



## On the log-normal distribution of stock market data

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### Abstract

We present our recent studies on the development of a statistical model of stock market data. For some stock market data, the statistical distribution of closing prices normalized by the corresponding traded volumes, fits well a log-normal law. For other stocks, the log-normal law is obtained after application of a detrending procedure. Different schemes for the trend determination are considered.

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### 1. Introduction

Time series originating from the stock market have a very complicated character due to a large number of factors influencing the underlying processes. The problem which presents the main interest for practically all researchers working in this area is to anticipate the behavior of stock market giving a certain amount of data.

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The investigation of the stock prices behavior, started more than 100 years ago with Bachelier's work [1], is now a rapidly developing direction in mathematics.

The formulation of a realistic mathematical model capturing the salient features of the underlying process will serve as a basis for the development of effective mathematical tools for processing stock market data and making a decision.

This work is devoted to the analysis of log-normal features of US and EU stocks and indices and can be considered as a first step for development of a statistical model of stock market.

The log-normal dependencies in the stock market data have been studied intensively for 30 years, mainly in connection with the price differences and option prices (the Black and Scholes model [2]). A full review of these investigations can be found in Ref. [3]. A review of models of prices behavior can be found in Ref. [4]. The log-normal properties of the volatility (or related values) in the stock prices and indices are considered in Refs. [5–7]. The functional relations between price shifts and corresponding transaction sizes have been studied in Refs. [8,9]. These investigations show that the impact functions have similar shapes and can be transformed to a single “master curve”.

In the present work, we analyze the statistical relations between prices and corresponding traded volumes. The analyzed stock market data are described in Section 2. Two types of data are considered: daily closing prices and daily traded volumes. In Section 3, we show that for some stock market data the statistical distribution of the closing prices normalized by corresponding traded volumes (“price/volume” ratio) fits well the log-normal law. Some other stocks demonstrate a similar distribution after specific transformations. In order to obtain the log-normal distribution for such data, we apply a detrending procedure. Different schemes of the trend determination are described in Section 4. The results of statistical analysis of detrended stock market data are presented in Section 5.

## 2. Selection of data sets

We investigate the closing prices and traded volumes of the US stock markets: IBM, Xerox, Boeing, Lockheed Martin, Delta, Airlines, Exxon Mobil, Texaco, Ford, General Motors, General Electric, Reebok, Merk, Bank of America (New York Stock Exchange—NYSE, USA) and Microsoft, Intel, Oracle, Dell, Sun (Nasdaq Stock Market, USA). In addition, we analyze the closing prices and traded volumes for some stocks in the EU markets: DaimlerChrysler (Exchange Electronic Trading—XETRA, Germany), Solvay and Arbed (Brussels Stock Exchange, Belgium).<sup>1</sup>

We also study different indices of the US stock market: S&P500, Dow Jones Industrial Average (DJIA), NYSE Composite, NASDAQ Composite, etc.

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<sup>1</sup> Such a choice of these data sets is explained by relatively low statistics in available files for European stocks.

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