R Package Development

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Chapter 1

Introduction

1.1 Abstract

This report discuss the R implementation of the major statistical models used for pricing financial options. The models introduced are classified into two sections based on their approachs, either analytical or computational.
Analytical models generate exact estimation for option prices. Fundamental models such as Black-Scholes formula, Binomial tree, and Trinomial tree methods are discussed, following by an extension to multinomial tree solutions.
For more complex cases where analytical formula is infeasible to find, Monte Carlo based models provides computational path to find the options prices. Basic Monte Carlo model and its extensions, including Heston model, Jump Diffusion model, and Merton model are discussed.

1.2 Literature Review

In 1973, economists Fischer Black and Myron Scholes introduced the Black-Scholes model, establishing the foundation for modern quantitative finance.

1.3 Existing R Packages for Options Pricing

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Concepts

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Chapter 3

Existing Option Pricing Packages within R Ecosystem

3.1 Packages Review

3.1.1 derivmkts

3.1.2 fOptions

3.1.3 RQuantLib

`RQuantLib` is an R interface to the QuantLib library, which embeded C++ programming.

Chapter 4

Package Development

4.1 Package Structure

4.1.1 Objective Oriented Programming in R

Existing packages in R ecosystem, such as `fOptions`, `derivmkts`, and `RQuantLib` provides comprehensive pricing algorithms for financial derivatives. However, their implementation of models are procedural oriented.
Generic S3 method.

4.2 Deterministic Methods

4.2.1 Black-Scholes

The Black-Scholes model perceive the movement of the stock price as an Geometric Brownian motion, explained by the stochastic differential equation:

$$\frac{dS(t)}{S(t)} = \mu(S(t), t)dt + \sigma dW(t)$$

4.2.2 Binomial Lattice Tree

Introduced by Cox, Ross, and Rubinstein in 1979, the Binomial Model
The Cox, Ross, Rubinstein (CRR) Binomial Model was introduced by

4.2.3 Trinomial Lattice

Extending the Binomial model, the Trinomial Lattice model was introduced by Phelim Boyle in 1988 [1].

```
1  Trinomial <- function(K, S, u, r, t, n, sigma = 0,
2      type = "call",
3      style = "European",
4      all = FALSE,
5      plot = FALSE) {
6
7  }
```

4.2.4 Discussion on Multinomial Option Pricing Models & Their Relationship with Binomial Model

4.3 Monte Carlo Methods

4.3.1 Vanilla Option Pricing

4.3.2 Asian Option Pricing

Different from a vanilla option whose payoff only depends on stock price at maturity (i.e. $t = T$), an Asian option's payoff is determined by the mean stock price throughout the option's life $\bar{S}$ and the strike price K. To calculate $\bar{S}$, we need to consider the price movement throughout $t \in [0, T]$, making the pricing of an Asian option path-dependent.
A generalised case of the stock pricing model is given by:

$$dS(t) = rS(t)dt + \sigma(S(t))S(t)dW(t) \tag{4.1}$$

By discritise the infinitesimal dt to Δt using Euler approximation, we can obtain the form:

$$S(t + \Delta t) = S(t) + rS(t)\Delta t + \sigma(S(t))S(t)\sqrt{\Delta t}Z \tag{4.2}$$

Where $Z \sim N(0, 1)$. Taking the logrithm of the above expression, we have:

$$log(S(t + \Delta t)) = log(S(t)) \tag{4.3}$$

Bibliography

[1] P. P. Boyle, "A lattice framework for option pricing with two state variables," *Journal of Financial and Quantitative Analysis*, vol. 23, 3 1988.