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What Can the Log-periodic Power Law Tell about Stock Market Crash in India?

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Abstract Stock markets have been of great interest to investors and academicians due to the uncertainty and expected pecuniary profits attached to them. For a few years, the Indian capital market has seen high volatility and market crashes. Market crashes are often preceded by speculative bubbles with two main characteristics: (a) power law acceleration of the market price, and (b) log-periodic oscillations. This paper attempts to investigate whether the Indian stock market follows log-periodicity. Here log-periodicity refers to the fact that the oscillations are periodic in the logarithm of the time-to-crash. Speculative bubbles of financial markets show similarities in the way they evolve and grow. This particular oscillating movement can be captured by the log-periodic power law. If market follows log-periodicity, a crash may be predicted. The analysis shows that log-periodic oscillations are present in the Indian stock market.

Keywords: log-periodic, stock market, stock market crashes

JEL Classification: G01, G19, P43

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Introduction

Stock market crash can cause a sudden and dramatic decline in the wealth of the stakeholders. The crash is characterized by dramatic and sudden devaluation of prices which is often triggered by panic and abrupt selling. A speculative bubble starts with increasing sales or production. The attraction for investment with good potential gains leads to increasing investments and rising prices. This causes the demand for stock to grow faster than that of the real money in the market. The number of new investors entering the market decreases. The market instability is exposed and then the market collapses.

The condition of panic is aggravated by the tendency of investors to act collectively in a manner that is referred to as herding. Herding is a process by which individuals in group start acting together without planned direction. It is both an outcome of external economic conditions clubbed with psychology which leads to the crowd behavior on the basis of certain private information not being shared publicly. The excessive volatility often leads to negative effects and inefficiency, which are seen to be highly correlated with high volatility in financial asset prices.

Partnoy (2000) pointed out that there are three main reasons that cause a crash namely cognitive error, moral hazard, and information asymmetry. Log-periodicity can be used as a tool to study the crash (see Bree and Joseph, 2007). Johansen and Sornette (1998); Johansen (2004); Lillo and Mantegna (2004); Sornette (2009) found that crash is an outlier representing an observation from a random sample that has an abnormal numerical distance from the rest of the numerical values in the data set. Among others, Johansen, Ledoit and Sornette (2000); Drozdz *et al.* (2008); Bartolozzi *et al.* (2008); Sornette and Woodard (2009); Canessa (2009) revealed that log-periodic structures exist in various markets of the world. Sornette and Woodard (2009) showed that the log-periodic structure is the precursor to financial crashes in the world stock markets.

The objective of this study is to investigate whether the Indian stock market crashes follow the log-periodic power law. The concept is based on the economic theory of rational expectation. It is assumed that the crash is caused by local self-reinforcing imitation between the participants in the market. The analytical model provided by Bree and Joseph (2007) is applied. The methods and data are described in the next section followed by results and discussions and conclusion.

Methods and Data

This study analyzes crashes in the Indian stock market: (1) BSE Sensex on 5 Oct 1998, 4 April 2000, 17 May 2004, 21 January 2008, 10 October 2008, 24 October 2008, and 7 January 2009, and (2) NSE Nifty 50 on 28 October 1997, 5 October 1998, 17 April 1999, 14 May 2004, 17 May 2004, 21 January 2008, and 24 October 2008. These two indexes are widely used by investors for tracking the stock markets in India. The time series data from 1997 to 2009 for the variables used in the model below were collected from websites of the National Stock Exchange of India and Bombay Stock Exchange.

According to Bree and Joseph (2007) a crash is said to occur when the value of the index has fallen from its peak. The particular characteristic of the peak is that its value is higher than the value of the index in the last 262 days (considering 262 trading days in a year). In this paper, the same definition is applied. A crash occurs when a huge number of participants in the financial market place sell orders at the same time. In normal situation, the participants differ in opinion and place equal buy and sell orders in totality. In such case a crash does not happen as the total number of buy and sell orders are equal; there are as many buyers as sellers.

It is proposed that all the participants are organized into a network of family, friends or colleagues. They influence each other locally through the network. Boissevain and Mitchell (1973) and Cosmides and Tooby (1994) found that participants influence each other in the network. A crash occurs when everyone in the network has the same opinion of selling. In the model, it is assumed that the participant tends to emulate the opinion of people connected to her/him within the network. Local imitation of participants leads to global cooperation. This global cooperation among participants ultimately causes the crash. This study uses the following equation provided by Bree and Joseph (2007) to analyze the crashes in the Indian stock market.

(1) $$Y_t = A + B\,(t_c - t)^{\beta}\,\{1 + C \cos(\omega \log(t_c - t) + \phi)\}$$

where Y_t is the price index; $Y_t > 0$

A is the value of Y_t at the critical time; $A > 0$

B is the increase in Y_t over the time unit before the crash; $B < 0$

C is the proportional magnitude of the fluctuations around the exponential growth; $|C| < 1$

t_c is the critical time; $t_c > 0$

t is any time into the bubble preceding t_c; $t < t_c$

β is the exponent of the power law growth; $\beta = 0.33 \pm 0.18$

ω is the frequency of the fluctuations during the bubble; $\omega = 6.36 \pm 1.56$

ϕ is a shift parameter; $0 \leq \phi \leq 2\pi$

In the analysis, we consider seven crashes each from BSE Sensex and NSE Nifty 50 for which the decrease in the value of the index is greater than 7% of the value of the index on the previous day of the crash. These fourteen observations are the major crashes of the Indian stock market during the period 1997-2009. In Equation 1, we apply various combinations for values of Beta, Omega and Phi as suggested by Bree (2009) and Sornette and Johansen (2001) to these fourteen crashes. The values are shown in Table 1. This is to identify a particular set of values of Beta, Omega and Phi that generates the log-periodic curve fitting the actual trend line of the index value. The data of two years prior to each crash were used. The data fitting technique is applied to identify the best fit (Bree, 2009). Thus, there are 112 graphs for log-periodicity for the above 8 sets of values for 14 crashes.

Table 1 The sets of Beta, Omega and Phi values used in the analysis

Beta (β)	Omega (ω)	Phi (ϕ)
0.33	11.00	0.00
0.50	11.00	0.00
0.51	7.92	0.00
0.51	4.80	2.00
0.51	4.80	6.28
0.55	7.92	0.00
0.55	7.92	6.00
0.15	7.92	6.00

Results and Discussion

Table 2 shows the number of fall days in the BSE Sensex from 2 July 1997 to 3 November 2009. Here we consider the falls in a day from < 0% to $\geq$ -1%, < -1% to $\geq$ -2%, < -2% to $\geq$ -3% and so on till < -7%.

The total number of working days for BSE Sensex was 3,049. The Sensex was closed in green for 1,636 days and in red for 1,413 days. Similarly the total number of working days for Nifty 50 was 3,087. The Nifty 50 was closed in green for 1,661 days and in red for 1,426 days. Around half of trading days was shown positive and the other half negative.

Table 2 The number of fall days in the BSE Sensex and NSE Nifty 50 from 2 July 1997 to 3 November 2009

Percentage decrease	BSE Sensex (days)	NSE Nifty 50 (days)
< 0 and ≥ -1	720	741
< -1 and ≥ -2	389	380
< -2 and ≥ -3	163	166
< -3 and ≥ -4	84	74
< -4 and ≥ -5	34	31
< -5 and ≥ -6	12	17
< -6 and ≥ -7	7	6
< -7	7	7

The analysis shows that out of 14 crashes, only 6 were most fit in the log-periodicity curve. All these crashes fit in at the same set of values: β = 0.51, ω = 4.80 and ϕ = 6.28. The set of values is in the range of β = 0.33 ± 0.18, ω = 6.36 ± 1.56 and $0 \leq \phi \leq 2\pi$ as suggested by Bree and Joseph (2007) for using Equation 1 of log-periodicity to study crash. For BSE Sensex, 3 crashes were found to fit the equation (Figure 1 to 3) and 3 crashes for Nifty 50 (Figure 4 to 6). The results correspond with Bree and Joseph (2007) who found the similar results of log-periodic model for Hang Seng index crash on 15 May 1989. In the case when crash does not occur, the fitted line would be far away from the actual trend line of the index values as shown in Figure 7 and 8.

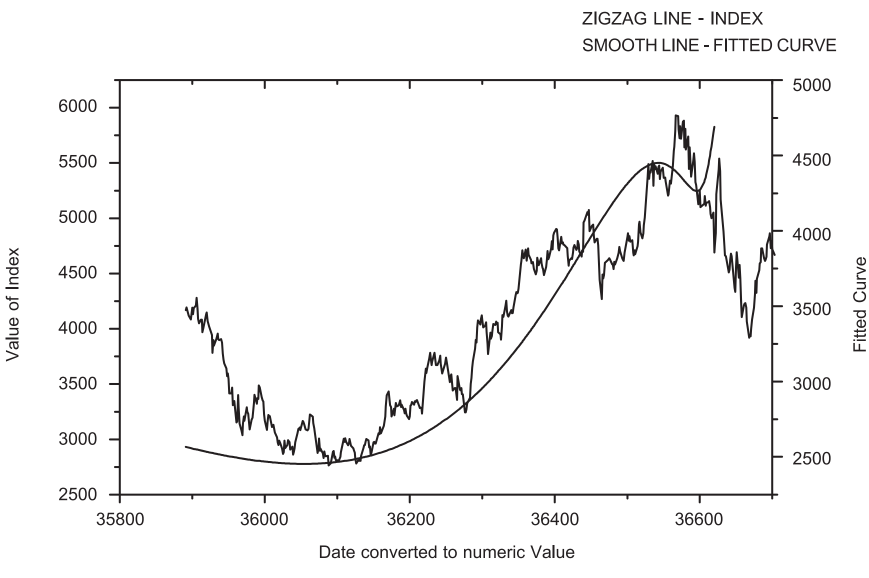

Figure 1 Best-fit crash of BSE Sensex as fittted by log-periodicity (4 April 2000)

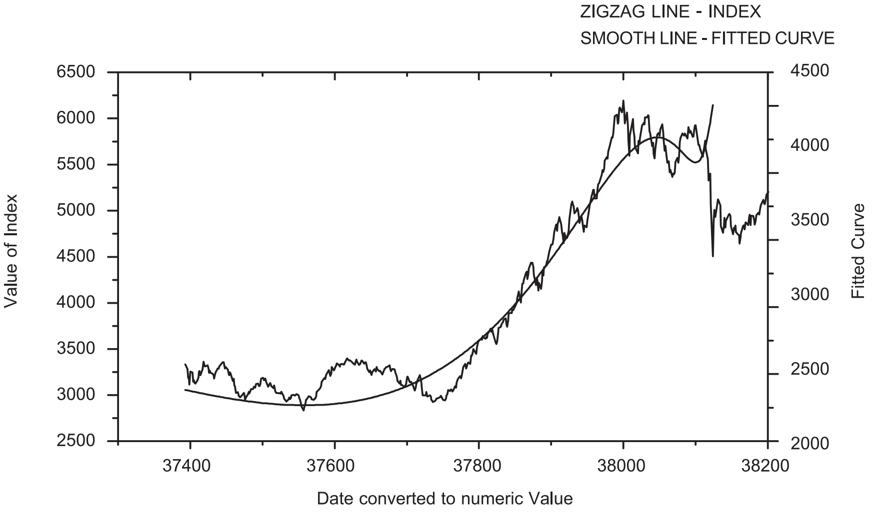

Figure 2 Best-fit crash of BSE Sensex as fittted by log-periodicity (17 May 2004)

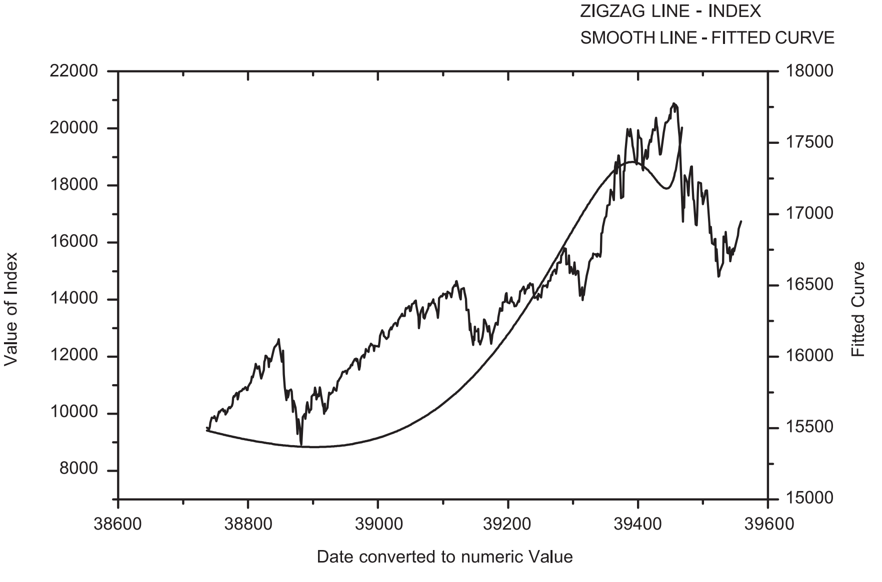

Figure 3 Best-fit crash of BSE Sensex as fitted by log-periodicity (21 January 2008)

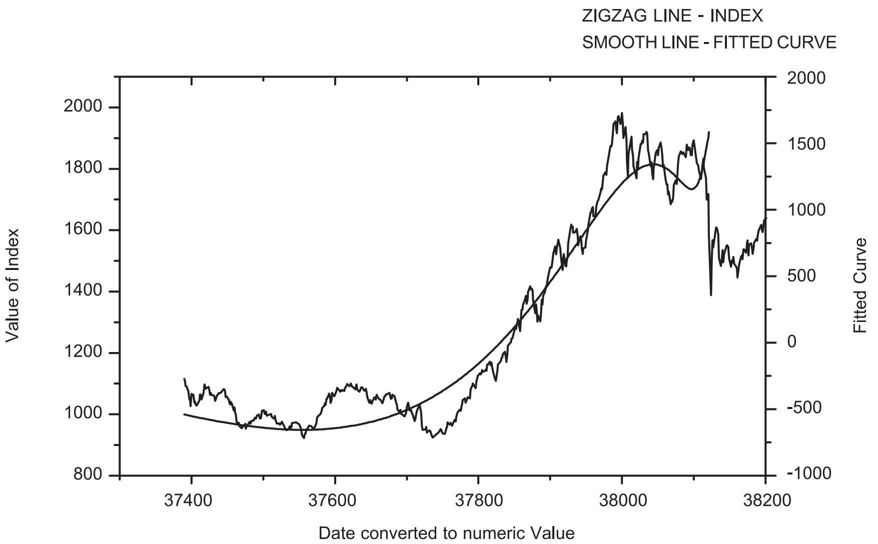

Figure 4 Best-fit crash of NSE Nifty 50 as fitted by log-periodicity (14 May 2004)

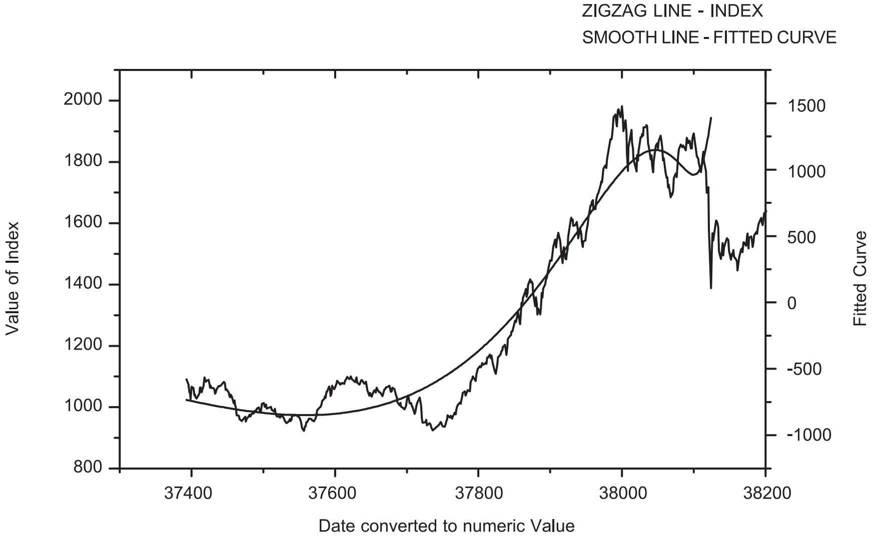

Figure 5 Best-fit crash of NSE Nifty 50 as fitted by log-periodicity (17 May 2004)

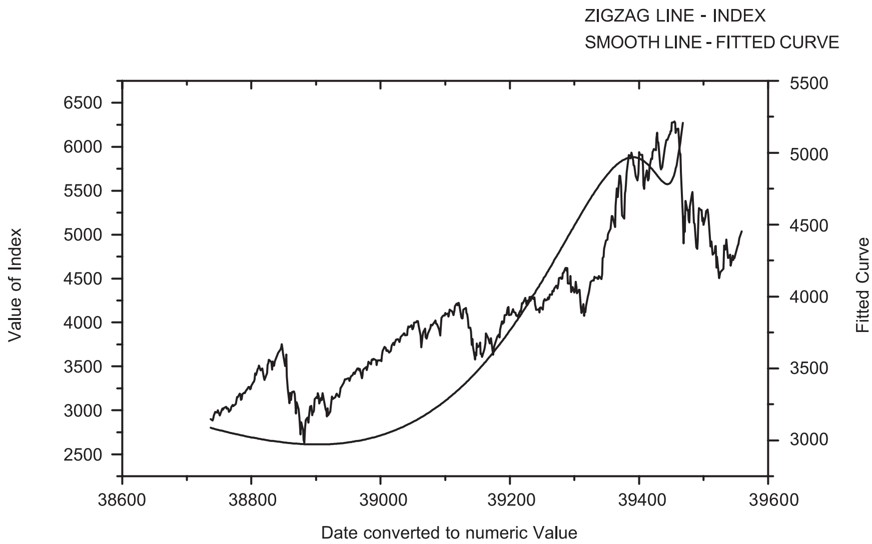

Figure 6 Best-fit crash of NSE Nifty 50 as fitted by log-periodicity (21 January 2008)

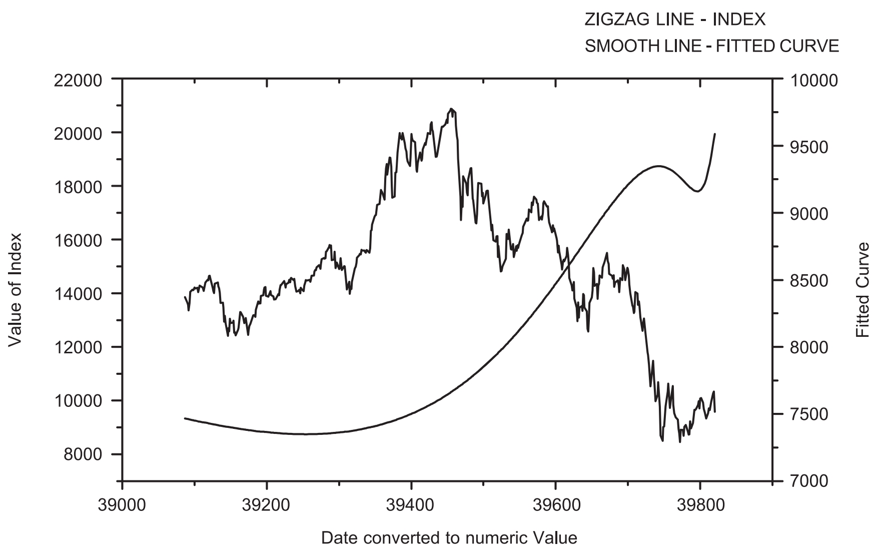

Figure 7 Case when crash does not occur on BSE Sensex

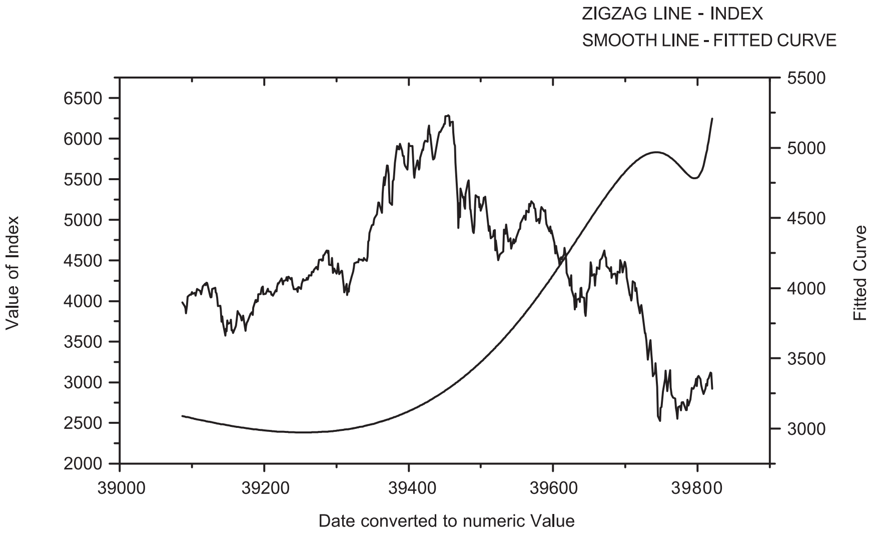

Figure 8 Case when crash does not occur on NSE Nifty 50

The log-periodicity graph can be continuously monitored along with the actual trend line. The analytical results imply that when the log-periodic curve fits closely to the actual trend line, a crash in a stock market can be expected. This information could be a warning signal for the investors.

Conclusion

A crash creates turmoil in the stock market. Various works analyze the stock market movements but the study of crashes particularly using log-periodicity in Indian stock market is not widespread in the literature. This paper studies fourteen crashes (seven each on BSE Sensex and NSE Nifty 50) of the Indian stock market from 1997 to 2009 using log-periodicity. The results show that the India stock market prima-facie follow log-periodic oscillations before crashes. The occurrence of crash can be indicated by using the log-periodicity power law. A future study could be done by using a longer range of time series data. Other techniques (e.g. optimization) may be used to predict crashes. The log-periodic power law could be applied as well in the study of crashes in debt, real estate market and the capital inflows in an economy.

References

Bartolozzi, M. *et al.* 2008. **Self-similar Log-periodic Structures in Western Stock Markets from 2000** (Online). http://arxiv.org/PS_cache/cond-mat/pdf/0501/0501513v4.pdf, April 13, 2009.

Banck, G. A. 1973. "Network Analysis and Social Theory," In J. Boissevain and J. C. Mitchell. (eds.). **Network Analysis Studies in Human Interaction**, Netherlands: Mouton and Co., 37-44.

Bree, D. S. 2009. **Equation Models versus Agent Models: An Example about Pre-crash Bubbles.** Paper presented at the First Workshop on Agent-based Modeling for Banking and Finance, February 9, 2009, ISI, Torino.

Bree, D. S. and N. Joseph. 2007. **Log-Periodic Power Law Fits to Financial Crashes: a Preliminary Replication.** Paper presented at the Second European Ph.D. Complexity School: Stochastic Effects in Differential Nonlinear Models – From Neutrality in Evolution to Efficiency in Markets, How to Bridge Theoretical Predictions to Empirical Data. November 2007, ISI, Torino.

Canessa, E. 2009. **Stock Market and Motion of a Variable Mass Spring** (Online). http://arxiv.org/pdf/0905.4450v1, May 5, 2009.

Cosmides, L. and J. Tooby. 1994. "Better than Rational: Evolutionary Psychology and the Invisible Hand." **American Economic Review** 84 (2): 327-332.

Drozdz, S., J. Kwapien, P. Oswiecimka, and J. Speth. 2008. "Current Log-periodic View on Future World Market Development." **Acta Physica Polonica A** (Online). http://arxiv.org/abs/0802.4043, June 3, 2009.

Johansen, A. 2004. **Origin of Crashes in 3 US Stock Markets: Shocks and Bubbles** (Online). www.arxiv.com/abs/cond-mat/0401210, June 5, 2009.

Johansen, A. and D. Sornette. 1998. **Stock Market Crashes are Outliers** (Online). http://arxiv.org/PS_cache/cond-mat/pdf/9712/9712005v3.pdf, August 3, 2009.

Johansen, A., O. Ledoit, and D. Sornette. 2000. "Crashes as Critical Points." **International Journal of Theoretical and Applied Finance** 3 (2): 219-255.

Lillo, F. and R. Mantegna. 2004. "Dynamics of a Financial Market Index after a Crash." **Physica A** 338 (1-2): 125-134.

Partnoy, F. 2000. "Why Markets Crash and What Law Can Do about It." **SSRN** (Online). http://ssrn.com/abstract=183473 or doi:10.2139/ssrn.183473, May 18, 2009.

Sornette, D. 2009. **Dragon-Kings, Black Swans and the Prediction of Crises** (Online). http://arxiv.org/ftp/arxiv/papers/0907/0907.4290.pdf, September 18, 2009.

Sornette, D. and A. Johansen. 2001. "Significance of Log-periodic Precursors to Financial Crashes." **Quantitative Finance** 1 (4): 452-471.

Sornette, D. and R. Woodard. 2009. **Financial Bubbles, Real Estate bubbles, Derivative Bubbles, and the Financial and Economic Crisis** (Online). http://web.sg.ethz.ch/wps/pdf/CCSS-09-003.pdf, September 12, 2010.