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Statistical properties of stock market indices of different economies

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Abstract

Daily changes in the logarithm of stock market index from 1997 to 2004 are analyzed for countries from three subgroups of economies classified by the International Monetary Fund (IMF): developing Asian countries, newly industrialized Asian economies and major advanced economies. For all markets, the daily changes are well fitted by a non-Gaussian stable probability density. The time evolution of the standard deviation of the daily changes for each market obeys a power law. However, the developing Asian countries have the smallest stable density characteristic parameters α and the largest exponents b of the power law, except China's SSEC and India's SENSEX. The values of α and b for these two markets are closer to those of the newly industrialized Asian economies; in particular, those for China's SSEC are close to those for Hong Kong's HSI. The values of α and b for the newly industrialized Asian economies are in between those for the developing Asian countries and major advanced economies, consistent with the results for generalized Hurst exponent [Physica A 324 (2003) 183]. The daily changes for the developing Asian countries and newly industrialized Asian economies have a weak long-range correlation, whereas the daily changes for the major advanced economies have a weak long-range anti-correlation.

Keywords: Econophysics; Stock market indices; Stable distribution; Power law

1. Introduction

Within the statistical physics community, there has been a rapid growth of interest in the statistical analysis of financial data in recent years [1–7]. One of the long-term aims of such studies is to use the established statistical characteristics as guides in developing models of financial markets [1,3–7]. Knowledge of the statistical properties of financial data is also crucial in solving the option-pricing problem [1,2].

For stock markets, a few comparisons of the statistical properties of market indices of different economies have started to appear recently [8–11]. The International Monetary Fund (IMF), in its "World Economic Outlook" September 2004 [12], classifies countries into two major groups: advanced economies, and emerging market and developing countries. Each of the two main groups is further divided into a number of subgroups.

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Among the advanced economies, there are the major advanced economies, the newly industrialized Asian economies, and the Euro economies. The emerging market and developing countries are further classified by region. The regional breakdowns are Africa, central and eastern Europe, commonwealth of independent states, developing Asia, middle east, and western hemisphere. Three additional regional groupings with analytical significance are sub-Sahara, sub-Sahara excluding Nigeria and South Africa, and Asia excluding China and India. Matteo et al. [8,9] recently showed that the generalized Hurst exponent $H(2)$ for the second-order moment of the increments of ln(index) can differentiate what they call mature liquid markets (major advanced economies, Euro economies, and other advanced economies) from less developed markets (newly industrialized Asian economies, and emerging market and developing countries). The former economies generally have $H(2)$ values smaller than 0.5, whereas the latter economies have $H(2)$ values greater than 0.5. They [8,9] did not however mention explicitly that $H(2)$ is also capable of differentiating newly industrialized Asian economies from emerging market and developing countries, although their plotted results reflect this behavior. Jung et al. [10] showed that the network structure of Korea's KOSPI200 (from a newly industrialized Asian economy) is different from that of US's S&P500 (from a major advanced economy). Wei and Huang [11] found that the correlation of the parameters of the multifractal spectra with the daily changes in the logarithm of stock market index for China's SSEC (from a developing Asian country) is different from that of Hong Kong's HSI (from a newly industrialized Asian economy).

In this paper, we follow IMF's classification of countries and study the daily changes in the logarithm of stock market index

$$z(i) = \ln(I_{i+1}) - \ln(I_i), \quad i = 1, \cdots, N-1, \tag{1}$$

from 1997 to 2004 for developing Asian countries: Malaysia's KLSE (now known as KLCI), Indonesia's JSX, Philippine's PSI, Sri Lanka's CSE, Pakistan's KSE, India's SENSEX, and China's SSEC; for newly industrialized Asian economies: Korea's KOSPI, Hong Kong's HSI, Taiwan's TWII, and Singapore's STI; and for major advanced economies: US's S&P, UK's FTSE, and Japan's Nikkei. The selection of stock market indices is solely based on the availability of data for the longest common period. We study the probability density and standard deviation of the daily changes with the aim to see if there are any other statistical quantities besides the generalized Hurst exponent $H(2)$ that can differentiate between the three subgroups of economies. For a statistical quantity that can differentiate, it is moreover not evident, a priori, how the values are ordered for the three subgroups of economies and whether there are any exceptions. The results of our analysis are presented in Sections 2 and 3, respectively, for the probability density and standard deviation. In Section 4, we conclude with a summary and a discussion of the results.

2. Probability density

The daily changes in the logarithm of indices were fitted with stable probability densities using John P. Nolan's STABLE program. Because of the low-frequency data, we studied the central part of the distribution and not the asymptotic tail behavior, and hence the stable model is appropriate [5,6]. The class of stable distributions [13], which includes the Gaussian distribution, is characterized by four parameters: characteristic exponent $\alpha \in (0, 2]$, skewness $\beta \in [-1, 1]$, scale $\gamma \in (0, \infty)$, and shift or location $\delta \in (-\infty, \infty)$. The stable fit employs [14] the maximum likelihood method based on reliable computations of stable densities. Two diagnostics [14] were employed to assess the goodness-of-fit: (1) density plots (smoothed calculated data density versus fitted stable density), and (2) variance-stabilized PP (percent–percent) plot.

The two goodness-of-fit diagnostics for the daily changes in the logarithm of index for each of the markets show that, for all the market indices, the stable fit is good since the fitted stable density is close to the calculated data density and the PP plot is essentially on the diagonal. Fig. 1 shows the diagnostic plots for a sample of two market indices from each category of developing Asian countries (KLSE and SENSEX), newly industrialized Asian economies (HSI and STI), and major advanced economies (S&P and Nikkei).

The fitted stable parameters in the S^0-parametrization [14] are listed in increasing order of the characteristic parameter α in Table 1. Firstly, from Table 1 we see that for all markets, the parameter α is less than 2, i.e., the fitted stable density is non-Gaussian (Gaussian if $\alpha = 2$). Secondly, for all markets, the fitted stable density is essentially symmetric. In a few cases (KSE, FTSE, TWII, SENSEX), although the skewness parameter β is