Multi-Scaling Analysis of the S&P500 under Different Regimes in Wavelet Domain

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ABSTRACT

In this article, the authors investigate the multi-scale structure of the S&P500 minute-by-minute time series. The authors attempt to find the answer to the following question: Are upward and downward regimes in the S&P500 time series exhibit different long-range power-law correlations? To answer this question, the authors apply the discrete wavelet transform (DWT) to the original time series for de-noising purpose. Then, the authors apply the generalized Hurst exponent (GHE) to the de-noised data to characterize the multi-scaling complexity of the signal (time series) under each regime and using different q-order moments. The authors found that S&P500 intra-day time series show long-range power-law correlations. In addition, this behavior varies depending on the stock market regime. This finding should be taken into account in active investment management.

Keywords: Discrete Wavelet Transform, Generalized Hurst Exponent, Regimes, S&P500, Stock Market

1. INTRODUCTION

During the last two decades, scholars have come to rely upon various types of statistical and intelligent systems to forecast financial markets (Davalos et al., 2009; Sun, 2010; Joseph & Mazouz, 2010; Hammami & Boujelbene, 2012; Lai & Joseph, 2012; Strang, 2012, Lahmiri, 2013). And, lately the scaling concept which is widely applied in physics receives an increasing attention in finance to find the existence of scaling laws (Dimatteo et al., 2005; Qi et al., 2011; Domino, 2011). The goal is to search for patterns that are repeated at different time scales in stock prices. Therefore, understanding their temporal dynamics is important to assess the potential impacts of their variations on wealth; and consequently to determine the optimal investment strategy. Investigating the dynamic behavior of stock prices has been an attractive topic in the literature during a relatively long time span. In particular, multi-scaling processes have been used in many studies to account for the time-scale dependence of the statistical properties of financial time series. For instance, it was found that stock prices reveal different properties such long-term correlation or memory dependence (Dimatteo et al., 2005), and fractals/multifractals (Qi et al., 2011; Domino, 2011).
Indeed, many empirical studies are concerned with the market multifractality formation, and it is found that there are two major sources of it: fat-tailed probability distribution and nonlinear temporal correlation (Kwapien et al., 2005; Du & Ning, 2008).

In recent years, the multifractal analysis has become an important technique to examine the intermittency observed in financial time series; including stock market prices (Alvarez-Ramirez et al., 2008; Suárez-Garcia & Gómez-Ullate, 2008; Mariani et al., 2010; Wang et al., 2010a; Alvarez-Ramirez et al., 2012; Ma et al., 2013; Reboredo et al., 2013), trading volume (Bolgorian & Raei, 2011, Alvarez-Ramírez & Rodríguez, 2012; Yuan et al., 2012; Wang et al., 2013), and volatility (Wang et al., 2010b; Lin et al., 2011), commodities (He et al., 2010; Siqueira et al., 2010; Kim et al., 2011; Wang et al., 2011a, 2011b, Lu et al., 2013; Liu, 2014), and exchange rate (Norouzzadeh & Rahmani, 2006; Abounoori et al., 2012; Cao et al., 2012). A review of recent works on multifractal analysis of stock market follows.

Alvarez-Ramirez et al. (2008) used detrended fluctuation analysis (DFA) to estimate S&P500 daily price fractals. They found that the scaling exponent is not constant; particularly, its dynamics has changed from correlated price fluctuations for 1960-1968 to nearly non-correlated dynamics for 1999-2007 time period. Suárez-Garcia and Gómez-Ullate (2008) examined the behavior of multifractality in the high-frequency returns of Madrid’s Stock Exchange IBEX35 index over a two year period (2009–2010) using multifractal DFA (MFDFA). They found strong evidence in favor of its multifractality. In particular, the analysis of linear correlations of the index showed that the IBEX35 can be considered as serially uncorrelated, the nonlinear correlations displayed long memory over very long periods, even as long as the time period analyzed. Wang et al. (2010) employed (MFDFA) to detect the evolution of efficiency degree of Shanghai stock market using daily closing price data from December 19th, 1990 to December 15th, 2008. The evolution of local Hurst exponents indicated that after reform, Shanghai stock market became more efficient in the long term but not in the short term. Mariani et al. (2010) used Hurst exponent and the DFA technique as tools to analyze the behavior of daily closing values of the iShares MSCI EAFE (EFA) Index (August 27, 2001 to May 1, 2009), the iShares MSCI Emerging Markets (EEM) Index (April 15, 2003 to May 1, 2009), the S&P500 (August 27, 2001 to May 1, 2007). The obtained results indicated that the S&P500 and the EFA indices possess long memory behavior, and that the EEM index returned to its pre-crisis (great crisis of 2008) behavior. In addition, the empirical results indicated that the behavior of the three indices is different during the crisis period, but mostly after a crisis period. The authors concluded that investors may have new investment opportunities in emerging markets during and especially after 2008 crisis. Recently, Alvarez-Ramirez et al. (2012) investigated the presence of a partisan effect in the dynamics of the Dow Jones Industrial Average (DJIA) over different presidential periods by means of the DFA. For instance, the sample period was from October 1st, 1929 to September 30, 2011 and was categorized into subperiods of Democrat administration and periods of Republican administration. The empirical results indicated that the DJIA contains different cycles that can be attributed to business conditions and partisan effect. The authors concluded that DJIA informational efficiency improved under Republican administrations and reduced under Democrat administrations. More recently, Reboredo et al. (2013) analyzed the speed of convergence to market efficiency by using DFA to examine the scaling properties of intraday prices. In particular, the Hurst exponent was estimated for different intraday time scales (from 1 to 30 minutes) in order to determine the time scales during which price differences converged to a fractional Brownian motion (fBm). They used two the DJIA, the IBEX-35, the EURO–USD exchange rate, and Telefónica España stock (TEF). The data sample covered the period from 1 February 2011 to 13 May 2011. The empirical results indicated that on average the
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