WORKSHOP ON NUMERICAL APPROXIMATION OF HYPERBOLIC PDES IN HONOR OF PROF. CARLOS PARÉS' 60TH BIRTHDAY
Málaga, November 16-17, 2023

PDE pricing models in renewable energy certificates markets

M. BAAMONDE-SEOANE[*], M.C. CALVO-GARRIDO[†], C. VÁZQUEZ[‡]

In this talk, some new pricing methods for Renewable Energy Certificates (RECs) or green certificates and associated derivatives products are presented. For this purpose, starting from a system of forward-backward stochastic differential equations (FBSDEs) and using Ito lemma, we first propose a mathematical model based on a semilinear PDE arising from the consideration of two stochastic factors: the accumulated green certificates sold by an authorized generator and the natural logarithm of the renewable electricity generation rate. 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. The nonlinear advection term is formulated in terms of a maximal monotone operator, so that Yosida regularization techniques will be involved [5]. The method has been previously applied for the same type of nonlinearity in the diffusion term in [1]. Several semi-Lagrangian techniques are used for the time discretization of the PDE and combined with either finite differences schemes or finite element methods for the spatial discretization, as for example the ones in [6]. Further details on the proposed models for pricing RECs and the numerical methods can be found in [2] and [3].

Moreover, we state the mathematical model that governs the valuation of derivatives of European style whose underlying is a REC, in particular we study European options and futures contracts. Thus, we first derive the PDE model to price these derivatives, study the existence of solution and propose how to solve the models by using appropriate numerical techniques. If we assume that the REC price is known and obtained from the models and methods described in the previous paragraph, then the PDE for pricing the European derivative is linear. Finally, we show some numerical results that illustrate the performance of the proposed model and the numerical methods. More details can be found in [4].

Acknowledgements

This research has been partially Spanish Ministry of Science and Innovation (Grant PID2019-108584RB-I00) and by Galician Government (Grant ED431C2018/033), both including FEDER financial support. Authors also acknowledge the support received from the Centro de Investigación de Galicia (CITIC), funded by Xunta de Galicia and the European Union (European Regional Development Fund-Galicia 2014-2020 Program), by grant ED431G 2019/01.

References

[1] I. Arregui, J.J. Cendán, C. Vázquez. A duality method for the compressible Reynolds equation. Application to the simulation of read-write processes in magnetic reading devices. *J. Comput. Appl. Math.*, 175: 31–40, 2005.

[2] M.A. Baamonde-Seoane, M.C. Calvo-Garrido, M. Coulon, C. Vázquez. Numerical solution of a nonlinear PDE model for pricing Renewable Energy Certificates (RECs). *Appl. Math. Comput.* 404: 126199, 2021.

[3] M.A. Baamonde-Seoane, M.C. Calvo-Garrido, C. Vázquez. Pricing renewable energy certificates with a Crank-Nicolson Lagrange-Galerkin numerical method. *J. Comput. Appl. Math.* 422: 114891, 2023.

[4] M.A. Baamonde-Seoane, M.C. Calvo-Garrido, C. Vázquez. Model and numerical methods for pricing renewable energy certificate derivatives. *Commun. Nonlin. Sci. Numer. Simul.* 118: 107066, 2023.

[5] A. Bermúdez, C. Moreno. Duality methods for solving variational inequalities. *Comp. Math. Appl.* 7: 43–58, 1981.

[*]Departamento de Matemáticas and CITIC, Facultad de Informática, Universidade da Coruña. Email: carmen.calvo.garrido@udc.es
[†]Departamento de Matemáticas and CITIC, Facultad de Informática, Universidade da Coruña. Email: maria.baamonde1@udc.es
[‡]Departamento de Matemáticas and CITIC, Facultad de Informática, Universidade da Coruña. Email: carlosv@udc.es

[6] A. Bermúdez, M.R. Nogueiras, C. Vázquez. Numerical analysis of convection-diffusion-reaction problems with higher order characteristics finite elements. Part I: Time discretization. *SIAM J. Num. Anal.*, 44: 1854–1876, 2006.