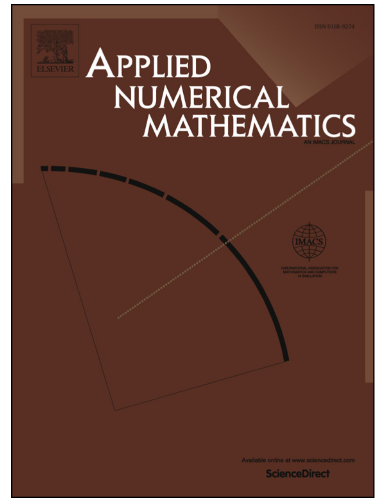
Accepted Manuscript



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PII: S0168-9274(18)30092-8
DOI: https://doi.org/10.1016/j.apnum.2018.04.003
Reference: APNUM 3357

To appear in: *Applied Numerical Mathematics*

Received date: 18 December 2017
Revised date: 22 March 2018
Accepted date: 9 April 2018

Please cite this article in press as: K.J. in 't Hout, J. Toivanen, ADI schemes for valuing European options under the Bates model, *Appl. Numer. Math.* (2018), https://doi.org/10.1016/j.apnum.2018.04.003

ADI schemes for valuing European options under the Bates model

Karel J. in 't Hout* and Jari Toivanen†

Abstract

This paper is concerned with the adaptation of alternating direction implicit (ADI) time discretization schemes for the numerical solution of partial integro-differential equations (PIDEs) with application to the Bates model in finance. Three different adaptations are formulated and their (von Neumann) stability is analyzed. Ample numerical experiments are provided for the Bates PIDE, illustrating the actual stability and convergence behaviour of the three adaptations.

Keywords: partial integro-differential equations, operator splitting methods, alternating direction implicit schemes, stability, Bates model.

1 Introduction

The traditional asset price model in financial option valuation theory is the geometric Brownian motion. It is well-known that this model assumes constant volatility while the market prices of options clearly indicate varying volatility. For the valuation of options with long maturities, stochastic volatility models like the Heston stochastic volatility model [18] are a common means to introduce such variability. For short maturities, however, pure Brownian motion based models such as the Heston model often require excessively large volatilities to explain the market prices of options. A modern way to resolve this is to incorporate jumps in the asset price model, like the classical Merton jump-diffusion model [36] does. The Bates model [6] combines the Merton model and the Heston model. This asset price model includes both jumps and stochastic volatility and it is therefore popular for valuing options with short as well as long maturities.

Under the Bates model, a two-dimensional parabolic partial integro-differential equation (PIDE) can be derived for the values of European-style options with the spatial variables representing the underlying asset price and its instantaneous variance [9]. The differential operator is of the convection-diffusion type. The integral operator, which stems from the jumps, couples all option values in the asset price direction.

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