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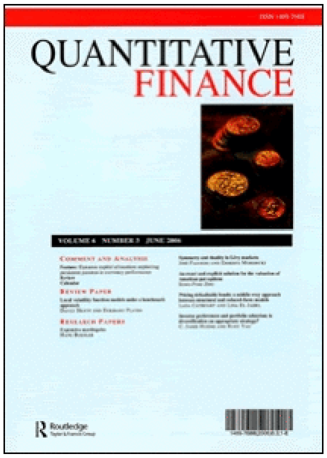

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The US 2000-2002 market descent: clarification

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The US 2000–2002 market descent: clarification

Didier Sornette and *Wei-Xing Zhou* respond to the issues raised by Anders Johansen in his comment 'An alternative view' published in *Quantitative Finance* **3** C6.

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In a recent comment [3], Johansen criticized our methodology and questioned several of our results published in this journal [13] and in our two subsequent preprints [15, 16]. Against this criticism we welcome the opportunity to clarify our work further.

Landau expansion, 'double cosine' and Weierstrass-type solutions

Johansen criticizes our use of the 'double cosine' function on the basis that a sound theoretical justification is lacking, while he puts his faith in the Landau expansion introduced in [12] and extended up to third order in [5]. In fact, the full solution of the simplest renormalization group equation for a critical point has been analysed in depth in [2] and provides an improvement of these approaches in the form of Weierstrass-type functions of the form

$$\ln[p(t)] = A + B\tau^m + \Re\left(\sum_{n=1}^{N} C_n e^{i\psi_n}\tau^{-s_n}\right) \qquad (1)$$

where $\tau = |t - t_c|$, $s_n = -m + in\omega$ and $\Re$ is the real part operator. The existence of different phases ψ_n criticized by Johansen can be seen to derive naturally from the Mellin transform of the regular part of the renormalization group equation. In simple words, the different phases ψ_n embody information on the mechanisms of interactions between investors. There is thus a sound theoretical justification for such a phase shift (assume $\psi_2 - \psi_1$) between the first and the second harmonics (assume the first two terms $n = 1$ and 2 of the expansion (1)). When the phases have certain relationships (phase locking), a discrete hierarchy of critical times emerges, which has been found to describe very well the US stock market since the summer of 2000 [16]. Johansen's misconception can probably be traced to the incorrect idea that the phase of the simple cosine formula (case $N = 1$) has no financial meaning because it can be gauged away in a redefinition of the time scale.

Symmetry between bubbles and anti-bubbles and universality

From a mechanistic viewpoint, we advocate the existence of anti-bubbles from the idea that the conflict between positive and negative feedbacks is operative both in bullish as well as in bearish markets [11]. From a descriptive viewpoint, our recent works [13, 15, 16] just follow Johansen and Sornette's previous works [5–7, 10], which introduced the concept of an 'anti-bubble' from a symmetry perspective. Symmetry may have distinct consequences. It can be used to justify the same functional expressions both for bubbles and anti-bubbles. Thus, in the mathematical expressions, the symmetry between bubbles and anti-bubbles amounts to changing $t_c - t$ for bubbles to $t - t_c$ for anti-bubbles. Here, we should stress that, if a log-periodic power-law (LPPL) anti-bubble follows a LPPL bubble (which is not the general case), the critical time t_c is not generally the same. A noteworthy exception is the Russian stock market around 1997 [10]. We report in [13, 15] dozens of anti-bubbles in many different stock markets worldwide of which almost all started in August 2000, that is, four months later than the end of the 'new economy' bubble and its crash in April 2000. Another case is Chile around 1994–1995, where the bubble ended in February 1994 while the anti-bubble started in July 1995 [6].

Johansen advocates that the symmetry between bubbles and anti-bubbles should be extended so that the same log-periodic angular frequency ω describes both cases. He thus invokes not only a functional but also a numerical symmetry. We think that this belief may be too rigid at the present time when we still have a rather limited understanding of this complex problem. We propose an open-minded approach more adapted to a learning phase. It is correct that, for LPPL bubbles, there is a rather well-defined cluster of values for $\omega \approx 6.36 \pm 1.56$ and for $m \approx 0.33 \pm 0.18$ as reported in [9] (see equation (4) of [4]). For anti-bubbles in the USA S&P and in many EU markets, we find almost the same value $\omega \approx 12$. This value is comparable with those obtained for the anti-bubbles in the Latin-American and Western markets in the 1990s [6]. It is interesting that this value $\omega \approx 12$ is approximately twice the most probable value ω found for LPPL bubbles. Does it correspond to a log-periodicity different from that of bubbles? Probably not, for the following reason: we have found in [13, 15] that both ω and 2ω were quite significant in the anti-bubbles, including the Nikkei case that started in 1990. Due to the probable variation of the strength of nonlinear processes in the stock markets, it can be expected that the amplitudes of the first and second harmonics can be different from one realization to the next. Within the renormalization group framework, the relative strength of the first and second harmonics is controlled by the regular part [2] which describes the specific interactions of the investors that led to a given realization of the market. Let us add that the importance of the role of log-periodic harmonics has been demonstrated for turbulence [14, 17], where the evidence is much stronger. For the emergent markets, the LPPL signatures are not as significant as for the major Western markets, as already noted in [6]. Johansen also notes the ω found for different worldwide markets are not peaked and may be due to noise. Instead, we think that this is due to a possible lack of sufficient robustness of the fits, which does not diminish the evidence for log-periodicity but suggests that we interpret with care the specific reported values. This can be seen from the fact that, if we impose the additional condition in our fits that the different worldwide markets exhibit an anti-bubble with the same critical time t_c, we find that their angular log-periodic frequencies ω are very close to each other. The quasi-simultaneity of

The different phases ψ_n embody information on the mechanisms of interactions between investors.

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the starting time and the ensuing strong synchronization of the anti-bubbles exhibited by the major stock markets in the world, which has been documented in [15], provides an additional justification for the use of the same critical time t_c.

Criticality

Johansen criticizes our abandoning of the constraint $m < 1$ as a necessary condition to qualify the existence of a bubble or anti-bubble, suggesting that we have renounced the concept of criticality. There are several issues here that need to be distinguished. First, the many tests performed by the present authors and previously by Johansen with Sornette (reported in [3] as work that Johansen performed with Matt Lee) show that the condition on the exponent m is much less effective in the detection of bubbles than a condition on ω for instance (see also the discussion in chapter 9 of [11]). This is one justification for abandoning any constraint on this rather sensitive parameter to 'let the data speak'. Second, finding values of $m \geq 1$ does not amount to an absence of criticality, because the equation is still critical (that is, it exhibits a singularity) due to the presence of the theoretically infinite hierarchy of log-periodic oscillations. In other words, criticality remains present due to the imaginary part ω of the exponent $s_n = -m + in\omega$ of the LPPL (see equation (1)) as long as it is non-zero, whatever the value m of its real part. Third, we can relax the condition $0 < m < 1$ for the present purpose because our LPPL formulae describe only a finite range of the time interval: it is well known that true singularities do not exist in nature as friction, finite-size effects and other regularization mechanisms come into play close enough to the theoretical mathematical singularity. What is important is the ability of the LPPL formula to describe with good accuracy a large range of the data, not necessarily the very close proximity to the phantom singularity. In this respect, we refer to the rather detailed discussion of the effect of finite-size effects on singularities presented in [8].

'Bullish anti-bubbles'

In our analysis of numerous stock markets in the world, we have identified six examples which give a positive coefficient B in (1). In particular, the statistical significance of this result is very high for Australia, Mexico and Indonesia. This regime $B > 0$ is different from the normal bubble and anti-bubble cases previously reported for which $B < 0$. This regime $B > 0$ has been coined 'bullish anti-bubbles' [15] to describe the joint features of decelerating log-periodic oscillations and of an overall increasing price. In contradiction to Johansen's remark, this regime $B > 0$ does not lead to infinite prices in a finite time but describes a long-term growth which turns out to be slower than standard exponential growth. The same remark applies for $m > 1$.

Absolute value of $t_c - t$

In complete disagreement with Johansen's remark, our use of $|t_c - t|$ in our fits to locate the critical time t_c does not abandon 'another restriction coming from the data'. Rather than adding a degree of freedom, this approach instead removes an arbitrariness previously present in the fitting procedure in choosing the time interval over which the fit is performed. Rather than determining an approximate starting time and/or estimating the critical time t_c by the location of the largest market peak, using $|t_c - t|$ makes the fits almost independent of the chosen starting time. This improved robustness has been documented in detail by the many numerical tests presented in [13, 15].

Fractal LPPL patterns

As we stated in [13], Drozdz et al [1] have reported the existence of LPPL within LPPL, using eye-balling in a single case. As mentioned by Johansen [3], he, with Sornette, studied this phenomenon rather systematically about a year earlier but never published due to the marginal quality level of the results. In [13], we mentioned that the worldwide anti-bubble that started in the summer of 2000 has also left its imprint on the Japanese market, leading to an anti-bubble within the large-scale anti-bubble that started in January 1990. This possibility of structures within structures is expected on general grounds from the renormalization group model of LPPL singularities leading to Weierstrass-like solutions (see [11, 16]). The problem is that such an observation is not very robust when one goes to small time scales, probably due to the fact that 'noise' and idiosyncratic news affect more and more strongly the price time series, the smaller the time scale of observation. However, we note that our report [13] of a 2.5 year long anti-bubble decorating a 13 year long anti-bubble of the Nikkei index should have a special status because both time scales are sufficiently long to compare with the time span over which previous LPPL have been qualified. Johansen himself acknowledges that 'the real success was with a LPPL analysis on time scales of one to two years of data'. Our report in [13] passes this criterion and should thus be considered at a level different from the published [1] and unpublished analyses at smaller time scales.

> There is thus no qualitative nor quantitative difference between the Japanese and USA data sets.

Similarity between the Nikkei index in 1990–2000 and the S&P 500 in 2000–2002

Johansen downplays the 'remarkable similarity' we, as well as many observers, noticed between these two markets. First, the factor of two in the value of the log-periodic frequency is explained by the competition between the two first harmonics $n = 1$ and $n = 2$ in (1), as we explained above. In [13], we stress the remarkable similarity in the two markets with respect to the existence of two harmonics in both cases.

Second, the Nikkei did go through a now well-recognized speculative bubble culminating at the end of December 1989, even if its price trajectory does not qualify as a very good LPPL. We note in this vein that an anti-bubble is usually the follow-up of very high prices, not necessarily of a LPPL bubble. Even in the case of the US market, we stressed above that the critical time of the bubble occurred four months before the critical time of the following anti-bubble. This again stresses that one should exercise caution in twinning rigidly in time the occurrence of bubbles and of anti-bubbles. Third, Johansen argues that the analysis of the Nikkei was based on nine years of data compared with less than three years for the US market which, he argues, makes these two cases. Johansen omits

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to mention that the 9 years of Nikkei data required the use of a log-periodic formula extended to third-order in the Landau expansion mentioned above while the analysis in [13] of the US market used only the first-order formula and its extension with a second harmonic. Johansen and Sornette's initial analysis of the Nikkei data in [5] showed that, similarly to the US market, the first three years of the Nikkei time series could be adequately described by the first-order formula. It is by extending to large time horizon that it was necessary to use the higher-order terms in the Landau expansion. It is also interesting to note that there was a global anti-bubble starting in January 1994 in the major Western stock markets [6], which also bears similarities to the present worldwide 2000–2003 anti-bubble case [15]. The global anti-bubble in the mid-1990s lasted less than one year, while the 2000–2003 anti-bubble is still alive on many more markets, resulting in a much higher statistical significance level. There is thus no qualitative nor quantitative difference between the Japanese and USA data sets. We would like to add that the similarity between the Nikkei in 1990–2000 and the S&P 500 in 2000–2002 can be further strengthened by paralleling the economic and financial distresses of the two countries, as explained in [13].

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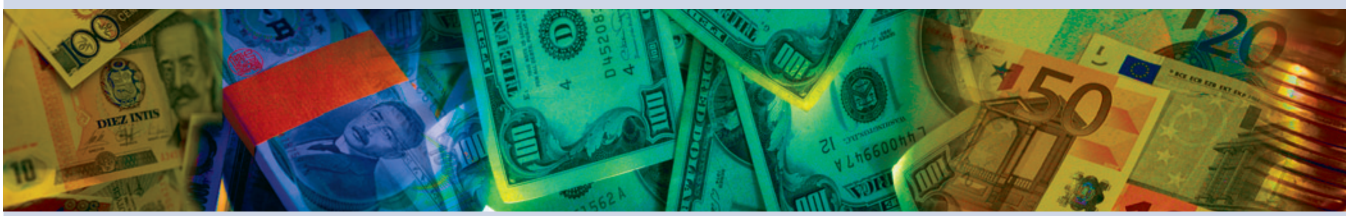

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