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Power–law properties of Chinese stock market

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Abstract

Price changes of primary returns of Chinese stock market are analyzed over a period of about 8 years. The probability distribution of relative changes in returns satisfies the power–law form. However, the distribution is not consistent with the analysis of US and other stock markets that seem to contain the exponent of an inverse cube. Furthermore, we find that the positive and negative returns do not behave consistently, which indicates a significant asymmetry in the distribution.

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Keywords: Stock market; Power–law; Asymmetry

1. Introduction

Using the methods developed for physical systems, the analysis of financial data has a long tradition [1–4]. In recent years, physicists have focused their interest on using the analysis methods of dynamic, complex systems in modeling the financial

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and economic processes [5–10]. Recent studies have revealed some interesting findings of the distribution of stock price fluctuations. Results show that it follows a power–law decay with exponents consistent with an inverse cube at the tails (the exponent $\alpha \simeq 3$), which lies outside the Lévy stable range ($0<\alpha<2$) [11–16]. This rule is regarded as a universal one since stocks in the United States [12,14,17], Germany [11] and Australia [18] all obey it. In addition, some market indices also have this characteristic, such as the index of S&P 500, Dow Jones, NIKKEI, Hang Seng, Milan, and DAX [11,13,15]. Several theoretical models have been proposed [19–21] to explain the mechanism of the empirical power–law distribution. For instance, Solomon and Richmond [19] build a multiagent system by the use of a generalized Lotka–Volterra model; Gabaix et al. [20] present another theory based on the economic optimization by heterogeneous agents.

However, further study of the Indian stock market [22] demonstrates another scenario. In the Indian stock market the distribution of daily returns of the stock price $P(g)$ decays as an exponential function $P(g) \sim \exp(-\beta g)$, where g is the normalized return and β is the decay parameter. In addition, Huang [23] found that by skipping the data in the first 20 min of each morning session, the 1-min data of the Hang Seng index show an exponential-type decay as $P(x) \sim \exp(-\alpha|x|)/|x|$, where $x(t) = \text{index}(t) - \text{index}(t - \Delta t)$. These distinct findings complicate the research work of the stock market behavior and diversifies the possible theoretical explanations.

In order to test the ubiquity of the inverse-cubic law in the stock markets, we investigate the distribution of daily returns in Chinese stock market. The database of closing prices from the Shanghai Stock Exchange and Shenzhen Stock Exchange is accumulated for calculation [25]. It is observed that the distribution behavior of daily returns follow the power–law rule but the positive and the negative tails show both inconsistence of the exponent of an inverse cube and an asymmetric characteristic.

2. Distribution analysis

We analyze the closing price of individual stocks from the Shanghai Stock Exchange and Shenzhen Stock Exchange [24]. In order to cover as many data as possible, we select all the stocks listed before 1 November 1993 in both stock exchanges, and choose the period for analyzing from 3 January 1994 to 31 December 2001. We have excluded data of the first couple of years when both stock exchanges were founded. The total number of selected stocks reaches 104, including 76 from the Shanghai Stock Exchange and 28 from Shenzhen Stock Exchange. In this case the total data reach the scale of around 2×10^5.

For a time series $S(t)$ of prices of a company [25], the return $G(t) = G_{\Delta t}(t)$ over a time scale Δt is defined as the forward change in the logarithm of $S(t)$

$$G_{\Delta t}(t) = \ln S(t + \Delta t) - \ln S(t) \,. \tag{1}$$

We investigate the time series of returns on time scale $\Delta t = 1$ day. In order to make a synthetic analysis of the data from different companies, we use a normalized