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SWIFT valuation of discretely monitored arithmetic Asian options

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Abstract

In this work, we propose an efficient and robust valuation of discretely monitored arithmetic Asian options based on Shannon wavelets. We employ the so-called *SWIFT* method, a Fourier inversion numerical technique with several important advantages with respect to the existing related methods. Particularly interesting is that SWIFT provides mechanisms to determine all the free-parameters in the method, based on a prescribed precision in the density approximation. The method is applied to two general classes of dynamics: exponential Lévy models and square-root diffusions. Through the numerical experiments, we show that SWIFT outperforms state-of-the-art methods in terms of accuracy and robustness, and shows an impressive speed in execution time.

Keywords: Arithmetic Asian options, Fourier transform, Shannon wavelets, SWIFT method, Exponential Lévy processes, Square-root diffusions, Option pricing
2010 MSC: 60E10, 60G51, 60G52, 65T60, 65T50

1. Introduction

In Asian derivatives, the option payoff function relies on some *average* of the underlying values at a prescribed monitoring dates. This fact implies that the final value is less volatile and the option price cheaper. In this work, we will primarily focus on the arithmetic average, i.e. the so-called *arithmetic Asian* options, due to its financial importance and, as we will see, challenging numerical treatment.

In the recent literature of arithmetic Asian valuation, multiple dynamics have been considered, of which two broad classes are addressed here: *exponential Lévy models* and *square-root diffusions*. Exponential Lévy processes have gained popularity in the last decades. Their special definition facilitates the mathematical treatment, usually based on the availability of the *characteristic function*, i.e. the Fourier transform of the density function, and the use of a Fourier inversion technique. The methods relying on Fourier inversion are highly appreciated, particularly for calibration purposes, since they are extremely fast, very accurate and easy to implement. The main drawback attributed to these type of methods is the lack of control in the free-parameter's setting (see [1], for example, and the references therein). The Fourier inversion approaches to price arithmetic Asian products are typically based on the work of Carverhill and Clewlow in [2], where a generic analytical algorithm was introduced. Benhamou in [3] proposed an improved version of Carverhill and Clewlow algorithm applied to arithmetic Asian options via *fast Fourier transform*. In [4] the probability density function of the logarithm of the sum of asset prices is obtained by a series of recursive quadratures. The strategy considered in [5] shows how the characteristic function of the logarithm of the sum of asset prices is obtained numerically

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