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Volatility forecasting with the wavelet transformation algorithm GARCH model: Evidence from African stock markets

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Abstract

The daily returns of four African countries' stock market indices for the period January 2, 2000, to December 31, 2014, were employed to compare the $GARCH_{(1,1)}$ model and a newly proposed Maximal Overlap Discreet Wavelet Transform (MODWT)-$GARCH_{(1,1)}$ model. The results showed that although both models fit the returns data well, the forecast produced by the $GARCH_{(1,1)}$ model underestimates the observed returns whereas the newly proposed MODWT-$GARCH_{(1,1)}$ model generates an accurate forecast value of the observed returns. The results generally showed that the newly proposed MODWT-$GARCH_{(1,1)}$ model best fits returns series for these African countries. Hence the proposed MODWT-GARCH should be applied on other context to further verify its validity.

Keywords: Volatility; Asset returns; MODWT; GARCH

1. Introduction

Stock market volatility is of paramount importance to both market practitioners and policy makers, particularly for emerging countries.[1,2] The practitioner is concerned about stock market volatility because it affects asset pricing and risk, whereas the policy maker attempts to curb excessive volatility to ensure financial and macroeconomic stability.[3] In both cases, an efficient quantitative tool for modeling stock market volatility is needed to minimize the risk of inaccurate measurement. In this regard, researchers continue to search for the best volatility model that is able to capture various stylized facts associated with market volatilities.

The volatility modeling of price returns was first performed in Ref. 4, wherein an autoregressive conditional heteroskedasticity model, the ARCH model, was used to predict UK inflation rate uncertainty. Engle noted that major changes tend to be followed by significant changes in either sign and that small changes tend to be followed by small

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changes. This phenomenon was designated volatility clustering. The author measured clustering effects based on an assumption of constant conditional return mean value.

However, other stylized volatility features could not be captured by the ARCH model. Bollerslev[5] generalized the ARCH model by creating the Generalized Conditionally Heteroskedasticity model (GARCH model). The model considerably extended the capacities of the ARCH model to account for stylized aspects of return volatility, given that it removed the excess kurtosis in returns series. However, the GARCH model, which is actually a linear model, could not address the fat-tailed distributions of financial time series.

The Exponential GARCH (EGARCH) model originated by Ref. 6, the Quadratic GARCH (QGARCH) model originated by Ref. 7, and other models such as the Glosten, Jogannathan, and Rankle (GJR) model,[8] are known as non-linear GARCH models, and they address the skewed distributions of financial time series, which are a very common characteristic of financial time series.

Furthermore, stock market returns are practically influenced by agent speculations and investor decisions over different time horizons that range from minutes to years. In such a situation, a useful tool of analysis may be wavelet analysis.[9]

Wavelets are particular types of function that are localized both in time and frequency domain that are utilized in the decomposition of time series into additional elementary functions containing various information relating to the time series. Within the numerous utilized statistical signal extraction and filtering methods, in addition to denoising methods, wavelets constitute just one tool. The ability to decompose macroeconomic time series into components of their time scale, is a major advantage of wavelet analysis. Haar (discreet), symmlets and coiflets (symmetric), daiblet (asymmetric), among others, make up the different categories of the available wavelets filters; they differ in their filter transfer function and filter lengths in terms of characteristics. This study is based on the Maximal Overlap Discreet Wavelet Transform (MODWT) tool. The MODWT represents an improvement on the Discreet Wavelet Transform (DWT). Through the simple modification of the pyramid algorithm utilized in computing DWT coefficient, the MODWT is obtained; and it is perceived as the DWT universal set. The MODWT, among other comparative advantages over the DWT, can accommodate any sample size; in addition, in terms of data filtering starting point of a time series, it is insensitive.[9]

The MODWT filtering method offers insights into the dynamics of financial time series beyond those revealed through existing methodologies.[10] A number of concepts, such as those of nonstationarity, multiresolution and approximate decorrelation, emerge from MODWT filters. Moreover, MODWT filters serve as a straightforward tool for studying the multiresolution properties of a process. They can also decompose a financial time series into different time scales, given that they reveal structural break and volatility clusters and identify the local and global dynamic properties of a process at such time scales. In addition, MODWT filters can conveniently dissolve the correlation structure of a process across time scales.

A book by Ref. 10 applied the DWT to daily IBM stock return series and found a large group of rapidly fluctuating returns between observations at certain intervals of the wavelet coefficients. They observed that, at the same frequency level, there were significant fluctuations in wavelet coefficient w_1 and a small increase in fluctuations of wavelet coefficient w_2 and that wavelet coefficients w_3 and w_4 were essentially zero. A study by Conejo et al[11] employed a time series analysis, a neural network and wavelet forecasting technique that predicts 24 market-clearing prices of a day-ahead electric energy market by using PJM Interconnection data. They exhaustively compared the forecasting errors generated from the techniques and recommended the study of combined wavelet transform and time series algorithms in future research. A study by Ref. 12 presented two hybrid forecasting frameworks, the Wavelet-Genetic Algorithm (GA)-Multilayer Perceptron (MLP) and the Wavelet-Particle Swarm Optimization (PSO)-Multilayer Perceptron (MLP), for predicting non-stationary wind speeds and for comparing the forecasting performance of the different algorithm combinations of the two hybrid frameworks. Their results, based on three experimental cases, show that among other results, in both of the hybrid frameworks, the contributions of the GA and PSO components to improving the MLP were not significant whereas those of the wavelet component were significant. A similar study by Ref. 13 proposed a novel price forecasting method based on wavelet transform approaches combined with ARIMA and GARCH models, and it was compared with some of the most recently published price forecasting techniques. The comparative results clearly showed that the proposed forecasting method was far more accurate than the other forecasting method.

Although several articles on the stock price volatility levels of developed capital markets have been published, scarce research has been conducted on this subject with respect to African markets. African stock markets are some of

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