ELSEVIER

Physica A 299 (2001) 521–527

PHYSICA A

www.elsevier.com/locate/physa

Long-range power-law correlations in stock returns

Pilar Grau-Carles

Department of Economics, Universidad Rey Juan Carlos, Paseo de los Artilleros s/n,
28032 Madrid, Spain

Received 6 July 2000

Abstract

This study investigates long-range power-law correlations in US, UK, Japanese, German, French and Spanish stock markets using daily data and applying a recently developed residual analysis termed detrended fluctuation analysis (DFA). We quantify correlations for the returns, absolute value of returns and square of returns. The results show that there is little evidence of long-range correlations in returns but there is strong evidence of long-range correlation in absolute and squared returns. For the absolute returns, a cross-over of approximately 41 days is found. © 2001 Elsevier Science B.V. All rights reserved.

PACS: 02.50.Ey; 05.45.Tp

Keywords: Stock market prices; Detrended fluctuation analysis; Long-memory processes

1. Introduction

There is a growing literature in financial economics that analyzes the temporal dependence of stock returns. The random walk hypothesis states that returns are serially random; in other words, that today returns are independent of previous periods stock returns. So the research on either short or long-term dependence has become somehow relevant. For example, the existence of long memory in financial data would affect the investment horizon of portfolio decisions. Furthermore, many empirical studies that are based on short memory statistical techniques would have to be revised. On the other hand, the literature of mean reversion in financial prices assumes the existence of some mechanism which works over long time horizons, because the mean-reverting behavior of stock prices corresponds to the idea that a given change in prices will be followed,

---

E-mail address: pgrau@ccee.ucm.es (P. Grau-Carles).

PII: S0378-4371(01)00248-5

in long time horizons, by changes with the opposite sign. Finally, the bases of the development of ARCH type family of stochastic models are the findings of significant autocorrelations in volatility measures, such as squared returns or absolute returns.

Previous approaches to long-memory analysis are the application of non-parametric statistic tests sensible to the persistence over long periods. The Hurst method [1] and the rescaled range analysis (R/S) proposed by Mandelbrot and Wallis [2], and Mandelbrot [3] have been applied to many financial series (e.g. Refs. [4–7]). But the findings of long memory in stock returns using R/S analysis have been disputed because this type of analysis might be biased due to the presence of short-term dependence.

More recently, Lo [8] developed a more refined technique of R/S analysis to identify long-term dependence. The modified R/S analysis is robust to serial correlation and some forms of non-stationarity. Some applications of this method to financial data sets are Refs. [9–12]; in most of the studies little evidence is found of long memory in returns.

Another test of long-memory hypothesis is the GPH [13], which is highly related to one of the dominant parametric discrete-time models that present hyperbolic decay of the autocorrelation function, the ARFIMA (fractional integrated autoregressive moving average) model introduced in Refs. [14,15]. This methodology captures the long-range correlations with the fractional difference parameter or d-parameter, which describes the higher order correlation structure of the series. This approach and the R/S analysis have been used together in some empirical analyses, for example in Refs. [9,12,16].

In this paper we will use a new methodology, a non-parametric approach that can be applied without a detailed assumption of the structure of the underlying model.

2. Methodology

The detrendend fluctuation analysis (DFA) [17,18] is a technique that permits the detection of long-range correlations. This methodology has been shown to be independent of inherent trends, local correlations and non-stationarity [19] avoiding the spurious detection of long-range correlations that are an artifact of non-stationarities; also, Taqqu et al. [20] proved that the DFA estimate is asymptotically unbiased.

The DFA method estimates a scaling exponent from the behavior of the average fluctuation of a random variable around its local trend. The method can be summarized as follows. For a time series $\{x_t\}$, $t = 1, \ldots, n$, first the integrate time series $y(t')$ is obtained:

$$y(t') = \sum_{t=1}^{t'} x(t) .$$

Next the integrate series is divided into non-overlapping intervals containing in each interval m data. In each interval, a least squared line is fitted to the data. The y coordinate of the straight line segments is denoted by $y_m(t')$. Next the root of the