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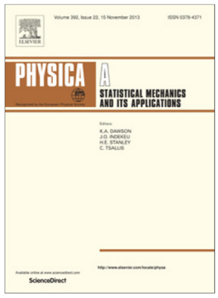

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Theory of earthquakes interevent times applied to financial markets

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Abstract

We analyze the probability density function (PDF) of waiting times between financial loss exceedances. The empirical PDFs are fitted with the self-excited Hawkes conditional Poisson process with a long power law memory kernel. The Hawkes process is the simplest extension of the Poisson process that takes into account how past events influence the occurrence of future events. By analyzing the empirical data for 15 different financial assets, we show that the formalism of the Hawkes process used for earthquakes can successfully model the PDF of interevent times between successive market losses.

Keywords: interevent times, self-excited Hawkes conditional Poisson process, financial markets

1. Introduction

The activity of many complex systems in social and natural sciences can be characterized by sporadic bursts followed by long periods of low activity. To quantitatively describe this kind of dynamics, we can use the interevent times (also called "pausing time", "waiting time", "intertransaction time", "interoccurrence time", and "recurrence time"), defined as times between two consecutive events of high (suitably defined) activity of the system. It was shown in many research papers that the probability density distribution (PDF) of interevent times plays the role of a universal characteristic of dynamical complex systems. Examples include anomalous transport and diffusion [1] (and refs. therein), pattern discovery [2], earthquakes [3–9] and rock fractures [10], extreme events and long-memory processes [11], email communications [12, 13], web browsing, library visits, stock trading [14], human dynamics [12, 14–16], social dynamics [17, 18], finance risks [19–22], letter correspondences [23], queuing processes [14], financial markets [24–28], and multifractality (multiscaling and dynamic phase transitions) studied in this context [29, 30].

In this paper, we analyze the probability density function of interevent intervals between times when market returns are producing excessive losses. Empirical market data on excessive losses are defined as losses below some negative threshold $-Q$ (or above threshold Q for the absolute value of negative returns). In addition, the mean interevent time can be used as

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