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Capital market based warning indicators of bank runs

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HIGHLIGHTS

- We substantiate the uni- and multivariate capabilities of the LPPL for bank run prediction.
- The univariate discriminative powers of four LPPL parameters emerge up to 40 trading days prior to the default events.
- Our analysis on synthetic data prompts that LPPL structures in financial time series do not arise by chance.
- Previously published results on HSI data are reproduced with less LPPL parameters.
- A multivariate pattern recognition approach based on three LPPL parameters is successfully developed.

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ABSTRACT

In this investigation, we examine the univariate as well as the multivariate capabilities of the log-periodic [super-exponential] power law (LPPL) for the prediction of bank runs. The research is built upon daily CDS spreads of 40 international banks for the period from June 2007 to March 2010, i.e. at the heart of the global financial crisis. For this time period, 20 of the financial institutions received federal bailouts and are labeled as defaults while the remaining institutions are categorized as non-defaults. The employed multivariate pattern recognition approach represents a modification of the CORA3 algorithm. The approach is found to be robust regardless of reasonable changes of its inputs. Despite the fact that distinct alarm indices for banks do not clearly demonstrate predictive capabilities of the LPPL, the synchronized alarm indices confirm the multivariate discriminative power of LPPL patterns in CDS spread developments acknowledged by bootstrap intervals with 70% confidence level.

1. Introduction

"What do a gas pressure tank carried on a rocket, a seismic fault and a busy market have in common? Recent research suggests that they can all be described as self-organizing systems which develop similar patterns over many scales, from the very small to the very large. And all three have the potential for extreme behavior: rupture, quake or crash. Are these events predictable?" [1].

In search of an answer to the last question, the log-periodic [super-exponential] power law (LPPL) has emerged. To put it in a nutshell, the LPPL hypothesis states that a super-exponential power law behavior decorated by log-periodic oscillations indicates a system's imminent transition into a critical state. It is important to note that the LPPL does not claim to predict financial crashes with certainty. Indeed, the rational expectation bubble model, the model behind the LPPL, implies that a

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bubble may end without a crash. The LPPL just claims that it can diagnose speculative bubbles and that the most probable time for the crash, if it occurs, is the end of this bubble.

LPPL structures have been identified as harbingers of extreme behavior in both natural sciences and finance. In natural sciences, the LPPL has been applied to acoustic emissions prior to rupture [2] and to seismic activity before large earthquakes [3,4]. The area of financial applications is, by contrast, much more diverse. LPPL structures have, for example, been established in real estate price bubbles [5,6], in the 2006–2008 oil bubble [7], in daily closing values of both stock prices and stock indices [8–14] as well as on further time-scales establishing the self-similar character of LPPL patterns [15,16], in the US FED Prime Rate [17], in US corporate bond spreads [18], and in credit default swap (CDS) indices [19,20]. Latest research has successfully tested the LPPL ex-post on CDS spreads of financial institutions [21] and governments [22]. Moreover, this line of research theoretically founded the occurrence of LPPL structures in CDS spread trajectories and primarily proposed the three LPPL parameters t_c, α, and ω as indicators of bank runs. Within this line of research, runs of institutional investors rather than of depositors are considered. It is assumed that creditors use CDS contracts to hedge their exposures against the risk of default. As more and more creditors demand protection against the default risk, the CDS spread rises.

"A run on a bank occurs when a large number of depositors, fearing that their bank will be unable to repay their deposits in full and on time, simultaneously try to withdraw their funds immediately" [23]. Such fragility to customers' withdrawals results from the widespread practice among banks of borrowing money on shorter time periods than lending it out (maturity transformation). Consequently, banks are continuously confronted with a maturity mismatch and thus vulnerable to bank runs [23]. Bank runs usually stem from a loss of public confidence in a bank. This loss of confidence can, for example, be attributed to bank-specific factors like a decline in performance or to macroeconomic factors such as an economic downturn [23]. Building on this, Gonzalez-Hermosillo proposed a regression model including both macroeconomic variables and bank-specific indicators, for example, of the credit risk, liquidity risk, and market risk in order to develop an aggregated early warning indicator [24]. Sirmorangkir used the percentage change in bank deposits as an early warning indicator of bank runs [23]. However, both approaches require data that are either not published at all or reported with a significant time delay. Thus, investors and even regulators often cannot estimate the present threat of a bank run by means of these warning indicators.

To the best of our knowledge, the three LPPL parameters t_c, α, and ω are the first proposed indicators of bank runs that can be derived from capital market data. So far, no one has yet explored the predictive potential of the three LPPL indicators as was emphasized at the end of Ref. [22]. Here, we take up this research question and first illustrate the univariate discriminative powers of the three parameters as well as of the parameter $b = B \cdot \alpha - |C| \cdot \sqrt{\alpha^2 + \omega^2}$ as functions of the prediction horizon. Second, we develop a pattern recognition method based on the parameter vector (b, α, ω) and investigate its predictive potential. The parameter t_c is excluded from the pattern recognition analysis since it "encodes the terminal time of the bubble" [25] and thus is "by definition event specific" [25].

In order to investigate the influence of the prediction horizon on the univariate discriminative powers of the four parameters, we apply the fitting procedure described in Ref. [21] to a data set comprised of 40 banks. Half of the banks received bailout money whereas the other half weathered the late-2000 financial crisis without any external support. The LPPL is adjusted to 101 intervals for each of the 40 CDS spread trajectories. Thereby, the interval start point is fixed to June 1st, 2007 while the interval end points range from 0 to 100 days prior to the maximum CDS spread, respectively. The discriminative powers in differentiating between banks of low and high credit qualities are measured by the area under the receiver operating characteristic (AUROC) for each of the 101 prediction horizons.

However, the univariate investigation of the four parameters' discriminative powers is not sufficient ground to claim their multivariate predictive capabilities for liquidity crisis detection. For this purpose, the construction of a classification scheme is needed. Inspired by Sornette and Zhou, we decided to employ the CORA3 pattern recognition approach in this investigation [26]. The authors in Ref. [26] apply this algorithm for predicting financial crashes on two financial time series, namely the Dow Jones Industrial Average index (DJIA) and the Hong Kong Hang Seng composite index (HSI). Their approach combines ideas from critical phenomena, multiscale analysis, and the pattern recognition of sparse data with the aid of a modification of the CORA3 algorithm. Sornette and Zhou demonstrated that the CORA3 algorithm exhibits strong robustness and remarkable generalizing ability being applied to financial problems. Additionally, the algorithm can be trained only on a few crashes and nonetheless decently predicts crashes not used in the training set. That is why the CORA3 algorithm also seems to be a proper candidate for the prediction of bank runs.

In summary, this article contributes to the current stream of literature on applying the LPPL to credit risk estimation by answering the following two research questions.

1. How does the prediction horizon influence the univariate discriminative powers of the four LPPL parameters b, t_c, α, and ω?
2. Can a multivariate pattern recognition approach based on LPPL parameters be used to predict bank runs?

The research article at hand is structured into six parts. In Section 2, the theory of the LPPL is briefly reviewed. Subsequently, the first research question is addressed in Section 3. Section 4 introduces the applied pattern recognition approach and thereby prepares the ground for investigating the second research question. Section 5 presents the empirical results of the validation of the pattern recognition algorithm and gives an answer to the second research question. Finally, the paper concludes with summarizing the main results and discussing the impact of the study.