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Chaotic behavior in national stock market indices New evidence from the close returns test

Michael D. McKenzie*

School of Economics and Finance, RMIT University, GPO Box 2476V, Melbourne, Victoria 3001, Australia

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Abstract

Attempts have been made to detect chaotic behaviour in financial markets data using techniques which require large, clean data sets. Although such data are common in the physical sciences where these tests were developed, financial returns data typically do not conform. The close returns test is a recent innovation in the literature and is better suited to testing for chaos in financial markets. This paper tests for the presence of chaos in a wide range of major national stock market indices using the close returns test. The results indicate that the data are not chaotic, although considerable nonlinearities are present. The commonly used BDS test is also applied to the data and, in comparison, the close returns test provides substantially more evidence of nonlinearity compared to the BDS test. © 2001 Elsevier Science Inc. All rights reserved.

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1. Introduction

The discovery, that deterministic nonlinear equations could generate data which appear random, provided a major breakthrough in the way scientists viewed a wide range of physical processes and natural phenomena. While by no means a complete list, chaos has been identified in hydrodynamic turbulence, lasers, electrical circuits, chemical reactions, disease

* Level 16, 239 Bourke Street, Melbourne, Victoria 3000, Australia. Tel.: +61-3-9925-5891; fax: +61-3-9925-5986.

E-mail address: michael.mckenzie@rmit.edu.au (M.D. McKenzie).

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epidemics, biological reactions, and climatic change.[1] Buoyed by the research of their physical science counterparts, financial market researchers have attempted to establish whether the apparently random nature of asset prices and economic time series could also be explained by the presence of chaotic behaviour.

One of the most commonly applied tests for nonlinearity is the BDS test of Brock, Dechert, and Scheinkman (1987), details of which may be found in Dechert (1996). Subsequent to its introduction, the BDS test has been generalised by Savit and Green (1991) and Wu, Savit, and Brock (1993) and more recently, DeLima (1998) introduced an iterative version of the BDS test. The BDS test is a statistical test of the null hypothesis of IID and is based on the Grassberger and Procacia (1983) correlation integral. As such, the BDS procedure may be considered as a test for linear and nonlinear departures from IID rather than a specific test for chaos. It is in this latter context however, that the test has most commonly been applied usually in conjunction with the estimation of entropy, Lyapunov exponents, or correlation dimensions.

The BDS test has been used to test for nonlinear behaviour in a wide range of financial data including national stock market indices (see Abhyankar, Copeland, & Wong, 1995, 1997; Ahmed, Rosser, & Uppal, 1996; Barkoulas & Travlos, 1998; Hsieh, 1991; Mayfield & Mizrach, 1992; Olmeda & Perez, 1995; Philippatos, Pilarinu, & Malliaris, 1993; Scheinkman & LeBaron, 1989; Sewell, Stansell, Lee, & Below, 1996; Willey, 1992), exchange rates (see Cecen & Erkal, 1996; Chiarella, Peat, & Stevenson, 1994; Hsieh, 1989; Serletis & Gogas, 1997; Vassilicos, Demos, & Tata, 1992), futures data (see Chwee, 1998; Eldridge & Coleman, 1993; Kodres & Papell, 1991; Vaidyanathan & Krehbiel, 1992), and commodity prices (see Frank & Stengos, 1988; Kohzadi & Boyd, 1995). In general, the BDS test results furnished by this literature provide substantial empirical evidence of nonlinear structure in a wide range of financial asset prices.

The BDS test belongs to the metric invariant class of tests for chaotic behaviour, which were developed for application in the physical sciences where long, clean data sets are the norm. In finance, however, small noisy data sets are more common and the application of the BDS test to such data presents a number of problems (a discussion of which is presented in Section 2). A recent development in the literature has been the introduction of the close returns test, which is a topological invariant testing procedure.[2] Compared to the existing metric class of testing procedures including the BDS test, the close returns test is better suited to testing for chaos in financial and economic time series. Despite these advantages, in comparison to the BDS test, the close returns test has largely been overlooked in the finance literature. Gilmore (1993a, 1993b) applied the close returns test to weekly CRSP data sampled over the period 1962–1989 and the results suggest the presence of nonlinear structure in the data, which was not chaotic. US macroeconomic, treasury bill, and exchange rate data were also considered with similar results. Gilmore (1996) extended the earlier

[1] See Gleick (1987) for discussion on the range of processes, which have been found to exhibit chaotic behaviour.

[2] See Gilmore (1998) for a survey.