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Implementation of digital fuzzy time series Markov chain in price forecasting and investment risk analysis with value at risk

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Abstract

This study aims to provide a comprehensive model to assist investors in strategic decision-making amid market uncertainty. Global economic uncertainty characterized by cycles of stagflation and recession has recurred in history and is expected to recur until 2025. This condition encourages the importance of investment strategies that can protect asset values from economic pressures. This study uses a quantitative approach with forecasting methods and risk analysis based on time series data. The data used are daily gold and silver prices from the London Bullion Market Association (LBMA) in USD, collected over a two-year period, namely from January 3, 2023 to January 4, 2025. The data is secondary and obtained from the official LBMA website. The research stages begin with a literature study to understand relevant concepts and methods, followed by data collection, and continued with data preprocessing. The preprocessing stages include checking for outliers, handling missing values using the series mean method, and merging data for temporal consistency. For the

forecasting process, the Fuzzy Time Series–Markov Chain method is used, which consists of several steps: the formation of universe and interval sets using the Sturges formula, the definition of fuzzy sets, the fuzzification process, the formation of Fuzzy Logical Relationships (FLR) and Fuzzy Logical Relationship Groups (FLRG), and the preparation of transition probability matrices. The forecasting results are obtained through the defuzzification process, which are then evaluated using the Mean Absolute Percentage Error (MAPE) indicator to assess the accuracy of the model. Risk analysis is carried out using the Value at Risk (VaR) approach using the Extreme Value Theory (EVT) method and the Generalized Pareto Distribution (GPD). The entire analysis process is carried out using Microsoft Excel and RStudio software to ensure accuracy and efficiency in data processing and statistical modeling. This study has succeeded in developing a hybrid Fuzzy Time Series–Markov Chain model to forecast precious metal prices, especially gold and silver, with a very high level of accuracy. Based on an evaluation of various training and testing data proportions, the best model was obtained at a 95:5 ratio, with MAPE values of 0.66% for gold and 1.18% for silver in the training data, and 0.55% and 0.94% in the testing data. These results indicate that the model is able to effectively capture historical price patterns and provide predictions close to the actual value. © 2026 by the authors; licensee Growing Science, Canada.

Author keywords

Fuzzy Time Series; Investment Risk Analysis; Markov Chain; Price Forecasting; Value at Risk

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