



# Abnormal statistical properties of stock indexes during a financial crash



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## HIGHLIGHTS

- Stock indexes have dual fractal structure which is consistent with previous studies.
- The return distribution of emerging markets shows abnormal dual power-law exponents.
- External shock of a crisis affects different markets at distinct stages.

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## ABSTRACT

We investigate minute indexes of stock markets in 10 countries during financial crashes by dividing them into several stages according to their stock price tendencies: plunging stage (stage 1), fluctuating or rebounding stage (stage 2), and soaring stage (stage 3). The tail distributions of the returns satisfy a power law for developed markets but show a dual power-law structure for emerging markets. Prominent dual fractal structures are found during the plunging stage in developed markets, and after the plunging stage in emerging markets. The fractal analysis on the sign series of the returns yields similar dual fractal properties.

The magnitude series of the returns provides surprising results during a crash. We find that developed markets have strong and weak long-range persistence in plunging and soaring stage respectively, while emerging markets behave oppositely. These results indicate that different types of markets are influenced strongly by the external shock of a crisis at different stages.

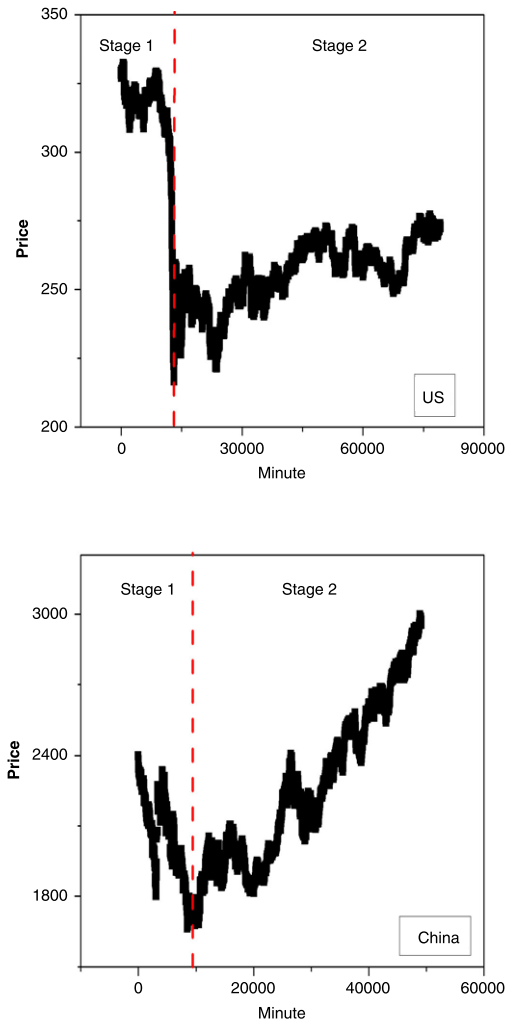
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## 1. Introduction

Various research fields have recently taken an interest in financial time series [1–5]. Several different aspects of stock market indexes have been extensively investigated [6–9]. From a statistical point of view, some studies have shown that the cumulative distribution function of logarithmic returns of stock indexes satisfies an inverse cubic power law for several developed markets [10–14]. Other research has shown that the root-mean-square fluctuation of logarithmic returns has a monofractal structure for most developed markets [15–17], or crossover-fractal properties for some other markets [18,19]. Another important feature common to many markets is that the volatility of returns has dual fractal dimensions as well as strong long-range persistence [6,18,20–25]. The aforementioned properties are well established in the analysis mainly for long time series. Here we investigate ten-month long stock minute indexes during which a financial crash occurred to determine how a financial crisis affects the behaviors of the stock indexes [26–33]. We specifically seek to identify how the abovementioned well-known statistical properties change at different stages of a crash.

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**Fig. 1.** The run charts of USA\_SP500 and China\_SSEC can be separated into two stages according to their trends. Stock prices plunge in Stage 1 and rebound in Stage 2.

The remainder of the paper is organized as follows: in Section 2, we describe our stock data and methodology. In Section 3, the cumulative distribution function of the logarithmic returns is investigated. In Section 4, we use detrended fluctuation analysis (DFA) to analyze the persistence of return series, along with their sign and magnitude series [34]. Concluding remarks are included in Section 5.

## 2. Market index data and methodology

### 2.1. Description of data

We analyze stock indexes at one minute interval during the global financial crisis between Sep 2008 and June 2009. Nine stock markets from different countries are considered: Australia\_AORD, Brazil\_BVSP, China\_SSEC, France\_CAC40, Germany\_XDAX, India\_SENSEX, Japan\_NIKKEI225, Portugal\_PSI20, and Taiwan\_TAIEX. We also analyzed the USA\_SP500 between Sep 1987 and June 1988 during which the notorious “Black Monday” crash occurred. We compare the statistical and fractal properties of the stock indexes in different periods of a crash. The index series can be divided into two or three stages according to the changes of stock prices tendencies: plunging stage (stage 1) in which the increments of the daily stock price are always a large negative value, fluctuating or rebounding stage (stage 2) where the increments are near to zero or positive, and soaring stage (stage 3) where the increments are mostly positive and large. We separate China\_SSEC and USA\_SP500 into two stages: plummet stage (stage 1) and rebounding stage (stage 2) (Fig. 1). We find the other eight stock market indexes (Fig. 2) are more appropriately separated into three stages representing the stock price plunging drastically (stage 1), fluctuating at low values (stage 2), and rebounding strongly (stage 3).

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