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Multiscale multifractal time irreversibility analysis of stock markets

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Abstract

Time irreversibility is one of the most important properties of nonstationary time series. Complex time series often demonstrate even multiscale time irreversibility, such that not only the original but also coarse-grained time series are asymmetric over a wide range of scales. We study the multiscale time irreversibility of time series. In this paper, we develop a method called multiscale multifractal time irreversibility analysis (MMRA), which allows us to extend the description of time irreversibility to include the dependence on the segment size and statistical moments. We test the effectiveness of MMRA in detecting multifractality and time irreversibility of time series generated from delayed Henon map and binomial multifractal model. Then we employ our method to the time irreversibility analysis of stock markets in different regions. We find that the emerging market has higher multifractality degree and time irreversibility compared with developed markets. In this sense, the MMRA method may provide new angles in assessing the evolution stage of stock markets.

Keywords: Multiscale multifractal time irreversibility analysis(MMRA); Segment size ; Statistical moments ; Delayed Henon map ; Binomial multifractal model ; Stock markets.

1. Introduction

Complexity, time irreversibility and fractal scaling characteristics reflect different aspects of nonlinear properties of living dynamical systems such as stock market fluctuations [1–4]. However, their joint analysis over the course of stock market is pending.

It is important to detect time asymmetry or irreversibility in nonstationary time series not only because time series may be easier to predict and model in one direction, but particularly because irreversibility is a symptom of non-Gaussian forcing and dynamic nonlinearities [5,6]. In addition, when time series represent the evolution of either stochastic or deterministic dynamical systems, irreversibility has a special meaning linked with the lack of equilibrium and detailed balance of the probability fluxes among the system states. Some notable work has been done in the analysis of time irreversibility [7–9].

In recent years, the Detrended Fluctuation Analysis (DFA) invented by Peng et al. [10] has been established as an effective tool for the detection of long-range (auto-) correlations in time series with non-stationarities. Then, in order to quantify long-range cross-correlations between two non-stationary time series, a new method named Detrended Cross-Correlation Analysis(DCCA), has been proposed recently. Many researchers have used DFA and DCCA in the time series analysis of various areas and have made great progress [11–16]. Its core algorithm of dividing the whole series into different segments, detrending fluctuation in every segment, and then utilizing the overall fluctuation function to study the long-range(auto-) correlations has inspired us a lot.

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