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# Are financial crashes predictable?

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**Abstract.** – We critically review recent claims that financial crashes can be predicted using the idea of log-periodic oscillations or by other methods inspired by the physics of critical phenomena. In particular, the October 1997 "correction" does not appear to be the accumulation point of a geometric series of local minima.

It is rather tempting to see financial crashes as the analogue of critical points in statistical mechanics, where the response to a small external perturbation becomes infinite, because all the subparts of the system respond cooperatively. Similarly, during crashes, a large proportion of the actors in a market decide simultaneously to sell their stocks. If one furthermore postulates that this critical point is decorated by "log-periodic" oscillations (for which there is a recent upsurge of interest in a wider context [1]), then one can interpret the oscillations seen on markets as precursors to predict the crash time $t_c$, which should be the point where these oscillations accumulate. Intriguing hints supporting this scenario have initially been reported in [2, 3], and more recently in [4, 5], where it was explicitly claimed that the October 1997 correction was predicted *ex-ante* (see also [6]). As a proof of this, the implementation of a winning strategy was reported in two papers published in physics journals [7]. In view of the considerable echo that these claims have generated, in particular in the physics community [8], we feel that it is important to temper the growing enthusiasm by discussing a few facts.

In general, the unveiling of a new phenomenon either results from a strong theoretical argument suggesting its existence, or from compelling experimental evidence. In the present case, there is no convincing theoretical model which substantiates the idea that crashes are

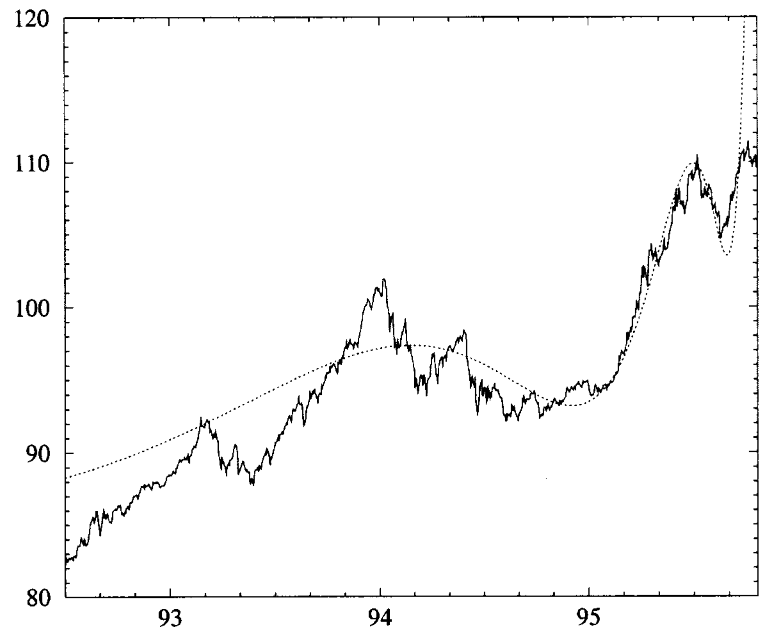


Fig. 1. – The JGB during the years 1993-1995, and a seven-parameter log-periodic fit. On this basis, a crash during the fall of 1995 was predicted in early May 1995 [9].

critical points—not even speaking about log-periodic oscillations. On the "experimental" side, there has been only very few crashes where this scenario (or any theoretical model for that matter) can be tested. Hence, although suggestive, the empirical findings are obviously not statistically significant. The fact of correctly predicting one event *ex ante* (the October 1997 correction [5,7]) is clearly not enough to prove the theory right: many "chartists" make a living by "recognizing" patterns on past charts of prices and are on average right 50% of the time. As a matter of fact, another "crash" prediction was made on the JGB (Japanese Government Bonds), on the basis of a log-periodic analysis [9] shown in fig. 1. The prediction, made in May 1995, was that a crash would occur in the fall of 1995, an information which was used by one of us (JPA) to buy put options on the account of CFM, a fund management company trading on the basis of statistical models. As shown in fig. 1, the crash did not occur, and only a delicate trading back allowed to avoid losses. The point is *not* that the out-of-sample prediction failed (the risk was deliberately taken), but rather that it worked one time and failed the other, a fact that should have been mentioned in [7]. Obviously, this *does not* mean either that the method works 50% of the time (which would already be quite interesting); an apparent success out of two trials is simply not statistically meaningful.

The methodological procedure used to extract the "crash time" $t_c$ is actually rather dubious, since a seven (or even nine) parameters fit to noisy data is required, which is of some concern. Sometimes, the time period over which the fit is performed is rather long, which implies that a small dip occuring more than five years before the crash must be seen as causally related to the crash, which is somehow hard to believe. A more robust prediction of the log-periodic scenario is that the price chart should exhibit a sequence of minima (and maxima) at times

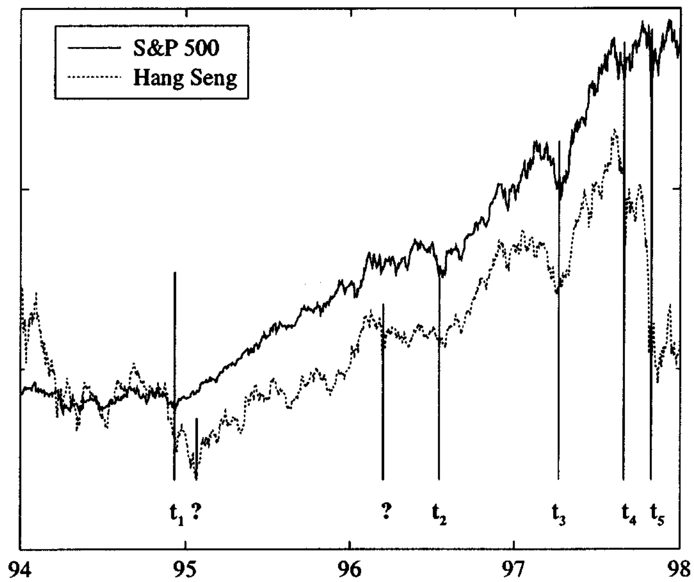


Fig. 2. – The S&P 500 and the Hang Seng Index rescaled to fit on the same (linear-log) graph, in the period 1994-1997. The five local minima $t_i$ are indicated along with two "extra" minima for the Hang Seng. Note that there are quite a few other "secondary" minima which make the identification of the $t_i$'s rather ambiguous.

$t_n$ such that

$$\frac{t_{n+1} - t_n}{t_n - t_{n-1}} = \lambda \frac{t_n - t_{n-1}}{t_{n-1} - t_{n-2}}, \qquad \lambda < 1, \tag{1}$$

*i.e.* that the time lags between minima follows a geometric contraction. The crash time is defined as the accumulation of these minima. Looking at the S&P chart between 1994 and the end of 1997 (see fig. 1), one can identify five "major" minima, most of them being identified as such by the press at the time, the last (at time $t_5$) one being the October 1997 "crash" [10]. (Of course, there are also many local minima of less importance.) One finds the following time lags (in days): $t_2 - t_1 = 403$, $t_3 - t_2 = 182$, $t_4 - t_3 = 97$ and $t_5 - t_4 = 44$. On the basis of the first four events, one obtains three time lags and thus two estimates of $\lambda$, namely 0.45 and 0.53, from which one estimates $t_5 - t_4 = 48 \pm 4$: this is the "crash" prediction, which indeed

TABLE I. – *Results of the monthly trading strategies based on the time series forecasting presented in* [6, 12]. *The procedure has been tested using* 3, 4 *and* 5 *past data points. The prediction errors measured through* $\overline{|r|}$ *or* $\sqrt{\overline{r^2}}$ *(where* $r$ *is the relative error) are systematically at least three times larger than the no-change prediction (i.e. constant price).*

| Method | $\overline{\vert r\vert}$ (%) | $\sqrt{\overline{r^2}}$ (%) |
|---|---|---|
| no-change | 2.8 | 3.4 |
| 3 months | 7.5 | 10.0 |
| 4 months | 5.8 | 11.3 |
| 5 months | 12.3 | 17.0 |

worked well since the observed $t_5 - t_4 = 44$.

*But*, the scenario also predicts that another drawdown should have occurred at $t_6$ such that $t_6 - t_5 \simeq 20$, *i.e.*, at the end of November 1997, and maybe another one 9 days later— none of which occurred. One can of course argue that the accumulation of crash times will be smeared out when one reaches the day (or the week) time scale, but in any case a 6th minimum should have been observed, otherwise the very notion of "critical point" is empty. In view of the fact that three successive ratios $\lambda$ were close to one another (and close to their 1987 value [11]), the possibility of a crash occuring at the end of November was real; conversely, its non-existence throws serious doubts on the validity of a log-periodic scenario. Furthermore, one can study the Hong-Kong index which did experience a serious crash at the end of November 1997. One finds that the above $t_n$, $n = 1, 5$ indeed corresponds to rather deep minima; however, there are also at least two extra "obvious" minima between $t_1$ and $t_2$ which ruins the idea of a constant $\lambda$ (see fig. 2).

Using somewhat related ideas, another prediction of the October 1997 correction was reported in [6]. These authors also predicted a 13% fall of the S&P during March 1998 [12], which did not occur (the index rose by 5% instead). We have systematically tested their method, where the price at the end of the next month is predicted on the basis of the previous three to five months. We studied the S&P from 1990 to the beginning of 1998, and found that, for example, the prediction error using the 3 point procedure described in [6] is about 10% (see table I), which is three times larger than the simplest "no-change" prediction, *i.e.* that next month price is equal to this month price.

To answer the question raised in the title, we have argued that the recent claims on the predictability of crashes are at this point not trustworthy. This, however, does not mean that crash precursors do not exist, an example could be a systematic increase of the volatility prior to the crash, which would account for the apparent acceleration of the oscillations. This general subject certainly merits further investigations. Finance is a fascinating field with huge amounts of money at stake. There is a danger that this might sometimes lead physicists astray from minimal scientific rigor.

*Additional remark.* Just before going to press, we received a new preprint by A. Johansen, O. Ledoit and D. Sornette (cond-mat/9810071), where they discuss a new microscopic model for financial crashes. Their model exhibits log-periodic precursors to crashes, which should not be surprising since discrete scale invariance (DSI), responsible for such log-periodic fluctuations, is built-in by hand: the model is based on a hierarchical diamond lattice.

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[5] For a more careful analysis, see: Ausloos M., Boveroux P., Minguet A. and Vandewalle N., *Eur. Phys. J. B*, **4** (1998) 139; their prediction was announced in the general press in *Tendances*, (18 sept. 1997) 26-27 and *ibid* (30 oct. 1997) 11.

[6] Gluzman S. and Yukalov V. I., *Mod. Phys. Lett. B*, **12** (1998) 75.

[7] This is reported in two identical footnotes, in Stauffer D. and Sornette D., *Physica A*, **252** (1998) 271, and again in Roehner B. M. and Sornette D, *Eur. Phys. J. B*, **4** (1998) 387, where a 5 to 1 reward based on the log-periodic "bet" is presented as the proof of the pudding. Under the reasonable assumption that option prices are not too far from "fair-game", this means that the market itself estimated the probability of such an adverse move to be about 20%. Indeed, the price of deep out-of-the-money puts has been very high ever since mid 1997.

[8] Chapman T., *Europhys. News*, **29** (1998) 4; 35-36.

[9] Sornette D., private communication to J.-P. Aguilar, May 1995.

[10] To call the October 1997 turmoil a crash is furthermore unadapted, since the S&P index made a strong rebound on the following day and reached a new historical high about a month later!

[11] Note that the parameter $\lambda$ for the 1987 crash is calculated using the 7 (or 9) parameter fit to a full log-periodic oscillating function, while for the 1997 crash, identification of the local minima is used. Neither method works convincingly in the other case.

[12] Gluzman S. and Yukalov V. I., cond-mat/9803059.