Another type of log-periodic oscillations on Polish stock market

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Abstract

Log-periodic oscillations have been used to predict price trends and crashes on financial markets. So far two types of log-periodic oscillations have been associated with the real markets. The first type oscillations accompany a rising market and end in a crash. The second type oscillations, called “anti-bubbles” appear after a crash, when the prices decrease.

Here, we propose the third type of log-periodic oscillations, where an exogenous crash initiates a log-periodic behavior of the market, and the market is bullish. The critical time is at the beginning of the oscillations. Such behavior has been identified on Polish stock market index WIG between the “Russian crisis” (August 1998) and the “New Economy crash” in April 2000.

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1. Introduction

Starting from 1996, Sornette et al. [1] in the series of papers give arguments that crashes are analogous to critical points, which are preceded by log-periodic

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oscillations. Such oscillations were studied in statistical physics. The interactions between investors lead to a speculative “bubble” which ends in a crash. Over 50 such crashes have been described on stock, FX and Gold market. Moreover, using the symmetric in time formula they have found the so-called “anti-bubble” price development which describes how a market behaves after a crash. Starting at a rapidly oscillating state after the crash a market goes down with its price decorated by log-periodic oscillations. Both types of oscillations: bubble and anti-bubble are assigned to herding behavior of investors. However, difficulties have been encountered when crashes on Eastern Europe stock markets were studied [3]. We propose another type of oscillation, where an exogenous crash initializes a log-periodic price development, but the prices are rising. We will call it “inverted bubble”.

In order to accurately define a crash we use the so-called “drawdowns”. A drawdown is a persistent decrease in the price over consecutive days [5]. We ignore corrections between local maximum and local minimum less than $\varepsilon = 30\%$ of the preceding price fall. The drawdown equals to $\ln(P_{\max}/P_{\min})$, where $P_{\max}$ and $P_{\min}$ are prices at the beginning and the end of a drawdown. According to Ref. [5] the distribution of drawdowns is a stretched exponential $f(x) = a \exp(-b|x|^z)$. The fit of stretched exponential to the distribution of drawdowns of WIG (Warsaw Stock Index) gives us: $a = 63.6$, $b = 0.019$, $z = 1.08$. Events with drawdowns less than $-14.5\%$ are outliers. We will adopt a definition of a crash as a drawdown with price loss over $14.5\%$.

2. Log-periodic oscillations

The prices or index values prior to crash are described by the first term “Landau” expansion. The expansion describes a power law behavior of price $p(\tau)$

$$\frac{d \ln p(\tau)}{d \ln \tau} = (\beta + i\omega).$$

This equation illustrates that the price $p(\tau)$ becomes self-similar with respect to the dilation of the distance $\tau$. The relative variations $d \ln p = dp/p$ of price with respect to the relative variations of the time to crash $d \ln \tau = d\tau/\tau$ are independent of time. From Eq. (1) one can obtain a log-periodic development of price

$$p(\tau) = A + \tau^\beta[B + C \cos(\omega \ln \tau + \phi)],$$

where $\tau = |t_c - t|$, and $t_c$ is the critical time (the time of crash).

The numerical way to identify log-periodicity in a time series is to fit the 7 parameters-function from Eq. (2) to the data. The least-squares fit was done using the amoeba fitting procedure [6].
To convince that the oscillations are really present in the data we transform the analyzed data to a pure cosine function [4]

\[ t_k \rightarrow \ln |t_k - t_c| \]  

\[ p_k \rightarrow \frac{p_k - (A + B\tau^\beta)}{C\tau^\beta} , \]  

where \( t_k \) and \( p_k \) are time and price of the \( k \)th data point. From the transformed data we made a Lomb periodogram [6]. The Lomb periodogram is used to find periodicity in unevenly sampled data. The Lomb periodogram should give us the same frequency as the fitting procedure.

3. Why inverted log-periodic oscillation?

The Nasdaq “New Economy” fall in April 2000 was a bubble ending in a crash [2]. This event is an instance of log-periodic price development on rising market ending with a crash. A fit with Eq. (2) describes the behavior of Nasdaq from Spring 1997 to April 2000. The examined period consists of four evident oscillations.

The “New Economy” crash was also observed on the Polish stock market. However, no satisfying long-term fit with Eq. (2) could be made. Our attempts to fit a bubble to the WIG index before the “New Economy” crash gave the critical time 4 months after the crash and were extended only by about 1.5 periods of the cosine function.

Therefore, we propose another possibility of describing the development of WIG index in the time period from August 1998 to April 2000. In August 1998 the “Russian crisis” occurred. The “Russian crisis” was an exogenous event for the Polish stock market. The critical time \( t_c \) (August 1998) means the starting point of the inverted bubble: a log-periodicity price behavior with a rising market. The fit extends over 4 periods of the cosine function (Fig. 1—left panel). We have found two satisfactory fits to the WIG index: the first fit is with \( \omega = 9.8 \) and second one is with \( \omega = 11.3 \).

The second example of an inverted bubble is the Polish index WIRR (Warsaw Index of the Parallel Market) in the time period between August 2002 and June 2003 (Fig. 1—right panel). This bubble was preceded by three subsequent drawdowns (−5.3%, −4.8%, −8.4%) from mid-June to mid-August 2002. The index fell 20.7% in these two months. After the end of the log-periodic behavior, in July and August 2003, two extraordinary drawups occurred (+26.7% and +21.5%).

The log-periodic oscillations seem to be an important propriety of stock markets. Their origin is still mysterious. The type of oscillations found in this paper creates even more questions about the nature of log-periodic oscillations.

Note: After finishing this paper we have recognized that inverted bubbles were independently described by Zhou and Sornette [7]. They have found six market indices with such behavior (they call them “bullish anti-bubbles”). All critical times were set between August and November 2000.
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References


Fig. 1. Inverted bubbles for the Polish stock indexes WIG (left panel) and WIRR (right panel). Parameters of fit to the WIG index are: $\beta = 1.07$, $\omega = 9.82$, $t_c = 1998.606$. For the WIRR index we have: $\beta = 1.7$, $\omega = 15.85$, $t_c = 2002.4$. Both fits expand over 4 periods of the cosine function. The middle panel shows the data transformed to the cosine function with the aid of Eqs. (3) and (4). The bottom panel is the Lomb periodogram.