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Physica A 338 (2004) 135 – 142

PHYSICA A

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Origin of crashes in three US stock markets: shocks and bubbles

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Abstract

This paper presents an exclusive classification of the largest crashes in Dow Jones industrial average, SP500 and NASDAQ in the past century. Crashes are objectively defined as the top-rank filtered drawdowns (loss from the last local maximum to the next local minimum disregarding noise fluctuations), where the size of the filter is determined by the historical volatility of the index. It is shown that *all* crashes can be linked to either an external shock, e.g., outbreak of war, *or* a log-periodic power law (LPPL) bubble with an empirically well-defined complex value of the exponent. Conversely, with one sole exception *all* previously identified LPPL bubbles are followed by a top-rank drawdown. As a consequence, the analysis presented suggest a one-to-one correspondence between market crashes defined as top-rank filtered drawdowns on one hand and surprising news and LPPL bubbles on the other. We attribute this correspondence to the efficient market hypothesis effective on two quite different time scales depending on whether the market instability the crash represent is internally or externally generated.

PACS: 89.65.Gh

Keywords: Financial markets; Crashes

1. Addressing the problem

The characterization of large negative moves on the stock market is by definition of profound importance to risk management of investment portfolios. An objective non-arbitrary definition of "large" or similarly "a crash" has yet to be agreed upon by the financial community. Here, such a definition of *a crash* is presented in terms of ε-drawdowns, i.e., noise filtered drawdowns where the size of the filter ε is determined

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0378-4371/$ - see front matter
doi:10.1016/j.physa.2004.02.035

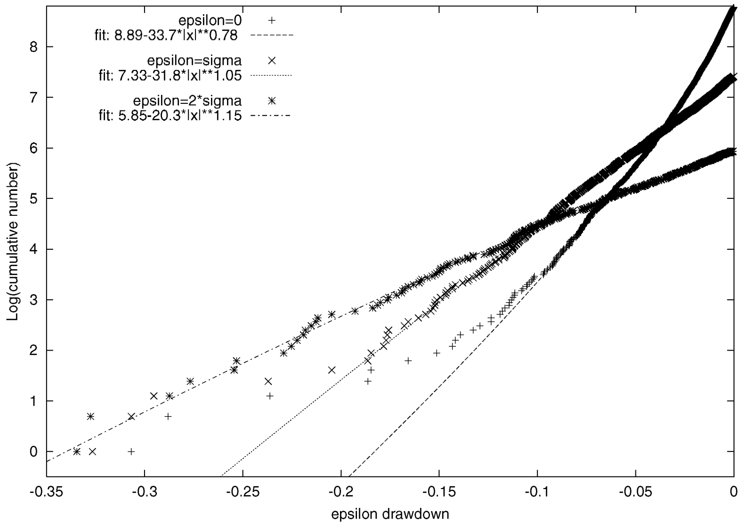

Fig. 1. ε-drawdown distributions for DJIA from 01/01 1900 to 17/07 2000.

by the historical volatility of the index. An ε-drawdown classifies as a crash if its rank $i \sim 1$, i.e., the special name "crash" is reserved for the "few" largest negative price drops. Ideally, one would like to "prove" that these largest negative price drops are outliers to the bulk of the distribution of price drops. As for now, a large body of evidence has accumulated which suggest that this is most likely the case [1–7] but not more. This problem will be further addressed in a future publication and this paper only provides for an "eye-balling" analysis by the reader with Figs. 1–3. The reader is then left to judge for himself but should note that for the largest filter used (see figure legends), all ε-drawdowns for all three indices are parametrized by the fit with function (4).

Specifically, for the Dow Jones industrial average (DJIA) the four largest ε-drawdowns are characterized as crashes, for the SP500 the five largest and for the NASDAQ the six largest. Naturally, this does not exclude, e.g., that the fifth largest ε-drawdown in the DJIA may also be characterized as a crash, but this is the interpretation of "few" put forward here. Returning to the other two indices, for the SP500 an additional ε-drawdown has been included due to the higher historical volatility of the SP500 compared to that of the DJIA. For the same reason, the six largest ε-drawdowns are considered for the NASDAQ. The time series extend from 01/01 1900 to 17/07 2000 for the DJIA, from 29/11 1940 to 17/07 2000 for SP500 and from 05/02 1971 to 17/07 2000 for the NASDAQ.

An ε-drawdown is defined as a persistent decrease in the price over consecutive days from a local maximum to the next local minimum *ignoring* price increases in between the two of relative size less than ε. Since they are constructed from runs of the same sign variations, ε-drawdowns embody a rather subtle dependence which captures the way successive drops can influence each other. This "persistence" is not measured by