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Physica A 377 (2007) 576–582
PHYSICA A
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Power law of quiet time distribution in the Korean stock-market

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Received 18 November 2005; received in revised form 20 November 2006
Available online 19 December 2006

Abstract

We report the quiet-time probability distribution of the absolute return in the Korean stock-market index. We define the quiet time as a time interval during the absolute return of the stock index that are above a threshold r_c. Through an exponential bin plot, we observe that the quiet-time distribution (qtd) shows power-law behavior, $p_f(t) \sim t^{-\beta}$, for a range of threshold values. The quiet-time distribution has two scaling regimes, separated by the crossover time $t_c \approx 200$ min. The power-law exponents of the quiet-time distribution decrease when the return time Δt increases. In the late-time regime, $t > t_c$, the power-law exponents are independent of the threshold within the error bars for the fixed return time. The scaled qtd is characterized by a scaling function such as $p_f(t) \sim (1/T)f(t/T)$ where the scaling function $f(x) \sim x^{-\beta_2}$ and T is the average quiet time. The scaling exponents β_2 depend on the return time Δt and are independent of the threshold r_c. The average quiet time follows the power law such as $T \sim r_c^{\delta}$ where the exponents δ depend on the return time Δt.

Keywords: Econophysics; Quiet time; Power law; Return; Stock market

1. Introduction

In recent decades, the dynamics of stock markets has been studied by a number of methods from statistical physics and complex systems [1–18]. The complex behaviors of economic systems have been found to be very similar to those of other complex systems, customarily studied in statistical physics; in particular, critical phenomena. Stock-market indexes around the world have been precisely recorded for many years and therefore represent a rich source of data for quantitative analysis. The dynamic behaviors of stock markets have been studied by various methods, such as distribution functions [10–13,17], correlation functions [12–14], multifractal analysis [19–30], network analysis [15], and waiting-time distributions or first-return-time distributions [31–44].

The quiet-time distributions (qtd's) have been studied for many physical phenomena and systems, such as self-organized criticality [31], rice piles [32], sand piles [33], solar flares [34], and earthquakes [35–42]. Studies of qtd have also been performed for many high-frequency financial data sets [43–47]. Concepts of the continuous-time random walk (CTRW) have also been applied to stock markets [43–45]. A power-law

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doi:10.1016/j.physa.2006.11.076

distribution for the calm time intervals of the price changes has been observed in the Japanese stock market. The power-law exponent monotonically decreased with respect to the threshold [46]. The probability density function of volatility return interval showed the power law with the exponent −2 for both the stock and currency market [48].

In the present work we consider the qtd for the Korean stock-market index Korean Composite Stock Price Index (KOSPI). A quiet time of the absolute return is defined as an interval between a time when the absolute return falls below a fixed threshold r_c, and the next time it again exceeds r_c. It therefore corresponds to a relatively calm period in the time series of the stock index. We observed power-law behavior of the qtd over one to two decades in time.

The rest of this paper is organized as follows. In Section 2, we introduce the return of the stock index and its probability density function. In Section 3, we present the qtd. Concluding remarks are presented in Section 4.

2. Probability density function of return

We investigate the returns (or price changes) of the Korean stock-market index KOSPI. The data are recorded every minute of trading from March 30, 1992, through November 30, 1999 in the Korean stock market. We count the time during trading hours and remove closing hours, weekends, and holidays from the data. Denoting the stock-market index as $x(t)$, the logarithmic return is defined by

$$g(t) = \log x(t) - \log x(t - \Delta t), \tag{1}$$

where Δt is the time interval between two data points, the so-called return time. The logarithmic return $g(t)$ is thus a function of both t and Δt. In this article we consider the return times $\Delta t = 1$, 60, and 600 min (= 1 day). The normalized absolute return is defined by

$$r(t) = \left| \frac{g(t) - \langle g(t) \rangle}{\sigma(\Delta t)} \right|, \tag{2}$$

where $\sigma(\Delta t)$ is the standard deviation of the time series $g(t)$ and $\langle \cdots \rangle$ denotes averaging over the entire time series. It is well known that the probability distribution function (pdf) of the return $g(t)$ has a fat tail [10,11]. The tail of the pdf obeys a power law,

$$p(r) \sim r^{-(1+\alpha)}, \tag{3}$$

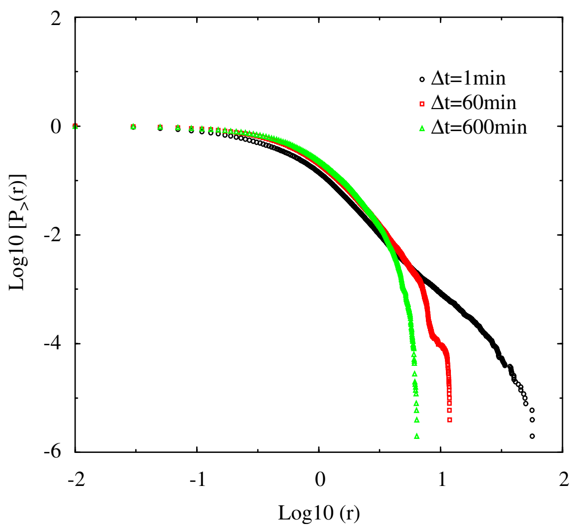

Fig. 1. Probability density function of the absolute return of KOSPI with $\Delta t = 1$, 60 and 600 min.