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Analysis of intermittence, scale invariance and characteristic scales in the behavior of major indices near a crash

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Abstract

This work is devoted to the study of the relation between intermittence and scale invariance. We find the conditions that a function in which both effects are present must satisfy, and we analyze the relation with characteristic scales. We present an efficient method that detects characteristic scales in different systems. Finally we develop a model that predicts the existence of intermittence and characteristic scales in the behavior of a financial index near a crash, and we apply the model to the analysis of several financial indices.

Keywords: Econophysics; Scale invariance; Intermittence; Stock market prices; Latin American indices

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1. Introduction

The presence of log-periodic structures in data analysis suggests that the system has characteristic scales. During the last years the study of this phenomena and its relation with the concept of scale invariance had grown, due to the great amount of physical systems presenting log-periodic structures: fluid turbulence [1,2], diamond Ising model [3], earthquakes [4], materials rupture [5], black holes [6] and gravitational collapses [7] among others. In a mathematical context, we recall constructions as the Cantor Fractal [3,8], with a discrete scale changes invariant. This phenomenon produces a non-real term in the fractal dimension.

The presence of logarithmic periods in physical systems was noted by Novikov in 1966 [9], with the discovery of intermittence effect in turbulent fluids. The relation between both effects has been deeply studied, but it has not been formalized yet.

At the same time a new discipline: Econophysics, has been developed [10]. This discipline studies the application of mathematical tools that are usually applied to physical models, to the study of financial models. Simultaneously, there has been a growing literature in financial economics analyzing the behavior of major stock indices [10–14].

The Statistical Mechanics theory, like phase transitions and critical phenomena have been applied by many authors to the study of the speculative bubbles preceding a financial crash (see for example Refs. [15,16]). In these works the main assumption is the existence of log-periodic oscillation in the data. The scale invariance in the behavior of financial indices near a crash has been studied in Refs. [17,18].

We first study the relation between intermittence and scale invariance. We give the conditions that a function has to satisfy when both effects are present, and we analyze the relation with characteristic scales. We present a new method that detects characteristic scales in different systems using the previous results. Finally we develop a model that predicts the existence of intermittence and characteristic scales in the behavior of a financial index near a crash, and we apply the model to the analysis of the behavior of several financial indices: The NASDAQ index near the crash in April 2000, the S&P500 index near the October1987 crash, and the Hong Kong HSI index as well as the Brazil BOVESPA index, the Mexico MMX index, and the Turkey XU100 index near the October 1997 Asian crash.

2. Scale invariance

A function A, that depends on a variable "x", is *invariant for the scale change* "λx" when

$$A(x) = \mu A(\lambda x)\,, \tag{1}$$

where μ is a constant independent of x.

For a better understanding of condition (1), we can present it in the following way:

$$\mu A'(x) = A(x) \tag{2}$$