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Empirical evidence of long-range correlations in stock returns

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Abstract

A major issue in financial economics is the behaviour of stock returns over long horizons. This study provides empirical evidence of the long-range behaviour of various speculative returns. Using different techniques such as R/S and modified R/S analysis, detrended fluctuation analysis (DFA), fractional differencing test (GPH) and ARFIMA maximum likelihood estimation, we find little evidence of long memory in returns themselves, by strong evidence of persistence in volatility measured as squared returns or absolute returns. These results allow us to conclude that any stock market model should show no temporal dependence in returns and long-range correlation in conditional volatility. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Long memory processes; R/S analysis; Fractional integration; Detrended fluctuation analysis; Periodogram; Stock market prices

1. Introduction

The long-range dependence, also known as long memory, is characterized by hyperbolically decaying autocovariance function, by a spectral density that tends to infinity as the frequencies tend to zero and by the self-similarity of aggregated summands. The intensity of these phenomena can be measured either by a parameter d, used as a differencing parameter in the ARFIMA model, or by the parameter H, that is a scaling parameter. Both parameters are related, in the case of finite variance processes by $H = d + \frac{1}{2}$, and in the case of infinite variance processes by $H = d + 1/\alpha$ [1]. Time

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series with long-range dependence are usually modelled with the ARFIMA (p,d,q). This model is given by

$$\phi(L)(1-L)^d x_t = \theta(L)u_t, \quad u_t \backsim \text{i.i.d.}(0,\sigma^2)\,, \tag{1}$$

where L is the lag operator, d is the fractional differencing parameter and all the roots of $\phi(L)$ and $\theta(L)$ lie outside the unit circle. For any real number d, the fractional difference operator $(1-L)^d$ is defined through a binomial expansion

$$(1-L)^d = 1 - dL + \frac{d(d-1)}{2!}L^2 - \frac{d(d-1)(d-2)}{3!}L^3 + \cdots \tag{2}$$

and for $-0.5 < d < 0.5$ the process is stationary.

There is a growing literature in financial economics that analyses 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 became 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 behaviour of stock prices corresponds to the idea that a given change in prices will be followed, 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.

2. Data

We have analyzed the behaviour of the stock market returns using daily data of five indexes: the Dow Jones (DOW), from 3 January 1927 to 27 September 1999; the Standard & Poor 500 (SP500) from 30 December 1927 to 23 November 1999; the FTSE from 9 September 1993 to 27 September 1999; the NIKKEI from 5 January 1973 to 24 November 1999 and finally the Indice General de la Bolsa de Madrid (IGBM), from 4 November 1985 to 24 September 1999. Each of the data sets has a different number of data. The Dow Jones yields 18535 daily entries, the Standard & Poor 500 yields 15646 daily entries, the FTSE 1555 daily entries, the Nikkei 4125 daily entries and the IGBM 3447 daily entries. The first four indexes correspond to big markets and the fifth is a small market in which important anomalies have been found [2]. We have calculated the returns, r_t, as the logarithmic difference in the index.

A common finding in much of the empirical literature is that returns themselves contain little serial correlation. However, the absolute returns and their power transformation present long-term correlations. The study of the behaviour of the absolute and square returns has become relevant, one reason is that the investors are influenced