Predicting Financial Market Crashes using Log-periodic Oscillation and Critical Slowing Down

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Outline

Motivation

Various resources of motivation to study forecasting of financial crises

- Monetary authorities supervising country's economy health
- Private financial institutions avoiding excessive investment losses

Hypothesis and Objectives

Multiple objectives

- Verification of the validity of the LPPL Model and CSD and comparison of their performance
- Testing two versions of the LPPL Model
- Enrichment of the LPPL model's literature by a description of non-linear methods
- Investigation of a proposal of cross-correlation as another leading indicator

Research Question

No single financial theory capable to explain the biggest stock market crash on Black Monday

Log-periodic Power Law Model Sornette (2003)

Accelerating growth punctuated by shortening local drops

Critical Slowing Down Scheffer et al. (2009)

Gradually worsening system's conditions leading to a sluggish recovery rate

Self-organization

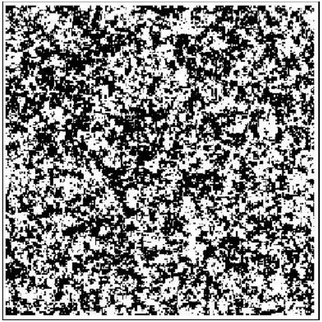
Definition Camazine et al. (2003)

In self-organizing systems, pattern formulation occurs through interactions internal to the system, without intervention by external directing influences.

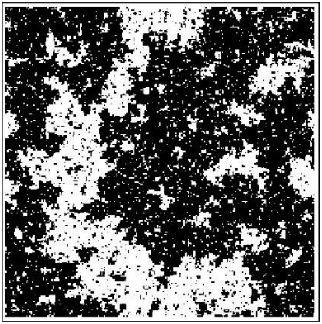
Simple power law:

$$\chi = A(K_c - K)^{-\gamma}$$

Self-organization



$|K_c - K| \gg 0$



$|K_c - K| \to 0$

Figures retrieved from Sornette (2003).

The Log-periodic Power Law Model

Initially, the simple Power Law Model was introduced

$$\log[p(t)] = A + B(t_c - t)^m$$

Sornette et al. (1996)

LPPL1 Model Sornette (2003)

$$\log[p(t)] = A + B(t_c - t)^m + C(t_c - t)^m \cos\left(\omega \log(t_c - t) - \phi\right)$$

LPPL2 Model Filimonov and Sornette (2013)

$$\begin{aligned}\log[p(t)] = A + B(t_c - t)^m + C_1(t_c - t)^m \cos\left(\omega \log(t_c - t)\right) \\ + C_2(t_c - t)^m \sin\left(\omega \log(t_c - t)\right)\end{aligned}$$

Critical Slowing Down

Leading indicators Scheffer et al. (2009)

- Serial correlation of order one $\nearrow$
- Variance $\nearrow$
- Cross-correlation $\nearrow$

Detrended fluctuations

$$y(t) = \log[p(t)] - \frac{\sum_{r=1}^{t} G(r-t)\log[p(r)]}{\sum_{r=1}^{t} G(r-t)}, \quad t = 1, \ldots, T,$$

Diks et al. (2015)

Data

Calibration set

- Past four financial crashes
- Daily time series data with a length between 0.5 year and 5 years

"Out-of-sample" set

- Two occasions, ca 15 predictions made over time
- Daily time series data with a varying time window from 1 year up to 2.5 years

CSD - 100 or 200 days prior to the end of time series.

Test Methodology

LPPL model

- The goodness-of-fit measured by R^2 and RMSE
- Parameters lying within the confined intervals

Critical Slowing Down

- Visual inspection of leading indicators
- Measuring a relationship by the Kendall rank correlation coefficient

Results - LPPL Model

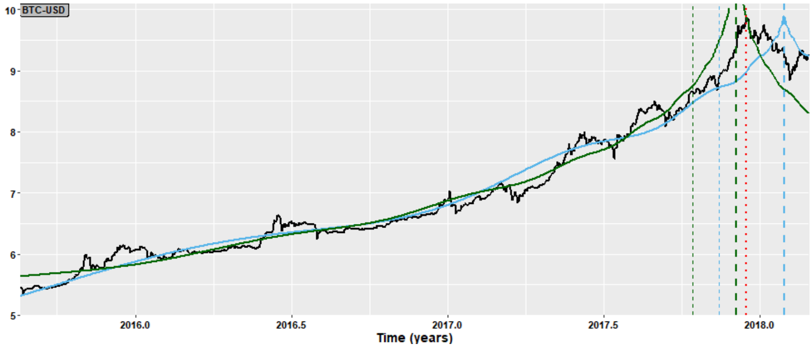
A. Calibration set

Model	t_c	$t_{c_{real}}$
LPPL1	1988.058	1987.792
LPPL2	1987.838	
LPPL1	1994.114	1994.107
LPPL2	1994.180	
LPPL1	1997.837	1997.800
LPPL2	1997.780	
LPPL1	2000.281	2000.191
LPPL2	2000.262	

Results - LPPL Model

B. "Out-of-sample" set

Burst of Bitcoin Bubble

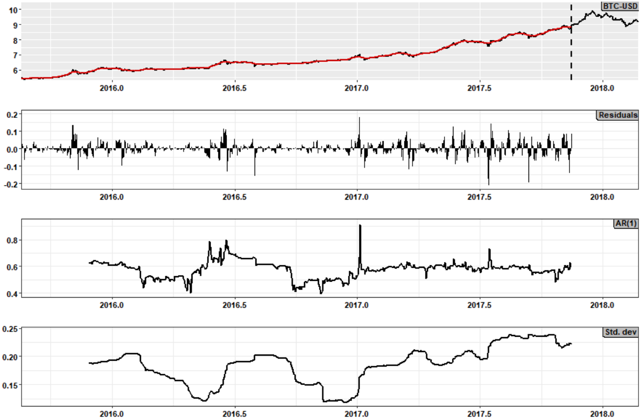


Results - Critical Slowing Down

A. Calibration set

- Serial correlation of order one ✗
- Variance ✓
- Cross-correlation ✗

Results - Critical Slowing Down



Conclusion

- The LPPL Model seems to be more promising
- Analysis of variance of detrended fluctuations is worthy
- Variance of residuals as a possible aspirant for completion of the LPPL Model
- Other recommendations: Flickering, more advanced versions of the LPPL model, exploiting combinations of different frameworks

Thank you!

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References

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