Semi-analytical Valuation for Discrete Barrier Options Under Time-Dependent Lévy Processes

Guanghua Lian, Song-Ping Zhu, Robert J. Elliott, Zhenyu Cui

PII: S0378-4266(16)30216-3
DOI: 10.1016/j.jbankfin.2016.11.012
Reference: JBF 5042

To appear in: *Journal of Banking and Finance*

Received date: 30 August 2015
Revised date: 30 October 2016
Accepted date: 6 November 2016

Please cite this article as: Guanghua Lian, Song-Ping Zhu, Robert J. Elliott, Zhenyu Cui, Semi-analytical Valuation for Discrete Barrier Options Under Time-Dependent Lévy Processes, *Journal of Banking and Finance* (2016), doi: 10.1016/j.jbankfin.2016.11.012

Semi-analytical Valuation for Discrete Barrier Options Under Time-Dependent Lévy Processes

Guanghua Lian[*], Song-Ping Zhu[†], Robert J. Elliott[‡], Zhenyu Cui [§¶]

ABSTRACT

Simple analytical solutions for the prices of discretely monitored barrier options do not yet exist in the literature. This paper presents a semi-analytical and fully explicit solution for pricing discretely monitored barrier options when the underlying asset is driven by a general Lévy process. The explicit formula only involves elementary functions, and the Greeks are also explicitly available with little additional computation. By performing a $\mathcal{Z}$-transform, we reduce the valuation problem to an integral equation. This equation is solved analytically with the solution expressed in terms of a Fourier cosine series. We then manage to analytically carry out the $\mathcal{Z}$-transform inversion, and obtain a semi-analytical formula for pricing discrete barrier options. We establish the theoretical error bound and analyze the convergence order of our method. Numerical implementation demonstrates that our numerical results are accurate and efficient, and match up with the results from the benchmark methods in the literature.

J.E.L. Keyword: Discrete Barrier Options, Lévy Processes, Fourier-Cosine Series.

J.E.L. Classification: G13, C3.

[*]Haas School of Business, University of California, Berkeley, and School of Commerce, University of South Australia. Email address: guanghua_lian@berkeley.edu.

[†]School of Mathematics and Applied Statistics, University of Wollongong. Email address: spz@uow.edu.au.

[‡]Adjunct Professor, University of Adelaide; Faculty Professor, University of Calgary. Email address: relliott@ucalgary.ca . Professor Elliott wishes to thank the ARC (Australian Research Council) and SSHRC (Social Sciences and Humanities Research Council) for support.

[§]Corresponding author. Financial Engineering Division, Stevens Institute of Technology, Castle Point on Hudson, Hoboken, NJ 07030, United States. Tel: +1 (201)216-3726. Email address: zcui6@stevens.edu

[¶]This version was completed on Oct 30th, 2016.