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Alternation of different fluctuation regimes in the stock market dynamics

J. Kwapień[a,b], S. Drożdż[a,b,c,*], J. Speth[a]

[a] *Institut für Kernphysik, Forschungszentrum Jülich, D-52425 Jülich, Germany*
[b] *Institute of Nuclear Physics, Kraków PL-31-342, Poland*
[c] *Institute of Physics, University of Rzeszów, Rzeszów PL-35-310, Poland*

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Abstract

Based on the tick-by-tick stock prices from the German and American stock markets, we study the statistical properties of the distribution of the individual stocks and the index returns in highly collective and noisy intervals of trading, separately. We show that periods characterized by the strong inter-stock couplings can be associated with the distributions of index fluctuations which reveal more pronounced tails than in the case of weaker couplings in the market. During periods of strong correlations in the German market these distributions can even reveal an apparent Lévy-stable component.

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1. Introduction

A series of papers devoted to the analysis of financial data fluctuations disclosed that the corresponding distributions can be characterized by the Paretian scaling [1–5]. These studies, based on the large data sets of historical stock prices and on the index values, showed that both the distributions of stock price fluctuations and the distributions of index returns reveal scaling over a broad range of time scales from minutes to days (although a more recent investigation found that scaling is restricted to rather

* Corresponding author.
E-mail address: stanislaw.drozdz@ifj.edu.pl (S. Drożdż).

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short time scales [6]). A remarkable related issue is that the stocks and indices exhibit similar value of the scaling exponent $\alpha \simeq 3.0$ [4,5]. In accordance with the Central Limit Theorem, the distribution of a random variable being a sum of a number of *iid* random variables with a finite second moment, has to converge to a normal distribution. From this point of view, the similarity of the distributions for the stocks and the corresponding indices requires that the financial data violate the assumptions of the theorem. And as these data have indeed finite variance, a plausible cause for the problems with the convergence can be related to the correlations among the data. This claim seems to be supported by findings that an artificial S&P index constructed from randomly reshuffled stock returns, presents a much better convergence to a Gaussian than the original index [4].

An appropriate measure of correlations among elements of a system is the spectrum of the correlation matrix eigenvalues, which can be easily compared with the universal properties of random matrices [7]. A few recent works have shown that the financial market can be described by at least one repelled eigenvalue with a magnitude exceeding the likely range of values allowed for a random matrix. This one or more deviating eigenvalues indicate that there are relations between various components of the market [8–11].

The main purpose of the present work is a quantitative description of the possible relation between the stock price movements and the properties of the distribution of the corresponding index fluctuations. We showed in a previous analyses which were focused on daily patterns of the German DAX index fluctuations that certain characteristic time intervals of a trading day with high index volatility are associated with fluctuation distributions with properties different from more silent intervals of trading [12,13]. Since high volatility is connected with stronger correlations between the stocks [14,15] we expect that strong and weak inter-stock correlations are reflected in different properties of the index fluctuations. By choosing a few distinct time scales (1–30 min) we are able to test the stability of the results.

2. Methodology

Our analysis is based on the high-frequency tick-by-tick data covering the two years 1998–99 period and comprising the recordings of 30 companies included in the Dow Jones Industrial Average and 30 companies included in the German DAX30 index, together with the two indices [16]. Inevitably, such a long interval of time comprises some changes of the index composition. We decided that only those stocks which were a part of an index for the majority of time, can be taken into consideration. Along this way, for the whole interval under study we analyze the data for the individual companies CHV, GT, S and UK, although on November 1, 1999 they were replaced in DJIA by HD, INTC, MSFT and SBC. In a similar manner for the German market, we analyze ADS instead of BVM (delisted due to its fussion with BHW). For the German stock market we have roughly 30% more data points, because of a longer trading day in Frankfurt (8:30 h vs. 6:30 h in New York). The data has been preliminary processed to clear out recording errors.