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Financial earthquakes, aftershocks and scaling in emerging stock markets

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Abstract

This paper provides evidence for scaling laws in emerging stock markets. Estimated parameters using different definitions of volatility show that the empirical scaling law in every stock market is a power law. This power law holds from 2 to 240 business days (almost 1 year). The scaling parameter in these economies changes after a change in the definition of volatility. This finding indicates that the stock returns may have a multifractal nature.

Another scaling property of stock returns is examined by relating the time after a main shock to the number of aftershocks per unit time. The empirical findings show that after a major fall in the stock returns, the stock market volatility above a certain threshold shows a power law decay, described by Omori's law.

PACS: C1; G0; G1; F3

Keywords: Volatility; Scaling; Stock market; Emerging markets; Omori's law; Multifractality

1. Introduction

For some years, the equilibrium models of financial markets, such as the Capital Asset Pricing Model [1,2] and the Arbitrage Pricing Theory [3], and the efficient market hypothesis have dominated the finance literature [4,5]. A common feature of empirical work in this area is that the analysis is conducted keeping the time interval fixed. Also, market participants are usually regarded as homogeneous entities with identical time horizons.

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In the early 1960s, Mandelbrot [6] introduced fractal models to describe certain features of financial and economic time series. In this approach, the dynamics of a given time series is analyzed at different time scales (daily, weekly, monthly, etc.). In other words, the object (time series) is viewed at different resolutions and certain characteristics are noted at each resolution. As a result, certain regularities have been discovered in most of the economic and financial data leading to further research to explain these regularities. Recent studies on multiscale analysis of financial and economic time series using new techniques [7–10] provide further empirical support to the idea that the agents have different time horizons and that they operate at different time scales. In other words, homogeneous market participants operating at a single time scale is a rare exception, rather than a rule, according to empirical work.

Multiscale analysis of economic and financial data points out certain "scaling laws", such as a "pure power law" [11–18]. Although some of the empirical scaling laws do not say anything specific about the data generating stochastic process, they are useful because (i) they stimulate the search for interpretive frameworks, (ii) they impose discipline on theory formation (the theory must generate data consistent with the observed scaling result), (iii) (they) give clues to properties of the space of possible underlying data generating process [19].

Recently, some studies claim that visual power laws and empirical long memory reported in the finance literature might be an artifact. LeBaron [20] provided a simple stochastic volatility model which is able to produce visual power laws and long memory similar to those from actual return series using comparable sample sizes. He pointed out that these are small-sample features for the stochastic volatility model, since asymptotically the model does not posses these properties. However, Stanley and Plerou [21] showed that the simple stochastic volatility model provided by LeBaron [20] cannot produce power laws and long memory. (See, also, other articles on this issue in the November 2001 issue of Quantitative Finance.)

Scaling behavior of financial time series is investigated by employing different methods in different studies [7,11–17,22–24]. One approach is to estimate the tail index. The tail index estimation is accomplished by keeping the time interval of returns constant and investigating the behavior of the tails of the distribution. For example, Gençay and Selçuk [8] studies the tail behavior of the return distributions in emerging markets (same sample used in this study) in a value-at-risk framework. According to tail index estimations in Ref. [8], the return distributions in emerging markets are fat-tailed and the fat-tailness of returns is much bigger than what is observed in developed markets.

Another approach to study the scaling behavior of financial time series is accomplished by examining the dynamics of volatility (defined as absolute returns) as a function of the time interval on which the time series is measured. Matteo et al. [15,16] use this approach to estimate the Hurst exponent of different financial time series in several developed and developing economies. They show that the deviations from pure Brownian motion is associated with the degree of development of the markets. Particularly, they found that there is a clear tendency for mature liquid markets to have a Hurst exponent less than or equal to 0.5, whereas less developed markets shows a tendency to have a Hurst exponent significantly greater than 0.5 [15].