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Study of memory effects in international market indices

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Abstract

Long term memory effects in stock market indices that represent internationally diversified stocks are analyzed in this paper and the results are compared with the S&P 500 index. The Hurst exponent and the Detrended fluctuation analysis (DFA) technique are the tools used for this analysis. The financial time-series data of these indices are tested with the Normalized Truncated Levy Flight to check whether the evolution of these indices is explained by the *TLF*.

Some features that seem to be specific for international indices are discovered and briefly discussed. In particular, a potential investor seems to be faced with new investment opportunities in emerging markets during and especially after a crisis.

Introduction

In recent years there has been a growing literature in financial economics that analyzes the major stock indices in developed countries; see for example Refs.[1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11] and the references therein. The statistical properties of the temporal series analyzing the evolution of the different markets have been of a great importance in the study of financial markets. The empirical characterization of stochastic processes usually requires the study of temporal correlations and the determination of asymptotic probability density functions *(pdf)*. The first model that describes the evolution of option prices is the Brownian motion. This model assumes that the increment of the logarithm of prices follows a diffusive process with Gaussian distribution[12]. However, the empirical study of temporal series of some of the most important indices shows that in short time intervals the associated *pdf's* have greater kurtosis than a Gaussian distribution[5]. The first step to explain this behavior was done in 1963 by Mandelbrot[13]. He developed a model for the evolution of cotton prices by a stable stochastic non-Gaussian Levy process; these types of non-Gaussian processes were first introduced and studied by Levy[14]. However, these distributions are not appropriate for working in long-range correlation scales. These problems can be

avoided considering that the temporal evolution of financial markets is described by a Truncated Levy Flight *(TLF)*[15] or by a Normalized Truncated Levy Flight[9].

The other major problem encountered in the analysis of the behavior of different time-series data is the existence of long term or short term correlations in the behavior of financial markets (established versus emerging markets[16], developed countries' market indices[1], [2], [3], [4], [5], Bombay stock exchange index[17], and Latin American indices[18] and the references therein). Studies that focus on particular country indices[17], [18], [19] generally show that a long term memory effect exists.

The main interest in this work is to compare the international stock market indices and other well-renowned market indices such as the S&P 500. Specifically, this paper seeks to determine whether long memory effects are also present in well-diversified international market indices; by testing the financial time-series data of these indices with the Normalized Truncated Levy Flight we wish to check whether the evolution of these indices is explained by the *TLF*.

Previous literature has concluded that the time series of financial indices are explained by the *TLF* model[15], [18], [19]. The Rescaled Range Analysis (R/S) and Detrended Fluctuation Analysis (DFA) methods are used to investigate long-range correlations. Previous work has shown that both methods are very powerful for characterizing fractional behavior (see for example Refs.[17], [18], [19], [20], [21]). As the time-series data for the indices are very small, and the exponents calculated could serve as verification and comparison of the results, both methods are used.

Based on our results we may conclude that using Truncated Levy Flight model is an important and useful tool in the analysis of long memory of time series. In many cases TLF model fits the data very well. However, for a further clarification of the image depicted its analysis should be complemented with the R/S and DFA methods since in many cases these approaches bring new facts into the picture.

Section snippets

The Truncated Levy Flight

Levy[22] and Khintchine[23] solved the problem of the determination of the functional form that all the stable distributions must follow. They found that the most general representation is through the characteristic function $\varphi(q)$, by the following equation:

$$\ln(\varphi(q)) = \begin{cases} i\mu q - \gamma|q|^{\alpha}\left[1 - i\beta\frac{q}{|q|}\tan\left(\frac{\pi}{2}\alpha\right)\right] & (\alpha \neq 1) \\ i\mu q - \gamma|q|\left[1 + i\beta\frac{q}{|q|}\frac{2}{\pi}\ln|q|\right] & (\alpha = 1) \end{cases}$$

where $0 < \alpha \leq 2$, γ is a positive scale factor, μ is a real number and β is an asymmetry parameter that takes values in the interval $[-1, 1]$.

The analytic form for a stable…

Rescaled range analysis

Hurst[28] initially developed the Rescaled range analysis (R/S analysis). He observed many natural phenomena that followed a biased random walk, i.e.,every phenomenon showed a pattern. He measured the trend using an exponent now called the Hurst exponent. Mandelbrot[29], [30] later introduced a generalized form of the Brownian motion model, the fractional Brownian motion to model the Hurst effect.

The complete numerical procedure to calculate the Hurst exponent H by using the R/S analysis is…

Detrended fluctuation analysis

The DFA method is an important technique in revealing long-range correlations in non-stationary time series. This method was developed by Peng[20], [21], and has been successfully applied to the study of cloud breaking[32], Latin American market Indices[18], DNA[21], [33], [34], cardiac dynamics[20], [35], climatic studies[36], [37], solid state physics[38], [39], and economic time series[40], [41], [42].

The numerical procedure that is used to calculate the DFA exponent α, by using the…

Data

We studied the behavior of well-known international market indices: iShares MSCI EAFE Index and the iShares MSCI Emerging Markets Index. We mention a previous study of long memory behavior in some Eastern European economies transitioning to EU[43].…

Results and discussions

Hurst as well as DFA analysis is performed to find the persistence of long correlations. Table1 presents the results of unit root stationarity tests, we refer to Ref.[31] for a discussion of this method. Table2 presents the estimated Hurst and the DFA parameters for the entire respective period. The Hurst exponent and the alpha values obtained are significantly greater than 0.5, thus implying the existence of long term correlations in the financial time series of all the indices analyzed.…

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> *Citation Excerpt :*
>
> …A method used to detect long-range correlation, which indirectly allows determination of the fractal dimension by the Hurst exponent estimation, is the detrended fluctuation analysis (DFA) [30]. The DFA, introduced by Peng et al. [30] is the most important technique, owing to the simplicity of its implementation, and is used in a wide range of fields: EEG bio-signals [31], memory effects in international market indices [32] and vegetation patterns in burned and unburned areas [33], to name but a few cases. Later, the generalisation of this method to the multifractal analysis (MFDFA) was proposed by Kantelhardt et al. [34] and used to study correlations due to features of multifractality on different temporal range in time series, generated from the binomial cascade as well as empirical series [35], and effect of time series length on

multifractal properties [36], for naming some In recent years, DFA for fractals and multifractals in higher dimensions has been proposed, with acceptable performance for a large variety of synthetic images [30–33,37], and is applied to irregular objects to obtain a measure of their irregularity [38], which is our particular interest here for the characterisation of copper corrosion scale formation at its initial stages in substitute ocean water.…

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