Faculty of Informatics
Department of Mathematics

Research Group M2NICA

University of A Coruña

Series of Conferences on

"Real Options and finance: Optimal Stochastic Control Formulation and Solution Techniques"

Prof. Peter Forsyth

Cheriton School of Computers Science, University of Waterloo

Prof. Margaret Insley

Department of Economics, University of Waterloo

Program and time schedule:

September 1st, 12:00: P. Forsyth, *Long term asset allocation for patient investor*
September 1st, 16:30: M. Insley, *On the timing of non-renewable resource extraction with regime swithchig prices: an optimal stochastic control approach*

September 2nd, 10:00: P. Forsyth, *Long term asset allocation: HJB formulation and solution*
September 2nd, 11:30: M. Insley, *An option pricing approach to ramping rate restricitions at hydro power plants*

September 3rd, 10:00: P. Forsyth, *Monotone schemes for two factor HJB equations with nonzero correlation*
September 3d, 12:00: P. Forsyth, *Methods for pricing American options uncer regime switching*

Place: Classroom of Master in Industrial Mathematics at University of A Coruña. In case of interest and availability it will be also delivered through videoconference systems to Santiago and Vigo Master rooms

Further information: Prof. Carlos Vázquez Cendón (**carlosv@udc.es**)**.** Although attendance is free of charge, notification in advance of attendance is welcome.

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Abstracts of conferences

1) Long Term Asset Allocation for the Patient Investor (1 hour), Peter Forsyth

Many studies have shown that the most important factor in investment success is asset allocation, as opposed to stock picking. At its most basic level, this amounts to the choice of how much to allocate to bonds and stocks. In fact, there are popular mutual fund products (target date funds) which automatically adjust the stock/bond ratio as the holder nears retirement.
In this talk, we will formulate the portfolio allocation problem as the solution to a problem in optimal stochastic control. I will discuss semi-self-financing mean-variance (MV) dynamic asset allocation strategies which are superior to self-financing MV portfolio strategies. Our strategies are built upon a Hamilton-Jacobi-Bellman (HJB) equation approach for the solution of the portfolio allocation problem.
MV strategies are often criticized for penalizing the upside as well as the downside. However, under our strategies, the MV portfolio optimization problem can be shown to be equivalent to maximizing the expectation of a well-behaved utility function of the portfolio wealth. We show that, for long term investors, the use of dynamic MV strategies can achieve the same expected value with a much smaller standard deviation and probability of shortfall compared to a constant mix strategy. We also show that the typical strategies used by target date mutual funds are sub-optimal.

2) On the timing of non-renewable resource extraction with regime switching prices: an optimal stochastic control approach (1.5 hours), Margaret Insley

Commodity prices are typically highly volatile and characterized by cycles of boom and bust. Investments in resource extraction tend to mirror these cycles, with resulting environmental consequences. This talk investigates the economics of non-renewable natural resource extraction taking account the boom and bust cycle of commodity prices, using investment in oil sands extraction in Alberta as an example.
We seek to deepen our understanding of the optimal response of resource investment to uncertain commodity prices, which provides the backdrop for devising appropriate environmental regulations. We model the decisions of a profit maximizing firm with the option to develop a non-renewable resource deposit, choosing the timing and pace of development, as well as the decision to produce the resource or shut down if prices become weak. The resource price is modelled as a regime switching process, which is calibrated to oil futures prices. A Hamilton-Jacobi-Bellman equation is specified that describes the profit maximization decision of the firm. The model is used to solve for critical price levels at which it is optimal for a firm to invest in extraction, begin production, or shut down operations.
The talk focuses on the impact of the prospect of regime shifts in commodity prices on optimal decisions and the pace of development. The paper also considers the effect on optimal decisions and production timing of the prospects of stricter environmental regulations in the form of a carbon tax.

3) Long Term Asset Allocation: HJB Formulation and Solution (1 hour), Peter Forsyth

This talk will discuss the technical details of the numerical methods used in the lecture "Long term asset allocation for the patient investor." An intuitive derivation of the embedding method used to formulate the HJB equation for dynamic mean variance problems is discussed. A simple algorithm for removing spurious points from the embedded solution is presented. We also present an intuitive derivation of the discretization method used for the HJB equation. This technique is unconditionally stable and monotone, yet does not require any policy iterations.

4) An Options Pricing Approach to Ramping Rate Restrictions at Hydro Power Plants (1.5 hours), Margaret Insley

Hydro electricity is considered an environmentally friendly source of power as it is not associated with the release of carbon and other harmful emissions. Water release rates can be easily adjusted in response to changing electricity demand and prices, making hydro a low cost option for meeting peak demands. However this operating flexibility is known to have environmental costs. This talk presents a real options approach to examining the impact of ramping rate restrictions imposed on hydro operations to protect aquatic ecosystems. We will consider the effect on hydro plant value in order to inform policy decisions. Electricity prices are modelled as a regime switching process.
We show that hydro plant value is negatively affected by ramping restrictions, but the extent of the impact depends on key parameters which determine the desirability of frequent changes in water release rates. Interestingly for the case considered, value is not sensitive to ramping restrictions over a large range of restrictions.
The results point to the importance of accurately modelling electricity prices in gauging the trade-offs involved in imposing restrictions on hydro operators which may hinder their ability to respond to volatile electricity prices and meet peak demands.
This talk is based on joint work with Shilei Niu.

5) Monotone Schemes for Two Factor HJB Equations with Nonzero Correlation (1.5 hours), Peter Forsyth

In the case of two or more stochastic factors, with a nonzero correlation between the factors, it is a non-trivial matter to construct a monotone discretization scheme for HJB equations. In this talk, we discuss use of a wide stencil method, based on a local virtual grid rotation. Special care must be taken to ensure consistency near the boundaries of the computational domain.
We use unconditionally stable fully implicit timestepping. In order to generate accurate efficient frontiers, it is crucial to modify the usual linear interpolation technique which is needed for semi-Lagrangian timestepping.
The non-linear discretized algebraic equations are solved using a Policy iteration algorithm. Numerical results are presented for an uncertain volatility option pricing problem and asset allocation with stochastic volatility. We also demonstrate the use of a hybrid PDE-Monte Carlo approach

6) Methods for Pricing American Options Under Regime Switching (1 hour), Peter Forsyth

Regime switching processes are considered to be excellent models of electricity prices, natural gas spot prices, and have also found application in long term insurance guarantees. We analyze a number of techniques for pricing American options under a regime switching stochastic process, using PDE (partial differential equation) methods. The techniques analyzed include both explicit and implicit discretizations with the focus being on methods which are unconditionally stable. In the case of implicit methods, we formulate the American pricing problem as an abstract optimal control problem.
We compare a number of iterative procedures for solving the associated nonlinear algebraic equations. Numerical tests indicate that a fixed point policy iteration, coupled with a direct control formulation, is a reliable general purpose method.