

Chapter 7

Comparing the Exact and Approximate Solutions of Financial–Type Stochastic Differential Equations

Nzotem Tchoumi Cyrille Audrey

 <http://orcid.org/0009-0007-1027-5728>

University of Ngaoundere, Cameroon

Jimbo Henri Claver

 <http://orcid.org/0000-0003-3859-8151>

Samarkand International University of Technology, Uzbekistan

Boris Zourmba Tizi

 <http://orcid.org/0009-0001-2685-5467>

University of Ngaoundere, Cameroon

Tchoua Paul

University of Ngaoundere, Cameroon

Eze Eze Donatien

 <http://orcid.org/0000-0002-3287-6264>

University of Ngaoundere, Cameroon

ABSTRACT

In financial engineering, stock price prediction remains one of the most interesting problems of stock market analysis. One approach to solution consists of using historical data of the underlying asset to predict future prices while relying on stochastic differential equations for modeling stock price dynamics. The analytical

DOI: 10.4018/979-8-3693-6215-0.ch007

solutions of financial-like stochastic differential equations are not always obvious; numerical methods for approximating the solutions are often considered. In this work, we propose the Euler-Maruyama method to compute the approximate solutions on both geometric Brownian motion and Heston-type models. We first perform the parameters estimation of the models and then compare the exact and approximate solutions of the models. We investigate the convergence of numerical solutions to analytical solutions for various situations and uncover interesting behaviors as we increase the time steps. Additionally, we discuss the impact of the volatility in price prediction with the specific case of stochastic volatility from the Heston model.

INTRODUCTION

Stochastic Differential Equations (SDEs) are considered today at the center of stock market analysis with other applications in biology, physics, and economics. Define as a combination of deterministic and probabilistic components, SDEs are used for predictive analysis and control of natural phenomena. Under specific conditions, solutions of SDEs can be found using mathematics and computational techniques. In financial mathematics, SDEs describe asset prices, interest rates, derivatives, options, and other financial products (Sauer, 2008). Some models based on stochastic differential equations have been developed to analyze stock prices. The Black-Scholes models of Fischer Black and Myron Scholes in 1973 (Black & Scholes, 1973) of options pricing is a reference in finance and economics based on constant volatility. The Heston Model 1993 (Heston, 1993) from Steven L. Heston is used to analyze stochastic volatility. The Geometric Brownian Motion was recently used in financial modeling by Peng and Simon in 2024 (Peng & Simon, 2024).

Stochastic Time Series ARIMA Modeling is used by Dadhich et al. for predictive Models of the Stock Market Index in 2021 (Dadhich et al., 2021). Gopinathan, K.N., et al. worked in 2024 with a Gaussian mixture model-hidden Markov model in a novel approach for stock price prediction (Gopinathan et al., 2024). Stochastic Neural Networks were used by Patel J. and Al. in 2020 (Jay et al., 2020) for Cryptocurrency price prediction. Vasicek Model, Geometric Brownian Motion, and the ARIMA (Nadarajan & Nur-Firyal, 2024). For SDEs, analytical solutions are not always obvious. Thus, numerical methods for approximating the solutions are often considered, and the numerical solution may not be unique in most cases. There are approximation methods that give good numerical solutions. We can enumerate the Runge Kutta method (Sauer, 2008) (Kloeden & Platen, 1992) (Tocino & Ardanuy, 2002) (Rößler, 2010) (Li et al., 2023), Milstein's method (Higham, 2001) (Ren et al., 2021) (Bayram et al., 2018), the Euler-Maruyama method (Kayode et al., 2016) (Higham, 2001) (Urama & Ezepeue, 2018) (Yuan & Zhu, 2024) for example.

26 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/chapter/comparing-the-exact-and-approximate-solutions-of-financial-type-stochastic-differential-equations/362724

Related Content

Experimenting with Proxy Agents in Online Combinatorial Auctions

Soumyakanti Chakraborty, Anup Kumar Sen and Amitava Bagchi (2014). *International Journal of Intelligent Information Technologies* (pp. 56-75).

www.irma-international.org/article/experimenting-with-proxy-agents-in-online-combinatorial-auctions/114959

Creating Engaging and Personalized Learning Experiences in Distance Education: AI and Learning Analytics

Palanivel Rathinasabapathi Velmurugan, R. Swadhi, Krati R. Varshney, Jimmy Carter Reginsand K. Gayathri (2025). *AI and Learning Analytics in Distance Learning* (pp. 103-126).

www.irma-international.org/chapter/creating-engaging-and-personalized-learning-experiences-in-distance-education/374562

Designing Ethical and Equitable AI-Supported Educational Games: Opportunities and Challenges

Zeynep Cömert (2025). *Navigating Barriers to AI Implementation in the Classroom* (pp. 93-104).

www.irma-international.org/chapter/designing-ethical-and-equitable-ai-supported-educational-games/382078

Wireless Sensor Node Placement Using Hybrid Genetic Programming and Genetic Algorithms

Arpit Tripathi, Pulkit Gupta, Aditya Trivedi and Rahul Kala (2011). *International Journal of Intelligent Information Technologies* (pp. 63-83).

www.irma-international.org/article/wireless-sensor-node-placement-using/54067

Using Fuzzy Logic to Control Combined Cycle Gas Turbine During Ambient Computing Environment

Mostafa A. Elhosseini (2020). *International Journal of Ambient Computing and Intelligence* (pp. 106-130).

www.irma-international.org/article/using-fuzzy-logic-to-control-combined-cycle-gas-turbine-during-ambient-computing-environment/258074