MÉTODOS MATEMÁTICOS Y COMPUTACIONALES APLICADOS A LAS FINANZAS Y LA ECONOMÍA

ORGANIZADA POR: MANUEL MAURETTE Y CARLOS VÁZQUEZ

Horario

15/12/2022, 12:30–12:55: Álvaro Leitao, *Deep learning for extracting implied information from American options.*
15/12/2022, 13:00–13:25: Agustín Muñoz-González y Juan Ignacio Sequeira, *Modelo de un mercado teórico por Caginalp et al.*
15/12/2022, 13:30–13:55: Luis Ortíz, *Estimation of stochastic volatility models via the likelihood function.*
15/12/2022, 15:30–15:55: Víctor Gatón, *Investment in cleaner technologies in a transboundary pollution game: A numerical investigation.*
15/12/2022, 16:00–16:25: Augusto Blanc-Blocquel, *Hedging at-the-money digital options near maturity.*
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Resúmenes

Shuaiqiang Liu, Álvaro Leitao, Anastasia Borovykh and Cornelis W. Oosterlee.
Deep learning for extracting implied information from American options
Extracting implied information, like volatility and dividend, from observed option prices is a challenging task when dealing with American options, because of the complex-shaped early-exercise regions and the computational costs to solve the corresponding mathematical problem repeatedly. We will employ a data-driven machine learning approach to estimate the Black-Scholes implied volatility and the dividend yield for American options in a fast and robust way. To determine the implied volatility, the inverse function is approximated by an artificial neural network on the effective computational domain of interest, which decouples the offline (training) and online (prediction) stages and thus eliminates the need for an iterative process. In the case of an unknown dividend yield, we formulate the inverse problem as a calibration problem and determine simultaneously the implied volatility and dividend yield. For this, a generic and robust calibration framework, the Calibration Neural Network (CaNN), is introduced to estimate multiple parameters. It is shown that machine learning can be used as an efficient numerical technique to extract implied information from American options, particularly when considering multiple early-exercise regions due to negative interest rates.

Agustín Muñoz-González; Juan Ignacio Sequeira. *Modelo de un mercado teórico por Caginalp et al.*

Presentaremos el análisis de un modelo de precio para un activo financiero creado por Caginalp y colaboradores. Se derivaran un conjunto de ecuaciones diferenciales que juntas describen una dinámica para el comportamiento de los inversores en un mercado financiero teórico.

Se utilizarán identidades básicas microeconómicas y de conservación donde se incorpora la idea de finitud de los activos. Además, una noción de sentimiento del mercado es modelada como la preferencia de compra o venta influenciada por el impulso del precio (aspecto emocional) y por el descuento del valor fundamental (aspecto racional).

Por medio de retardos discretos consideraremos escenarios donde la dinámica del precio del activo se actualiza utilizando información pasada, y analizaremos su estabilidad.

Finalmente, la relevancia del sentimento de mercado puede considerarse variable obteniendo así un modelo más general que permite representar distintos patrones de compra y venta del grupo de inversores.

Augusto Blanc-Blocquel, Luis Ortíz-Gracia; Rodolfo Oviedo. *Estimation of stochastic volatility models via the likelihood function*

We propose a maximum likelihood approach to estimate the parameters of a stochastic volatility (SV) model. The SV model can be seen as a state-space model, this is, a stochastic model in discrete-time which contains two sets of equations, the state equation and the observation equation. While the first describes the transition of a latent process in time, the second shows how an observer measures the latent process at each time period. We infer the properties of the latent variable by means of a filtering algorithm. The evaluation of the likelihood function is a time-consuming task that involves updating and prediction steps of the state variable, leading to the computation of complicated integrals. We calculate these integrals by means of finite expansions of Shannon wavelets, and compare the root mean square error (RMSE) of the estimation with state-of-the-art methods. The results show that the RSME is dramatically reduced with a short CPU time with the use of wavelets.

Javier de Frutos, Víctor Gatón, Paula M. López-Pérez, Guiomar Martín-Herrán. *Investment in cleaner technologies in a transboundary pollution game: A numerical investigation*

The analysis and design of efficient policies to face transboundary pollution problems between countries, such as global warming, is a relevant issue on the political agenda. A (differential) dynamic game is a very useful framework for the analysis of this kind of problems.

Unfortunately, we usually lack an explicit solution, even for the simplest games, so numerical methods have to be employed. The evolution of the state of the system (pollution in different countries which might share or not a common boundary) depends both on the previous state and the decisions (controls) of the different players. So, this a multidimensional problem where the computational cost to obtain the optimal policy in each moment grows very fast as the number of players increase.

We will see that Chebyshev polynomials can be employed in the design of efficient numerical methods for obtaining a numerical solution for this kind of problems.

Augusto Blanc-Blocquel; Luis Ortíz-Gracia; Rodolfo Oviedo. *Hedging at-the-money digital options near maturity*

In the present work, we have investigated the hedging of at-the-money digital options near maturity, which remains a challenge in quantitative finance. We carry out a hedging strategy by means of a bull spread, and solve different optimization problems, with the aim of minimizing the probability of sub-hedging the digital option at maturity, taking into account transaction costs and illiquidity issues. We perform a wide variety of numerical experiments under different asset dynamics, GBM, Heston and CGMY models. The CGMY model is calibrated to market data and used to get the optimal composition of the bull spread satisfying the cost of hedging restriction. Derivative-free algorithms are employed within the minimization problems. For the GBM dynamics, a gradient based algorithm is implemented, showing a best performance than derivative-free algorithms. In terms of ease of implementation, the GBM model is preferred, since formulae are available in closed form. For the other two models, the choice should be based on their ability to fit the real data, which in turn depends on the underlying asset. All in all, we provide a set of solutions for hedging digital options that can be potentially used in practice.

María A. Baamonde-Seoane; M. Carmen Calvo-Garrido; Carlos Vázquez. *PDE models for pricing renewable energy certificates and related products*

Some new models and methods for pricing Renewable Energy Certificates (RECs) and associated European style derivatives on RECs are presented. For this purpose, we consider two stochastic factors: the accumulated green certificates sold by an authorized generator and the natural logarithm of the renewable electricity generation rate.

Next, starting from a system of FBSDEs and using Ito lemma, we obtain a mathematical model formulated in terms of a semilinear PDE for pricing RECs. One main novelty of the work comes from the numerical treatment of the nonlinearity that appears in the term containing first order derivative in the PDE. Thus, we combine a duality method for the nonlinear term with a Lagrange-Galerkin technique for the full discretization.

Moreover, we state the mathematical model that governs the valuation of European style derivatives whose underlying is a REC, in particular we study vanilla options and futures contracts. Once the REC price is given, the value of the European derivative is the solution of a linear backward Kolmogorov PDE. We study the existence of solution by probabilistic methods and propose how to solve the model by using appropriate numerical techniques.
