for about five decades where the algorithm can be broadly described by repeatedly partitioning the regions of the explanatory variables and thereby creating a tree-based model for predicting the response. Innovations to the original methods, such as random forests and gradient boosting, have further improved the capabilities of using decision trees as a predictive model. In addition, the extension of using decision trees with multivariate response variables started to develop and it is the purpose of this paper to apply multivariate tree models to insurance claims data with correlated responses. This extension to multivariate response variables inherits several advantages of the univariate decision tree models such as distribution-free feature, ability to rank essential explanatory variables, and high predictive accuracy, to name a few. To illustrate the approach, we analyze a dataset drawn from the Wisconsin Local Government Property Insurance Fund (LGPIF) which offers multi-line insurance coverage of property, motor vehicle, and contractors’ equipment. With multivariate tree models, we are able to capture the inherent relationship among the response variables and we find that the marginal predictive model based on multivariate trees is an improvement in prediction accuracy from that based on simply the univariate trees.

Keywords: Tree-based models; univariate regression trees; random forests; gradient boosting; multivariate regression trees; multivariate tree boosting; predictive model of insurance claims.
Abstract

We study tail estimation in Pareto-like settings for datasets with a high percentage of randomly right-censored data, and where some expert information on the tail index is available for the censored observations. This setting arises for instance naturally for liability insurance claims, where actuarial experts build reserves based on the specificity of each open claim, which can be used to improve the estimation based on the already available data points from closed claims. Through an entropy-perturbed likelihood we derive an explicit estimator and establish a close analogy with Bayesian methods. Embedded in an extreme value approach, asymptotic normality of the estimator is shown, and when the expert information is precise, a simple combination formula can be deduced, bridging the classical statistical approach with the expert information. Following the aforementioned combination formula, a combination of Value at Risk estimators can be naturally defined. In a simulation study, the estimator is shown to often outperform the Hill estimator for censored observations and recent Bayesian solutions, some of which require more information than usually available. Finally we perform a case study on a motor third-party liability insurance claim dataset, where Hill-type and Value at Risk plots incorporate ultimate values into the estimation procedure in an intuitive manner.

Keywords: Penalized Likelihood; Heavy Tails; Expert Information; Extreme Value Analysis
Multi-Population Mortality Modelling and Forecasting: A Hierarchical Credibility Regression Approach

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Abstract

This work proposes a multi-level hierarchical credibility regression method to model the mortality dependency between multiple countries. Future mortality rates are derived using different extrapolation techniques, while the forecasting performances between the proposed model, the classical Lee-Carter model and two Lee-Carter extensions for multiple populations are compared for both genders of three northern European countries (Ireland, Norway, Finland). Empirical illustrations show that the proposed method produces more accurate forecasts, based on the mean absolute percentage forecast error (MAPFE) values.

Keywords: Hierarchical Credibility Regression; Mortality Modelling; Multiple Populations
Abstract

Insurance is usually defined as “the contribution of the many to the misfortune of the few”. This idea of pooling risks together using the law of large number legitimizes the use of the expected value as actuarial “fair” premium. In the context of heterogeneous risks, nevertheless, it is possible to legitimate price segmentation based on observable characteristics. But in the context of “Big Data”, intensive segmentation can be observed, with a much wider range of offered premium, on a given portfolio. In this talk, we will briefly get back on economical, actuarial and philosophical approaches of insurance pricing, trying to link a fair unique premium on a given population and a highly segmented one. We will then get back on recent experiments (so-called “actuarial pricing game”) organized since 2015, where (real) actuaries were playing in competitive (artificial) market, that mimic real insurance market. We will get back on conclusions obtained on two editions, the first one, and the most recent one, where a dynamic version of the game was launched.

Keywords: Competition; Segmentation; Heterogeneity; Machine Learning
Hidden Markov Over-dispersed Poisson Models Applied to Highway Accident Counts

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Abstract

The Brazilian highway system has been a key element in the country’s development. The high rate of cars per capita illustrates the strong relationship between Brazilians and their cars; the road system is important for passenger transportation and for production logistics. Unfortunately, a high accident rate is observed on Brazilian roads. Among several factors, the number of accidents shows a high correlation with space and location. Statistical models are useful to find and measure differences between dangerous profiles in stretches along highways. Hidden Markov Models (HMMs) have been shown to be adequate to study accidents location data. It is a flexible tool that allows the use of distinct distributions. Here we illustrate the application of two-state Hidden Markov Models using Poisson, Borel-Tanner and Lagrange Poisson distributions fitted to the Brazilian highway accidents dataset, made available for highway BR-381 in 2016 (1st semester). This dataset lists 1,379 accidents occurred along a 449.1-kilometer segment of BR-381, stretching from Belo Horizonte to Extrema, two cities in Minas Gerais state, in southeast Brazil. The data is over-dispersed and has been compiled using accident counts in sections of 0.1-kilometer granularity (100-meters). Therefore, there are 4,491 spots with accidents counts. Point estimators of the parameters in HMMs combined to Lagrange-Poisson, Borel-Tanner and Poisson distributions are obtained by maximum likelihood (EM Algorithm). It is shown that HMMs with Lagrange-Poisson outperform the other models fitted to this dataset. Additionally, the location and profiles of dangerous sections (hot spots) are obtained. The profile of safe locations is also discussed, as well as the use of Viterbi’s algorithm to identify hot spots along the highway.

Keywords: Hidden Markov Models; Lagrange-Poisson; Over-dispersion Data; Highway Accidents
Abstract

We consider a production-inventory control model with finite capacity and \( n \) different production rates. It is possible at any time to switch over from the different production rates but it is mandatory to switch-off when the inventory process reaches the storage maximum capacity. We consider holding, penalty and switching costs. This model was introduced by Doshi, Van Der Duyn Schouten and Talman in 1978. Our aim is to minimize the expected discounted cumulative costs up to infinity over all possible switching strategies in the compound Poisson setting. We show that the \( n \) optimal value functions satisfy the corresponding HJB system of equations in a viscosity sense and prove the following verification theorem: If the \( n \) value function of a switching strategy satisfies the HJB system of equation in a viscosity sense, then the switching strategy is optimal. We also show that there are examples where the switching strategy presented by Doshi et al is not the optimal strategy.

Keywords: production-inventory model, optimal strategies, HJB equation, compound Poisson process.
For a Few Bitcoins More

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Abstract

The probability of successfully spending twice the same bitcoins is considered. A double-spending attack consists in issuing two transactions transferring the same bitcoins. The first transaction, from the fraudster to a merchant, is included in a block of the public chain. The second transaction, from the fraudster to himself, is recorded in a block that integrates a private chain, exact copy of the public chain up to substituting the fraudster-to-merchant transaction by the fraudster-to-fraudster transaction. The double-spending hack is completed once the private chain reaches the length of the public chain, in which case it replaces it. The growth of both chains are modeled by two independent counting processes. The probability distribution of the time at which the malicious chain catches up with the honest chain, or equivalently the time at which the two counting processes meet each other, is studied. The merchant is supposed to await the discovery of a given number of blocks after the one containing the transaction before delivering the goods. This grants a head start to the honest chain in the race against the dishonest chain.
Obfuscation and Honesty Experimental Evidence on Insurance Demand with Multiple Distribution Channels

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Abstract

We aim at shedding light on the dilemma faced by insurance purchasers faced with multiple distribution channels. Should the consumer herself choose from a large set of insurance policies or rather delegate a part her decision to an intermediary who is more or less honest? We consider decisions based on a number of real-world insurance distribution channels with different information frames. Beliefs about intermediary honesty are the main determinants of individual choice. In addition, the obfuscation of information is the main source of inefficiency in decision-making, particularly regarding the characteristics of the insurance contracts chosen by consumers.
A Value-Based Longevity Index for Hedging Retirement Income Portfolios

Jonathan Ziveyi, UNSW; Kevin Krahe, UNSW; Michael Sherris, UNSW; Andrés Villegas, University of New South Wales

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Abstract

The availability of a longevity index that closely tracks the value of longevity-linked liabilities has the potential to significantly lower the costs and improve the efficiency of index-based to longevity hedging techniques relative to standard mortality rate indices typically referenced in current financial markets. This paper presents a universal value-based longevity index, constructed from US states economic and population data. The index is defined as the expected present value of a unit of longevity and inflation-indexed income, thereby incorporating both interest rate and inflation risk unlike other longevity indices in existing literature addressing mortality risk only. This contribution demonstrates how the market can design an index that closely tracks the value of longevity-linked liabilities; a critical requirement for the development of a viable, liquid longevity risk transfer market. The second contribution draws from key aspects of the Longevity Basis Risk Working Group (LBRWG)’s longevity basis risk quantification framework (Haberman, 2014; Li, 2017; Villegas, 2017) to demonstrate that hedges referencing the value-based longevity index generate material reductions in basis risk relative to survivor swap instruments based on standard mortality rate indices such as the Lifemetrics Index. Indeed, the minimization and robust quantification of longevity basis risk represents a critical element in establishing the credibility of longevity-linked securities as viable risk management instruments for retirement income providers in practice. Our third contribution is the comparison of the continuous-time multi-population mortality modelling techniques introduced in Sherris (2017) to the discrete-time M7-M5 Cairns (2009) of multi-population mortality model advocated by the LBRWG. Despite the differing approaches developed by these authors for modelling the relationship between the mortality patterns of multiple populations, our analysis indicates that the two frameworks suggest relatively similar outcomes when hedging retirement income portfolios by means of index-based swap
instruments. Ultimately by making these contributions to the literature, our research has the potential to support the transition towards index-based longevity hedging. This is of critical importance since index-based longevity hedging represents arguably the most realistic prospect for a viable and liquid longevity risk transfer market, given all the complexities associated with indemnity-based longevity hedges. Our book population is constructed from a synthetic dataset under the assumption that the aggregation of high-income states sufficiently approximates the demographics of a typical retirement income portfolio. Furthermore, the longevity hedging strategy is based on a closed portfolio where all members belong to a single cohort.

**Keywords:** Value-based longevity index; longevity risk; interest rate risk; inflation risk; longevity basis risk; longevity hedging
Affordable and Adequate Annuities with Stable Payouts: Fantasy or Reality?

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Abstract

This paper introduces a class of unit-linked annuities that extends existing annuities by allowing portfolio shocks to be gradually absorbed into the annuity payouts. Consequently, our new class enables insurers to offer an affordable and adequate annuity with a stable payout stream. We show how to price and adequately hedge the annuity payouts in a general financial environment. In particular, our model accounts for various stylized facts of stock returns such as asymmetry and heavy-tailedness. Furthermore, the generality of our framework makes it possible to explore the impact of a parameter misspecification on the annuity price and the hedging performance.

Keywords: Unit-Linked Annuities; Buffering of Portfolio Shocks; General Financial Market; Risk Management Framework; Model Risk
Enhancing the Insurer’s Expected Return by Reinsurance and Financing

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Abstract

A reinsurance contract is an effective risk management tool for an insurer to reduce the risk level of the aggregate loss from policyholders. It is also common that the insurer raises external capital to meet the regulation requirement. However, the interaction effect of these two methods hasn’t been discussed adequately in current insurance literatures. In this work, we incorporate methods of external financing and reinsurance in one optimization problem, and determine the optimal strategy on external capital amount and reinsurance coverage from the insurer’s point of view. We also discuss impacts on the insurer’s behavior of changes in reinsurance pricing and in the cost of external capital.

Keywords: Reinsurance; external financing; insurance regulation; Value-at-Risk; Conditional Value-at-Risk
Pricing Insurance Contracts with Natural Hedging Effect

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Abstract

We investigate the pricing of offsetting contracts. It is demonstrated that joint pricing of term annuity and term insurance contracts does not necessarily justify more favorable premiums as compared to the stand-alone pricing, and that the simultaneous choice of competitiveness and risk reduction requires a careful monitoring of the portfolio. Moreover, for an insurer who is active on both business lines, it is found that switching from the stand-alone pricing to the joint pricing may lead to a decrease in the demand for annuities and a reduction in the total collected premiums of the combined portfolio.
Contributed Talks
The Bayesian Modelling, Monte Carlo Sampling and Capital Allocation of Insurance Risks

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Abstract

The main objective of this work is to develop a detailed step-by-step guide to the development and application of a new class of efficient Monte Carlo methods to solve practically important problems faced by insurers under the new solvency regulations. In particular, a novel Monte Carlo method to calculate capital allocations for a general insurance company is developed, with focus on coherent capital allocation that is compliant with the Swiss Solvency Test. The data used is based on the balance sheet of a representative stylized company. For each line of business in that company, allocations are calculated for the one-year risk with dependencies based on correlations given by the Swiss Solvency Test. Two different approaches for dealing with parameter uncertainty are discussed and simulation algorithms based on (pseudo-marginal) Sequential Monte Carlo algorithms are described and their efficiency is analyzed.

Keywords: capital allocation; premium and reserve risk; Solvency Capital Requirement (SCR); Sequential Monte Carlo (SMC); Swiss Solvency Test (SST)
A Data Analytics Paradigm for the Construction, Selection, and Evaluation of Mortality Models

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Abstract

Humanity has made, and continues to make, significant progress in averting and delaying death, which burdens society with increased longevity costs. This has brought to the fore the critical importance of mortality forecasting for actuaries and demographers. Consequently, numerous mortality models have been proposed, with the most popular and commonly-referenced models belonging to a generalized age-period-cohort framework. These models decompose observed historical mortality rates across the dimensions of age, period, and cohort (or year-of-birth), which can then be extrapolated to forecast future outcomes. Recently, a large number of models have been proposed within this framework, many of which are over-parameterized and produce spurious forecasts, particularly over long horizons and for noisy data sets. In this paper we exploit data analytics techniques to provide a comprehensive framework to construct, select, and evaluate discrete-time age-period-cohort mortality models. To devise this robust framework, we leverage two key statistical learning tools—cross validation and regularization—to draw as much insight as possible from limited data sets. We first propose a cross validation framework for model selection, which can be tailored to determine the features of mortality models that are desired for different actuarial applications, including period and cohort-based forecasting. This enables the answering of questions regarding the effects of population size and structure, age, and forecasting basis and horizon on the preferred model selection. We also present a regularization approach to construct bespoke mortality models by automatically selecting the most appropriate parametric forms to best describe and forecast particular data sets, using a trade-off between complexity and parsimony. We illustrate this using empirical data from the Human Mortality Database and simulated data sets.

Keywords: Mortality Modelling; Statistical Learning
Construction of Mortality Tables for the Peruvian Private Pension System

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Abstract

Longevity poses major long-term problems for pension funds and life insurance companies that have portfolios of annuities. It is therefore important to have models which accurately describe the change of the mortality rates of insured people. In addition, these models would need to provide reasonable forecasts for the future since it is assumed that longevity will continue to improve. For this purpose, the Superintendence of Banking, Insurance and Private Pension Funds Administrators (SBS) gathered data from the System participants on lives covered by the pension plans (passive members); as well as those that have the right to access a pension benefit if certain events take place (active members). Following the data collection and validation processes, an Actuarial team within the SBS proceeded to work on the construction of the mortality tables. It is important to point out that the set of the population on which these Tables are based is a subset of the total Peruvian population, and as such, has its particular behavior in respect of mortality experience, which will differ from the experience of the Peruvian population as a whole. As new participants join the Private Pension System (PPS), and possible changes in pension regulations come into place, the mortality experience of the PPS will evolve, and this should lead in time to an update of the Tables in order to reflect material changes that could have an impact in the required technical reserves. The ability for individuals to take a lump sum at retirement – and the fact that currently approximately 95% of them are choosing this option – means that there will be a more significant selection effect for individuals opting for an annuity or programmed withdrawal going forward. Nevertheless, this problem cannot be addressed with the current tables, which must be developed to be as accurate as possible for the pensioners today. Regular revisions of the table, however, will capture the future impact of changes in the rules of the pension system. The construction process of the mortality tables consisted in the following steps: 1) Cleansing of data and calculation of observed mortality rates. 2) Selection of the central ages that show a reasonable mortality progression in order to smooth the observed rates applying the Whitaker – Henderson Type B Adjustment Model (WH). In addition, the WH
resulting adjusted rates were tested for significance by running different statistical tests. The raw rates for very young ages and older ages were discarded. 3) Use of a parametric model to project mortality rates for older ages. 4) Use general population mortality data to estimate mortality rates for very young ages. 5) Estimation of the future mortality improvement factors by using the Lee Carter model. Finally, the result of the work is the delivery of a set of two mortality tables: for healthy lives and for disabled lives. These new tables will be used to value pension liabilities of the Peruvian PPS.
The Portfolio Allocation and Consumption in a Levy-Type Jump-Diffusion Market Model with Insurance Risk

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Abstract

We study a continuous-time portfolio allocation problem for a firm that invests in financial assets that follow a multi-dimensional Levy-type process and holds a portfolio of one-type insurance contracts. The model allows the firm to decide the volume of underwriting. The goal is to find a strategy that maximizes expected risk-averse utility from the final value of a self-financing portfolio over a finite investment horizon. We extend the standard martingale approach to this setting and prove a sufficient condition for existence of optimal investment-consumption and insurance underwriting strategies for CRRA utility. We provide numerical examples for the case of one risky asset, policy limit (maximum loss) for the insurance contracts and bounded variation (but possibly infinite activity) jumps for the Levy process.
A Capital Allocation Rule for the Haezendonck-Goovaerts Risk Measure with a Power Young Function

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Abstract

Once a financial institution, such as a bank, an insurance company, or an investment fund has determined the risk-based capital requirement for a portfolio, it is often necessary to allocate the risk capital over its constituents, for example, individuals; products; and sub-portfolios. Capital allocation is important for the division of capital reserves among business units, performance measurement, and portfolio management. In the literature, there is a well-established theory for additive risk contributions based on the concept of marginal contributions, sometimes called Euler allocation. In this setting, the capital allocated to a sub-portfolio is the derivative of the underlying risk measure at the whole portfolio in the direction of the sub-portfolio, see Kalkbrener (2005). The family of coherent risk measures, introduced by Artzner et al. (1999), has been widely accepted by academics and practitioners in the interdisciplinary area of finance and insurance. In particular, the tail value-at-risk (TVaR) measure is the most popular member of the aforementioned class and has received considerable attention; see for instance Acerbi and Tasche (2002), Tasche (2002), and Rockafellar and Uryasev (2000, 2002). As a generalization of the TVaR the Haezendonck–Goovaerts (HG) risk measure was introduced by Haezendonck and Goovaerts (1982) and Goovaerts et al. (2003, 2004); recently, it has attracted increasing attention, see Bellini and Rosazza Gianin (2008, 2012), Mao and Hu (2012), Ahn and Shyamalkumar (2014), Tang and Yang (2012, 2014), Wang and Peng (2016), among others; in this setting, TVaR corresponds to the linear Young function case. Aside from preserving coherence and being law invariant, the HG risk measure is derived from a homogeneous premium principle based on the economic concept of the certainty equivalent (see and Ben-Tal and Teboulle (2007)). In the present work, we quantify risk through the HG risk measure with power Young function. So, we prove that the HG risk measure is Gateaux differentiable and give a formula for its directional derivatives; as a by-product, we establish the associated Euler allocation principle. As an illustration, we compute the capital allocation rule under some specific distributional assumptions. Moreover, this capital allocation principle provides a
consistent plug-in estimator. As a bonus, we establish the asymptotic behavior of the capital allocation rule as the confidence level in the definition of the HG risk measure approaches to one for a regularly varying structure. Finally, we present some numerical studies.

**Keywords:** Risk measure, capital allocation, Euler principle
Modelling Risks with Cellular Automata

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Abstract

In contrast to classical geometric Brownian motion, some exceeding simple cellular automata exhibit naturally the fat tail, heteroscedasticity and auto-regressive properties of financial time series. We heuristically explore some of these properties by comparing the different modelling principles with observed data.

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Abstract

Discrete Markov Chains are widely used in several contexts for their great applications at modeling the evolution of random behaviors over time. Unfortunately, the non-homogeneous properly involves the estimation of several transition probabilities for each of the possible ages of the process that highly increase the complexity of the modeling, and reduce the quality of the overall estimations. In these scenarios, traditional estimators, such as the empirical transition frequency, give poor performance. In this paper, we discuss the application of generalized additive models (GAM) for the parsimonious estimation of the several transition matrices of a non-homogeneous discrete Markov chain, with the possibility of including profiling variables to take into account the heterogeneity of the population in the estimation. Moreover, we argue that the proposed estimation is consistent and efficient by showing that the likelihood function of a Markov chain is proportional to the likelihood of a GAM with Binomial response, hence the GAM estimation inherits all the properties of the maximum likelihood estimator. We also discuss some advantages of the approach proposed, including how to do statistical inference for the parameters of the Markov Chain, emphasizing in how to easily perform a likelihood ratio test of homogeneity with the GAM estimation output. Furthermore, some extensions for dynamic modeling are discussed. Finally, we illustrate the performance of the methodology with real data in some actuarial models, including dynamic life tables with portfolio experience and multi-state models for health insurance.
Are foreigners the vectors of Contagion?

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Abstract

In a study of seven emerging markets contagion has been identified as a negative side effect of Globalization on emerging markets, but it’s not clear what type of investor drives it. We investigate the role of Foreigners, local Institutions and local individuals in days of Contagion from US markets in a set of seven emerging markets from 2007 to 2016. We propose a simple measure of the degree of Contagion based on the probability of a random coincidence of daily negative returns among the S&P500 and the local index, controlling by worldwide and country-specific fundamentals. Using a VAR setting, we find that Foreigners Net selling induce Contagion and that they keep selling a few days after, acting as the transmitters of large price drops from the US to the seven emerging markets. Local Institutions are also net sellers in Contagion days, but they become net buyers in the following days. Individuals appear as the liquidity providers on and after those episodes.
Financial Options Valuation Adjustment for Market Liquidity Risk

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Abstract

We consider a market in which large agents or many small agents following the same hedging strategy using options, the transactions of the underlying for dynamic hedging has an effect on its price due to changes in net demand (liquidity). This effect on the price has an impact on the valuation of the option, generating a feedback effect. An adjusted option valuation model is presented to incorporate this feedback effect, describing the liquidity risk of the market through stochastic elasticities. The non-linear PDE associated with the valuation and an approximation to its solution by the finite difference method is presented.

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Abstract

This study empirically contrasts the hypothesis of the existence of MILA integration through the application of econometric techniques and time series. Using data from July 2002 to May 2018, we examined the indexes of the stock exchanges of Colombia, Peru, Chile and Mexico, member countries of the MILA. In order to capture the degree of integration in the long term we make use of cointegration techniques, finding that the series are cointegrated into subgroups. This fact leads to the series in the long term reach an equilibrium and therefore the movements of the long term are explained by the dynamics that exist between the series. On the other hand, to capture the short-term effects of the integration process, a multivariate model of the Garch family is used, finding the existence of a relationship in the short term between the series. This implies that the volatility shocks of one market are transmitted to the rest of the member countries, so that a fraction of the short-term dynamics of each of the series is explained by the others. The results of this study suggest that while there is integration between the markets that make up the MILA, it is not as strong as expected. This can be caused by the independence that is still maintained in regulatory, normative and monetary terms.
Abstract

We introduce a multi-factor stochastic volatility model for commodities that incorporates seasonality and the Samuelson effect. Conditions on the seasonal term under which the corresponding volatility factor is well-defined are given, and five different specifications of the seasonality pattern are proposed. We calculate the joint characteristic function of two futures prices for different maturities in the risk-neutral measure. The model is then presented under the physical measure, and its state-space representation is derived, in order to estimate the parameters with the Kalman filter for time series of corn, cotton, soybean, sugar and wheat futures from 2007 to 2017. The seasonal model significantly outperforms the nested non-seasonal model in all five markets, and we show which seasonality patterns are particularly well-suited in each case. We also confirm the importance of correctly modelling the Samuelson effect in order to account for futures with different maturities. Our results are clearly confirmed in a robustness check carried out with an alternative dataset of constant maturity futures for the same agricultural markets.

Keywords: Agricultural Commodities, Seasonal Commodities, Seasonal Volatility, Stochastic Volatility, Samuelson Effect, Time-Series Estimation, Kalman Filter
Moments Based Approximation for the Renewal Type equations of the Credit Rate Dynamics

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Abstract

In recent years, credit risk modeling has become an important tool in many applications in risk management of financial firms. The credit risk rating associated with any kind of credit-linked event which changes from time to time and can be modelled by renewal processes. Markov and Semi-Markov processes are widely used in the literature to credit risk, however, the Markov property is not appropriate for credit rate dynamics. The objective of this paper is to address the non-Markov behavior of the rating dynamics by using renewal type equations and method of approximations based on the moments of the underlying distributions. We also compare the results based on the proposed approximation with the special case of the Continuous-time Markov chain and Semi-Markov models and present an application of a specific example of credit risk problem.

Keywords: Credit rating, renewal equation, default distribution
Index Tracking with Stochastic Dual Dynamic Programming

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Abstract

The index tracking problem (ITP) has become one of the most analyzed problems in portfolio management, especially with the increase in popularity of passive strategies and the increase of ETF instruments available. The ITP consists in finding a portfolio composed by liquid instruments that can replicate the return of an specific index in time. The complexity of the problem is how to rebalance the portfolio dynamically in order to follow the index with small tracking error, and simultaneously generate a small but positive alpha. The aim of this work is to construct allocations policies for the ITP, using multistage stochastic programming (MSP). In particular with the Stochastic Dual Dynamic Programming (SDDP), proposed by Pereira and Pinto (1991). The algorithm uses a decomposition scheme and, unlike classical MSP numerical schemes, SDDP is not based on state-space discretization.

Keywords: Index tracking; portfolio replication, Stochastic Dual Dynamic Programming; risk management
Non-Standard Profit Efficiency in Banking: A Copula Approach

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Abstract

This paper estimates profit efficiency using a seemingly unrelated stochastic frontier model where both cost and revenue efficiencies are obtained simultaneously. This method implicitly accounts for and estimates the correlation between revenue and cost efficiencies and allows us to achieve consistent and more efficient estimates. We use a copula-based maximum likelihood method applied to a well specified non-standard profit function to generate the distribution of the composite error. We show the performance of this estimating method using a sample of US commercial banks to study the evolution of profit efficiency for U.S. Community Banks from 2004 to 2017. Our results with the new methodology show that banks are less efficient in cost, revenues and profit, we find the average in the efficiency of 76.6 % in revenues, 75.2 % in cost and 53.6 % in profits. We find a positive and statistically significant correlation between the composite errors of the revenue and cost function, that means that banks, which are more efficient in cost, are efficient in revenues and profits

Keywords: Banks; Stochastic frontier; Copula- based maximum likelihood; Efficiency.
Modeling of Electrical Energy Demand: Beyond Normality

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Abstract

The main characteristic that differentiates electricity markets from other markets corresponds to the need to produce energy at the same time it is consumed, to such an extent that in real time the systems must maintain a perfect balance: at each moment the demand for electrical energy is equal to its generation. This characteristic prevents, for example, intertemporal arbitrage by those who carry out transactions in this market. In this regard, when modeling demand, it is common to find econometric analyzes that consider the assumption of normality; however, this assumption may ignore, a priori, an eventual presence of bias, kurtosis or higher order moments in this variable. In this paper, the Semi-Nonparametric approach (SNP) is studied to describe the demand for electricity in Colombia and the residuals of an ARIMA process. We propose the selection of probability density functions in terms of a finite Gram-Charlier expansion adjusted by the criterion of maximum likelihood. As a case study, the demand for electrical energy in the Colombian market is considered. As a result, it is found that the SNP type distribution achieves better adjustment than the normal distribution for some transformations of the electrical energy demand where it can be required more than four moments to represent this variable.

Keywords: electrical energy demand; semi nonparametric distribution; Power market
Some Methodological Considerations of Stochastic Modeling of Hydrological Contributions in the Colombian Electric System

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Abstract

In this work we show that hydrological contributions in the Colombian electrical system during the period between 2004 and 2016 follow a periodic dynamic, with fundamental periods that are repeated every three years and that tend to oscillate around a long-term average. In this context, such contributions can be characterized by mean reversion stochastic processes with periodic functional tendency. Therefore, the objective of this research is to model and forecast the dynamic behavior of hydrological contributions in the Colombian electric system. Firstly, a description of climate and hydrology in Colombia is carried out, as well as an analysis of periodicity and distributional properties of the data. The results indicate four fundamental periods of three years between 2004 and 2016 with sub-periods of annual frequency, and mean reversion in the data. Afterwards, a Gaussian estimation is performed, which allows to find all the constant and functional parameters from the historical data with daily frequency. Thus, two phases of estimation are defined, in the first phase through Gaussian techniques and using the Euler-Maruyama discretization, we obtain the maximum likelihood function, that will allow us to find estimators of the external parameters and an estimation of the expected value of the process. In the second phase, an estimate of the periodic functional tendency, with its parameters of phase and amplitude is carried out through Fourier’s analysis, this will allow to improve the initial estimation. Finally, we illustrate the forecast of hydrological contributions for a period of three years between 2010 and 2013 and contrast them with the real data through forecast bands. The results of the forecast indicate that the bands constructed from the maxima and minima of the simulated paths of the process with historical information, are adjusted to the real data. Similar results are presented in the bands constructed from the functional trend and the addition of different levels of historical standard deviation of the process, from where 2.6 deviations the entirety of the real data is covered. The proposed forecast is highly useful for electric market agents in Colombia, since it provides a window of time of approximately three years.
Keywords: Hydrological Contributions; Fourier; Mean Reversion Processes; Stochastic Modeling
Behavior of The Islamic Market Mena Index, The Market Mena Index and its Relation of Convergence

Susana Marin Arango, EAFIT University; Maria Camila Adaime Zapata, EAFIT University; Hermilson Velásquez Ceballos, EAFIT University

Abstract

Islamic stock markets have developed as a benchmark for the financial markets in the MENA region over the last decade. In order to represent both markets, the Dow Jones Islamic MENA Index and the Dow Jones MENA Index were chosen and analyzed due to their success at representing the overall region behavior of the Islamic Stock Market and the traditional stock market. In this paper, the cointegration between the time series mentioned above is analyzed. Moreover, GARCH models are used to analyze short term behavior of both the volatility patterns over the period of 2013-2018. It is discovered that both series can be modeled through a hybrid model, specifically ARIMA-GARCH and how they cointegrate with each other, finding that there is a common long-term trajectory between the two indices. The findings of the study may help investors and market regulators to reduce uncertainty in their portfolios through the diversification in Islamic indexes given its peculiar nature in Shariah compliant laws and good governance and disclosure mechanisms.

Keywords: Time series; Islamic stock market; MENA region; Cointegration; ARIMA; GARCH
Simulating Heston Using Explicit Weak Solutions

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Abstract

In this presentation, I discuss new simulation algorithms for the Heston model, which are based on the results of Kour (2019). Therein, it is shown that the Heston model presents an explicit weak solution that can be used for simulating volatilities and option prices. Most often, efficient simulation is done under an artificial reference probability and then converted to the real probability with the appropriate likelihood. The resulting simulation algorithm can therefore be seen as the analog of a weighted particle filter. It is then natural to introduce some type of resampling to improve the performance of the simulation algorithm. Here we focus on the branching algorithms of Kour (2017), which have the advantage of preserving the historical property of the particle system. Through numerical results, we illustrate the increased performance and accuracy due to branching. We also compare the resulting simulation algorithm to popular Heston simulation methods.

Keywords: Sequential Monte Carlo; Branching Processes; Heston Model; Stochastic Volatility; Option Pricing
A curious inequality involving the Black–Scholes pricing function is explored. One way to understand the inequality is via a natural noncommutative semigroup structure of the space of call price functions. The binary operation is compatible with the convex order, and therefore a one-parameter sub-semigroup gives rise to an arbitrage-free market model. It is shown that each such one-parameter semigroup corresponds to a unique log-concave probability density, providing a family of tractable call price surface parametrizations in the spirit of the Gatheral–Jacquier SVI surface. An explicit example is given to illustrate the idea.
American-Type Basket Option Pricing: A Simple Two-Dimensional Partial Differential Equation

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Abstract

We consider the pricing of American-type basket derivatives by numerically solving a partial differential equation. The curse of dimensionality inherent to basket derivative pricing is circumvented by using the theory of comonotonicity. We start with deriving a partial differential equation (PDE) for the European-type comonotonic basket derivative price, together with a unique self-financing hedging strategy. We show that American basket option prices can be determined by applying a finite difference method. We show that our results of the comonotonic market can be used to approximate American-type basket derivative prices for a basket with correlated stocks. Our methodology generates American basket option prices which are in line with the prices obtained via the standard Least-Square Monte Carlo approach. The numerical tests highlight the deficiency of the standard LSM method, which is outperformed by our methodology in both accuracy of the price and computation time.

Keywords: semigroup with involution, implied volatility, peacock, lift zonoid, logconcavity
The Volatility Surface for Real Option Analysis: The Case of Renewable and Traditional Energy Projects

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Abstract

The aim of this paper is to provide a suitable method to estimate the volatility parameter for the purpose of real option project valuation, especially that of renewable and traditional energy projects. For a certain date and given debt-to-equity relation of the project, the implied volatility may be obtained by employing the volatility surface for real options and this value would be used for project valuation. The volatility estimation method is mainly based on the concept of implied volatility of financial options. We obtain implied volatility point estimates for different values of debt-to-equity ratios from both renewable and traditional energy firms instead of “moneyness” or the strike price used in the case of financial options. The shape of the volatility graph is interpolated by employing the stochastic alpha-beta-rho (SABR) model to obtain other values different from the initial estimates. Our methodology may be extended to find the volatility of a project in any industry, subject to the availability of market data. Our empirical results show that the annual volatility for renewable energy projects ranged between 16.44% and 38.15% in the period from April 2014 to June 2016.
Data-Driven Distributionally Robust Optimization
Applied to Portfolio Optimization

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Abstract

In the field of mathematical optimization, stochastic programming is a framework for modeling optimization problems that involves uncertainty in the form of a random variable. Usually, the probability distribution of the variable is unknown, hence another approach known as Distributionally Robust Optimization (DRO) has emerged recently. This approach assumes that the true distribution of the random variable involved in the problem belongs to a set of distributions called Ambiguity Set. Therefore, every stochastic optimization problem has its DRO counterpart. When this set is defined as a ball with respect to the Wasserstein metric centered at the empiric distribution, the DRO problem can be reformulated as a semi-infinite optimization problem and, depending on the objective function, this problem can be formulated as a finite convex optimization problem. There are several fields in which stochastic optimization problems appear. In this work we show one application, this is a DRO version of the portfolio optimization problem in the context of the Markowitz Mean-Variance Portfolio Theory. Here, we wish to find the portfolio that minimizes the variance subject to the expected return being greater than an amount established by the investor. In practice the returns are random, and its distribution is unknown and therefore sample estimations are used for the mean vector and the covariance matrix providing solutions highly sensitive to the sample. We show that this phenomenon is reduced with our method.

Keywords: Robust Optimization, Wasserstein metric, portfolio optimization.
Optimal ALM for Insurers with Multiple Underwriting Lines: A Martingale Approach

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Abstract

We study a continuous-time asset-allocation problem for an insurance firm with multiple lines of business that backs up the liabilities raised by the insurance contracts with the underwriting profits and the income resulting from investing in the financial market. We assume a standard multi-dimensional Black-Scholes model for the financial assets and a multi-dimensional perturbed compound-Poisson model for the insurance risk processes. We allow the Brownian motions in both models to be correlated and consider both cases with dependent and independent claims. Using the martingale approach we characterize strategies that maximize expected utility from consumption and final wealth under CRRA preferences. We present numerical results for some distributions of claims/liabilities with policy limits.

Keywords: Portfolio management; Martingale approach; Utility maximization.
Market Models with Alternating Jumps Depending on Inter-Arrival Times

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Abstract

We study optimal investment strategies that maximize expected utility from consumption and terminal wealth in a market model with jumps and mean rates of returns that alternate between two states and depend on the waiting times between jumps. We characterize explicitly the compensator of the counting process associated with the arrival times and use this to derive a coupled system of Volterra equations of second kind for the expected values of the process. As an application, we consider the growth-optimal portfolio and approximate numerically the solution of the associated Volterra system for inter-arrival times with hyper-exponential and Weibull distributions.
Method for Selecting Portfolios: An Approach Based on the Assets Distribution Rotation

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Abstract

A typical problem in Finance is to find the portfolio weights that maximize an expected utility. Hadar and Russel proved that if the risky assets are i.i.d, the naive portfolio gives the maximal expected utility. Later this result was generalized by replacing the assumption of independence with the assumption of exchangeability. In this work, we suppose that an agent has to allocate a budget in different and dependent risky assets and we propose an optimal solution based on rotations of the risky assets (random variables) such that the maximal diversification in the rotated assets gives the maximal expected utility. The case when the assets follow a multivariate elliptical distribution is also discussed.

Keywords: Portfolio Selection, Utility Function, Risky Assets
A Model of Market Weights Process and Related Portfolio Performance

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Abstract

We study a type of stochastic differential equation arising from nonlinear optimal filtering problem. This equation has some interesting properties, for example it has a unique strong solution that stays in the unit simplex, which can be seen as the weights of stocks in a capital market. Furthermore, based on this model of market weights, we investigate long-term behavior of the market, relative arbitrage opportunities and other portfolios generated by this market structure. This model can be applied to stock market indices, where weights correspond to relative market prices or capitalizations of stocks.

Keywords: Stochastic Portfolio Theory, Ergodic Process, Relative Arbitrage, Portfolio Optimization, Capital Distribution
Quadratic Optimization based Static Hedging of Weather and Price Risks in the Energy Market

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Abstract

We propose a Quadratic Optimization based method to find an optimal hedging claim by an economic agent facing both weather and price risks, without making any assumption on the underlying distributions. This paper concentrates in the case of an energy retailer procuring power from the wholesale market at the standing spot price and selling it at a fixed price to consumers exhibiting variable demand. This paper determines the optimal derivative pay-off written on both electricity price and a weather-linked index; aiming to construct a hedging claim to mitigate price and weather related risks. Numerical experiments illustrate the possible gains obtained from the proposed procedures.
Constrained Utility Maximization Problem of a Variable Annuity Policyholder.

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Abstract

We discuss a portfolio management problem of the rational policyholder of a variable annuity who aims to maximize the utility of maximal wealth with financial guarantees. This problem generalizes the classical Merton’s portfolio optimization problem in that the utility of the payoff is non-concave. The problem is formulated as a constrained optimal stochastic control problem. We solve the problem using a martingale approach and compare with existing results.

Keywords: portfolio; variable annuity; utility
Fixed Income Asset Allocation through Risk Factors with Dynamic Term Structure Form Factor Forecasts

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Abstract

It is well known that three factors can explain over 90% of the volatility of the US Treasuries interest rate spot curve (level, slope and curvature) Litterman, Robert and Scheinkman (1991) and for that reason the idea of using a Dynamic Term Structure Factor model in which latent factors are stochastic (Diebold and Li, 2006) to forecast returns and use them for asset allocation is so appealing (Caldeira, Moura, and Santos, 2012). First we will find the set of latent factors to be used for curve building. Then we will construct two sets of forecast of the latent factors: the first one based on time series analysis methods and the second one in which we will forecast some macroeconomic factors, we will find a mathematical expression relating latent and macroeconomic factors and we will find the corresponding forecasts of the latent factors. With these forecasts we will estimate expected returns for each asset class included in the optimization process and used them as input for the second phase of the Black-Litterman approach. Finally we will compare them against four benchmarks (the equal weights portfolio, the equilibrium portfolio, the minimum variance portfolio and the equal risk contribution portfolio). For the comparison we will use cumulative returns, VaR/CVaR breaches, draw-downs (including time underwater) and diversity measures.

Keywords: fixed-income asset allocation, risk factors, macroeconomic factors, Dynamic Nelson-Siegel, Dynamic Term Structure Factor model, risk sensitivities
Posters
Artificial Neural Networks Model for Sovereign Risk Rating

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Abstract

This research has a double purpose. First, it seeks to develop a sovereign credit risk model that replicates the sovereign credit rating published by the most recognized credit rating agencies (CRAs): Fitch, Moody's and S&P Global (formerly Standard & Poor's). To do this we use artificial neural networks (ANN). Second, its objective is to evaluate the performance of the credit risk model in the presence of a different set of explanatory variables of the sovereign credit rating. The first set of variables (traditional variables) is composed of those which have been identified as relevant for the sovereign credit rating in the literature. The second set, identified as extended variables, includes some of the items that CRAs rated as relevant for the sovereign rating, and which have not generally been identified as relevant for the credit assessment, such as: governance indicators, participation in world GDP, volatility of real GDP growth, and volatility of inflation, among others.
Calidad del Mercado de Renta variable de Colombia

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Abstract

This study monitors several observable dimensions and measures a non-observable one of the Colombian intraday equity market quality. For this purpose, an intraday database containing trades and quotes (TAQ) of some the principal companies that trade on the Colombian Stock Market (BVC) is used. Relating these dimensions between each other, we find that at the beginning of trading hours, liquidity (measured as bid ask spread and depth) is the lowest and price volatility is high. Additionally, we observe that stocks with lower levels of price impact also have the highest levels of depth.
Discrete Time Markov Chain Model with Catastrophe to Determine Mean Time to Default of Credit Risky Assets

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Abstract

In this talk, the author deals with the problem of probabilistic prediction of the time distance to default for a firm. To model the credit risk, the dynamics of an asset is described as a function of a homogeneous discrete time Markov chain (DTMC) subject to a catastrophe, the default. The behavior of the DTMC is investigated and the mean time to the default is expressed in a closed form. Further, the methodology to estimate the parameters is presented. Numerical results are also provided to illustrate the applicability of the proposed model on real data and their analysis is presented.
Enhancing the Insurer's Expected Return by Reinsurance and Financing

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Abstract

A reinsurance contract is an effective risk management tool for an insurer to reduce the risk level of the aggregate loss from policyholders. It is also common that the insurer raises external capital to meet the regulation requirement. However, the interaction effect of these two methods has not been discussed adequately in current insurance literatures. In this work, we incorporate methods of external financing and reinsurance in one optimization problem, and determine the optimal strategy on external capital amount and reinsurance coverage from the insurer's point of view. We also discuss impacts on the insurer's behavior of changes in reinsurance pricing and in the cost of external capital.
Estimation of Salary Paths and Application to the Problem of The Existence of Subsidies in the Average Premium Regime

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Abstract

This paper shows the methodology for calculating the wage path proposed by Montenegro, Jiménez and Hurtado (2013), and also proposes a series of methodologies for the construction of the wage path through non-parametric regressions, focusing mainly on the Premium Regime Defined Benefit Media (RPM-PD). Taking into account this, the objective of this work is to conduct a comparative study between these two methodologies using the data of the city of Medellín for the periods 2008, 2011 and 2014; then determine which methodology is most appropriate to quantify the path wage. Likewise, the salary paths calculated to estimate the contributions of a generic worker during his working life are used, such contributions plus the financial returns are the accumulated capital that is invested in the purchase of a pension through an annuity. Eventually, based on this estimate will be established, if the conditions allow for subsidies in the RPM-PD, and if so, quantify the subsidy that will be transferred by the State.
Firm Size and Concentration Inequality: A Flexible Extension of Gibrat’s Law

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Abstract

The study assesses the performance of the lognormal distribution (Gibrat, 1931) compared with its generalization in terms of a semi-nonparametric (SNP) expansion, the log-SNP distribution, for determining economic concentration and providing adequate values of inequality based on the Gini index adjusted to flexible functional forms. Data from a sample of 1,772 companies from Colombia were collected from 1995 to 2015 and analyzed, and the results indicated that, compared with the lognormal distribution, the log-SNP distribution provided a better fit to firm size distribution, especially in the higher quantiles, which represent larger and smaller companies. Therefore, the traditional assumption of lognormality overestimates the level of economic concentration, rejecting Gibrat’s law. In addition, the estimates of a dynamic panel model indicate that firm characteristics, including size, age, and leverage, are determining factors in explaining firm growth.
Markov Switching Autoregressive Models with Elliptical and Skew-Elliptical

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Abstract

In the financial stock market, it is important to have knowledge about distribution of the stock return and its implications. There have been several proposals about the distribution the stock returns could have, different to the gaussian assumption, which have desirable distributional properties such as multimodality, skewness, asymmetry, heavy tails, consenting be more flexible in the aim of describing the real behavior of data. Historically, it has been taken normal distribution as a starting point but distributions of the elliptic and skew elliptic family share properties of the original one and greater shape flexibility depicting better fit with data.

An increasing interest to work with these distributions in a markov switching framework has been developed in recent years. This approach of markov switching models permits, in economy, suggest marginal contributions of institutions to systemic risk in times of instability and explain periods of recession and expansion, a dynamic that may be modelled under regime changes.

In this work we are going to study and compare markov switching models with univariate conditional distributions that belong to elliptic and skew elliptic family. This analysis is done with emphasis on autoregressive markov switching models which describe the evolution of the parameters in time, capture regimes that are not considered by a classical linear model, and tested with real financial data where the selected model is made by an information criteria.
Nonparametric Approach to Measure Risk: The Case of Electricity Markets

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Abstract

Considering a discrete setting, this research looks for hedging price risks strategies for Energy Retailers (ER) by constructing a portfolio based on different plain vanilla derivatives. The method is based on nonparametric technics, using kernel density distributions, to establish more accurate and adequate risk management in those markets. In conclusion, the assumption of a parametric VaR produces a bias in the interpretation of the data. Instead, the application of the nonparametric VaR as the measure of risk represents a better interpretation of electricity markets and improve hedging strategies.
Numerical Solutions to PDE Representations of Derivatives with Bilateral Counterparty Risk and Funding Costs

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Abstract

The purpose of this paper is to present numerical solutions to PDE representations for pricing derivatives including bilateral credit valuation adjustments and funding costs valuation adjustment as presented in Burgard & Kjaer (2011). In particular, we use Crank-Nicolson finite-difference scheme to solve Black-Scholes risk-free PDE, for European and American options, and later show how this numerical solution approach is extendable to solve the PDE for the risky value of the same derivative, using the same finite-difference scheme and algorithm. Also, we present numerical solutions to valuation adjustments derived from PDE representations for European options through Monte Carlo simulation and numerical integration, and we finish by exploring an empirical approach for American options through Monte Carlo simulation, least-squares and numerical integration.
Portfolio Selection Based on Margin Risk and Joint Information

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Abstract

In this research, we develop three simple methods for portfolio selection based on joint information and margin risk of the assets. We use robust and non-parametric statistical techniques to estimate margin risk and correlation, respectively. We assign higher weights to those assets with lower risk and negative correlation. Also, we compare the out of sample performance of our methods with classic methods on the literature over four data sets using a rolling horizon procedure. As the main conclusion, we find that our method outperforms the classical strategies considered in terms of higher Sharpe ratios and lower turnover measures.
Stochastic Optimization Applied to Portfolio Management at Higher Education Institutions

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Abstract

Nowadays, financial sustainability is one of the most critical issues in organizations around the world. This fact is not unfamiliar at higher education institutions. In this context, universities often have temporary funds and receive donations that can be part of an investment portfolio. If managed wisely, the returns generated can support a portion of the university’s annual budget. The above is known as “endowment” Universities such as Yale, Harvard, MIT, Texas, UAM, Unicamp — to name a few — use it widely.

Quantitative techniques can be used to help the decision makers at portfolio management solve the portfolio choice problem to maximize the expected value of returns and adjust the risk measurement defined by the university. The risk profile of higher education institutions frequently involves safety risk measures. These kinds of problems are known in optimization literature as NP-Hard.

This research focused on developed stochastic optimization models for the portfolio choice problem, including the particularities of a public university in Colombia and assets from the capital market in this country. We worked with two-stage and multi-stage stochastic models with different risk measures. In the end, we formulated six stochastic models and one traditional model, that were contrasted and evaluated. We used the software R and AMPL for treatment, models, and results.

The possible set of assets to be selected in the portfolio were bonds, stocks index, stocks, and derivatives. We worked with a lot of missing values, as the Colombian market is highly illiquid. Besides, this research found out the assets analyzed did not present normal returns as usually are treated in theory. As a consequence, bootstrap technique was used to generate the multi-stage scenarios.
The models were evaluated using the Expected Value of Perfect Information (EVPI) and Value of Stochastic Solution (VSS). The results showed the best model implemented for the university case was the two-stage stochastic model. Besides, the analysis in the objective function about the level of importance at returns or risk, let concluded that when the risk profile gives an importance up to 0.7 or more at risk level, stochastics’ models performed better than static’s ones.

Among other conclusions, we found a broad application of stochastic optimization to solve the portfolio choice problem in international literature. In contrast, we did not find evidence of publications using stochastic optimization in Colombia. Finally, this work let the public higher university to incorporate the model as a tool to support its investment decisions. Besides, the university opened a line of research in a financial laboratory at that university, and so it became a successful case of an alliance between the academic and administration areas in a university.
Stochastic Volatility Models in The FX Markets

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Abstract

The identification of the price movement with risk such as the geometric Brown motion from Black, Scholes and Merton, led to the deduction of Black Scholes model for validation of European options; however, that model is not compatible with the practice in some financial markets like FX (Foreign Exchange Markets), because it supposes a constant volatility. In this poster, I will present the results of my master's thesis in which we studied more general models like: Stochastic volatility models, local volatility model and local stochastic model.
Stop-Loss Estimation Via Single Loss Approximation. An application to Critical Illness Reinsurance

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Abstract

This poster consists of the calculation of the actuarial price of the insurance policy for high cost or catastrophic illness, offered by a private health insurance company (HIC). The methodology applied assumes the classical Cramer-Lundberg collective risk model for a year-long contract, and presents the actuarial valuation of the retention point in a Stop-loss (SL) reinsurance, denoted \( R \), and defined as the maximum limit assumed by the HIC, of the total annual cost generated in the portfolio of a high-cost illness. Costs that exceed this \( R \) value are assumed by a reinsurer. The methodology for the determination of \( R \), is based solely on the frequency and severity of the claims, and will not take into consideration solvency problems or associated considerations about the probability of ruin.

This work determines the retention value \( R \), as an extreme percentile in the right tail of the distribution of the total annual cost, which is known as Value at Risk (VaR). Associated with this value, the Tail Value at Risk (TVaR) and the Expected Shortfall (ES) are estimated, which have a simple relationship, where the estimation of two of them allows the estimation of the third. In this case, the VaR and the TVaR are estimated, and these values are allowed to determine the ES, which corresponds to the actuarial net annual premium for the SL reinsurance treaty.

To carry out the proposed estimation, it is required that the distribution of the severities be heavy-tailed, a distribution that will be associated with the costs of a high-cost illness. For the total claim, an asymptotic estimate of the tail is assumed, given by the formula of Bocker-Kluppelberg, in order to obtain the VaR. Since this formula underestimates the VaR, the corrections suggested in Bocker and Sprittulla (2006) and in Albrecher, et al. (2017, pag. 199) are used.
For the approximate calculation of TVaR, the proposal of Biagini and Ulmer (2009, Theorem 2.5) is used, assuming that the severities have a heavy-tail distribution. Finally, the VaR correction of Bocker and Sprittulla (2006) is applied to obtain an expression of TVaR, called Single Loss Approximation (SLA). To apply the correction, it is required to estimate the heavy tail index, as well as adjust the appropriate distributions for frequency and severities.

A numerical illustration of this implementation of the SLA methodology is included for the estimation of an annual premium of SL reinsurance, in the specialty of surgery in an HIC. In addition, we compared the results with another methodology based on the fact that the SL premium can be expressed as the price of a European purchase option, and calculate it using the Black-Scholes formula. Since this methodology assumes that the total annual cost is distributed Log-Normal, the effect of this hypothesis is also examined in case of not met. To perform all the calculations, the R language is used, together with several of its libraries and models for the distribution of costs.
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