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Newsletter

Groupe d'études et de recherche en analyse des décisions

GERAD

Publishing that Bears Witness to the Quality of Research

In this issue, the GERAD Newsletter provides readers with an overview of eleven research projects whose results have recently been published. This sample shows the broad diversity of problems in which mathematics in decision-making plays a key role. The projects presented differ as regards both the areas in which methodological developments are achieved (e.g., optimization, statistics, financial engineering, game theory) and the applications (e.g., revenue management, valuing of options, electricity sector investments, climate and environmental management). The eleven articles nonetheless have a point in common, namely that they were all published in the leading journals in their respective fields. These are *Automatica, Energy Journal, IEEE Transactions on Automatic Control, Journal of the American Statistical Association, Management Science, Mathematical Programming, Operations Research* (3 articles), *Production and Operations Management* and *SIAM Journal of Optimization*. These published articles represent another clear indication of the high scientific quality of research conducted at GERAD by members and their students.

Enjoy the newsletter,

Georges Zaccour

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Volume 5 • Number 2
December 2008

In this issue... ***scientific articles in leading journals.***

Dynamic Programming Approach for Valuing Options in the GARCH Model

Hatem Ben-Ameur, Michèle Breton and Juan-Manuel Martinez

An option gives its holder the right to buy (or to sell) a specified underlying asset, at some given future date, for a given fixed price. Options or other derivatives are now used routinely by firms, mainly to manage their exposure to financial risk, for example to foreign exchange, interest rate and commodity price risk.

In this paper, the authors propose an efficient computational method to evaluate the price of an option written on an underlying asset when the price of this asset is described by a GARCH process. This model assumes that the volatility of asset prices is not constant, but shows persistence over time, so that it can be represented by an auto-regressive process. This assumption is supported by empirical evidence of market prices of many traded assets. One feature of practical interest of this model is the fact that volatility can be estimated using observable market prices.

In the GARCH framework, the Markov chain approximation proposed by J.-C. Duan and J.-G. Simonato in 2001 was the most efficient method to date. H. Ben-Ameur, M. Breton and J.-M. Martinez proposed a Dynamic Programming (DP) algorithm, coupled with a finite element approximation of the option's value, which gives a much more precise evaluation in less computing time. They also showed that Markov chain approximation could be considered a special case of the DP algorithm. The paper is partly based on the M.Sc. thesis of Juan-Manuel Martinez, in the financial engineering program at HEC Montréal.

The method is very efficient for the evaluation of derivatives written on a single asset. It computes the value of the derivative corresponding to all possible values of the asset's price and volatility, at all observation dates. For derivatives written on more than one asset, DP can no longer be used because of memory requirements (the value of the derivative for all possible combinations of factors can no longer be stored). An interesting development would be to adapt DP approximation procedures and obtain reliable estimations for the approximation error.

Efficient pricing methods and algorithms for options or other derivatives are important in both the practical and the academic context. First, while some options are exchange-traded, there is a huge market for Over-the-counter (OTC) derivatives, traded directly between two parties. Under the GARCH assumption, an efficient pricing algorithm allows the computation by both parties of the value of the option, given the series of observable market prices of the underlying asset. Second, pricing algorithms are also used by academics for empirical applications: prices quoted (on an exchange market) are compared with theoretical prices computed by a pricing algorithm, to assess the validity of the model for the price of the underlying asset.

(*Management Science*, doi: 10.1287/mnsc.1080.0925., 2008)

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Locating a Circle on a Sphere

Jack Brimberg, Henrik Juel and Anita Schöbel

The idea for this project came from discussions between the three authors while they attended the Ninth International Symposium on Locational Decisions (ISOLDE IX) in Fredericton, New Brunswick, June 2002. We were together at a presentation on methods and latest results for location problems on a sphere. Continuous location models typically assume that the problem may be represented on the plane (R^2). However, it is recognized that when distances between facilities are sufficiently large, the model accuracy is enhanced when it includes the earth's curvature. At the same time, the new facilities to be located, and the market areas that they serve, are typically represented as points in the location space. In certain cases, however, such as the location of transportation or communication lines, the dimensions of the facility cannot be ignored. Thus a significant body of research in the location field deals with the problem of *linear* facilities as well as other types of dimensional facilities. The question of locating a (large) linear facility while taking into account the earth's curvature seemed to the authors to be a natural extension of the line location problem on the plane. It turns out that this question had not been asked before!

The paper considers two types of objectives: minimize a sum of (weighted) shortest distances between the circle and a set of fixed points on a sphere, known as the *minisum* criterion; minimize the maximum such distance between the circle and the set of fixed points, or the *minimax* criterion. We consider general spherical circles, but we also examine the important special case of great circles. The main result for the minimax problem is that every optimal great circle is at a max-