Physica A 388 (2009) 1879–1886

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

Tail distribution of index fluctuations in World markets

Mehmet Eryiğit [a], Sadik Çukur [a], Resul Eryiğit [b,*]

[a] Department of Management, Abant Izzet Baysal University, 14280-Bolu, Turkey
[b] Department of Physics, Abant Izzet Baysal University, 14280-Bolu, Turkey

ARTICLE INFO

Article history:
Received 2 October 2008
Received in revised form 15 December 2008
Available online 22 January 2009

PACS:
89.65.Gh
89.65.-s
05.45.Tp

Keywords:
Power law
Tail distributions
World stock market indices

ABSTRACT

We have investigated the tail distribution of the daily fluctuations in 202 different indices in the stock markets of 59 countries for the time span of the last 20 years. Power law, log-normal, Weibull, exponential and power law with exponential cutoff distributions are considered as possible candidates for the tail distribution of the normalized returns. It is found that the power exponent depends strongly on the choice of the tail threshold and a sizeable number of indices can be better fitted by a distribution function other than the power law at the region that has power law exponent of 3. Also, we have found that the power exponent is not an indicator of the maturity of the market.

1. Introduction

The distribution of fluctuations in the stock and commodity prices and stock market indices has been one of the active areas of research in finance and econophysics for a long time. The character of the tail part of the distribution is especially important in practice because it gives an indication about the maximum risk and reward in a portfolio. Based on the efficient market hypothesis, the distribution of returns is expected to be normal which is found to be not realized in the real data more than 40 years ago [1,2]. Return distributions have fatter tails compared to the normal distribution.

The character of the tails of the distribution of fluctuations in financial time series has been investigated by using many different distribution functions. The extreme returns have been studied by fitting to a generalized Pareto and generalized extreme value distributions [3,4]. On the econophysics area, the power law is the most studied distribution. Stanley's group has investigated the tail distribution of several stock indices as well as return of individual stocks and found a power law distribution with a universal exponent of 3 [5–7]. Following Ref. [5], many studies on the distribution in different markets have been carried out. Among these Makowiec and Gnacinski [8] have considered a five year period of Warsaw Stock Exchange index and found power law exponents of 3.06 and 3.88 for the negative and the positive tail, respectively. Some reported work find an exponential distribution for the emerging markets, such as Oh, Kim and Um [9] for the 1-minute Korean KOSDAQ index, Couto Miranda and Riera [10] for daily data of Brazilian Bovespa index in the period 1986–2000 and Matia et al. [11] for the Indian Sensex 30 index, (a reanalysis of the Indian index by Pan and Sinha [12] finds a power law tail with an exponent close to that of mature markets). Yan et al. study the Chinese stock exchanges for the 1994–2001 period and report a strong asymmetry for the negative and positive tails with power exponents of 4.29 and 2.44, respectively. Among the many different proposals for the tail distributions normal inverse Gaussian of Barndorff-Nielsen [13], exponential [14,15], hyperbolic [16] and stretched exponentials. Also, at short time scales, a single q-Gaussian is found to fit the return

* Corresponding author.
E-mail address: resul@ibu.edu.tr (R. Eryiğit).

0378-4371/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.physa.2009.01.019

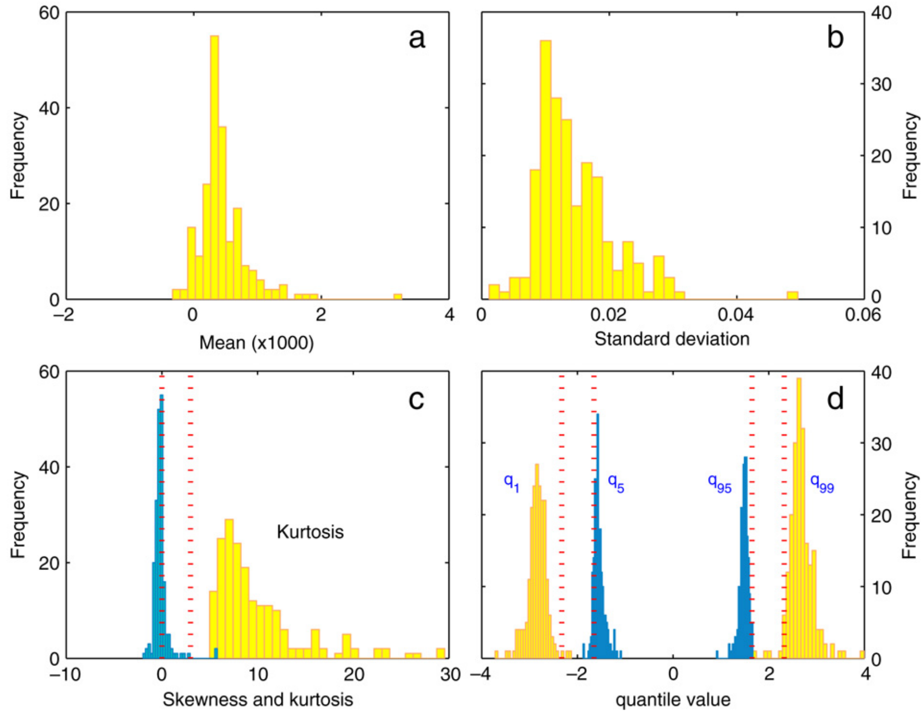

Fig. 1. Descriptive statistics of the returns of 202 indices. Distribution of (a) means, (b) standard deviations and (c) skewness and kurtosis. The dotted lines in (c) show the value for the normal distribution. The distribution of the 1, 5, 95 and 99% quantiles for the normalized returns are shown in (d). The dotted vertical lines indicate the corresponding quantiles for the normal distribution.

distribution of the Polish WIG20-index well [17]. Even for the same market different distributions are proposed to explain the data at different economical conditions [18] (power-law for the inflationary period and exponential for the deflationary period). Recently, Drozdz et al. [19] examined the 1 min returns of S&P 500 index for the May 2004–May 2006 period and concluded that the tail is getting thinner and the exponent is larger than 3 which might be explained in part by the role of better dissemination of information on the efficiency of the markets. One of the outcome of power law research in financial return series is the stylized-fact "power law tail with an exponent which ranges from two to five depending on the data set used in the study" [20]. There has been much effort to explain the microscopic origins of the power law tail [21] and the exponent of 3 [22,23].

The most widely used method for validating the power law and estimating its exponent has been criticized on statistical grounds [24]. The tail index type approaches are also criticized based on bias due to the underlying series not being iid and tail threshold dependent problems in estimating the distribution parameters [3,4].

The aim of the present study is to answer following questions: Are power law tails universal across the markets with different efficiencies? Is the power exponent of 3 universal? Is there any difference between the mature and emerging markets in terms of the distribution of the tails of the fluctuations? Is there any asymmetry of positive and negative tails? To answer these questions, we have analyzed the distributions of historical index fluctuation data of 202 indices from the stock markets of 59 countries by using statistically sound methods.

2. Data

The data in the present study consist of daily value of 202 different indices from stock markets of 59 countries. The period covers from February 8th 1988 until February 8th 2008. Since some of the indices have no data going back to 1988 we choose only the indices that were active at least for the last ten years. The data is taken from DataStream servers and a list of indices is given in the Appendix.

We consider the distribution of the normalized log return of indices. The log return for a time period τ is given by $R(\tau) = \ln S(t+\tau) - \ln S(t)$ where $S(t)$ is the value of the index at time t. The normalized log return is defined as $r(\tau) = \frac{R(\tau) - <R>}{\sigma}$, where $<R>$ is the time average of log return and σ is the standard deviation of the returns.

The summary statistics of the data is presented graphically in Fig. 1. The mean of the returns (Fig. 1(a)) is found to be dominantly positive except for some Japanese indices which have a small negative average. The distribution of standard deviations (σ) is shown in Fig. 1(b). We have found that among all the characteristics investigated in the present study, σ is the sole quantity that shows different behavior for mature and emerging market indices. In Fig. 1(b), the highest σs are for Ukraine, several Chinese indices, Turkey, Taiwan, Indonesia, Poland, Romania and semiconductor and computer indices