Classification and diagnoses of market crashes in synthetic price series

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Abstract

We use an Ising-like agent-based model of financial market on different lattices to generate synthetic market crashes. By classifying the pre-crash patterns and finding the corresponding ones in the real financial markets, our result suggests that different diagnoses methods are needed to cope with different pre-crash patterns. Fortunately, most pre-crash patterns fall into the log-periodic power law (LPPL) pattern which can be identified by the Johansen-Ledoit-Sornette (JLS) model. For the other two kinds of pre-crash patterns, we need new methods to diagnose them.

Keyword: financial system, multi-agent system, disaster simulation, log-periodic power law, market crash

1. Introduction

Detecting financial bubbles and predicting the potential upcoming market crashes are always the foci of market practitioners, governments and academic researchers. Although very difficult, people have invented some methods to make the pre-crash diagnoses. For instance, the JLS model is one of the few methods showing the possibility of detecting financial bubbles and predicting the critical points [1]. However, the validity and the valid range of such diagnostic methods need lots of "patients" to be evaluated. What we can do now is to look back to financial history with reliable data recorded for only several decades. Unfortunately, what we may find is the insufficiency of samples of these extreme events. On the other hand, agent-based model (ABM) of the financial markets have been developed to successfully reproduce many stylized facts observed in the real financial markets. Therefore, ABM simulation is now a practical way to generate the synthetic financial data. In this study, we construct a simple (with zero-intelligence) ABM on the hierarchical network structure to produce samples of market crashes efficiently.

Based on these synthetic samples, we find that: 1) the signature of bubble in JLS model, that is, the LPPL pattern can be reproduced in our simple market model; 2) In our simulations, we have identified three kinds of pre-crash patterns; 3) the predictive power of the diagnostic models depends on the pre-crash patterns of price series.

2. The Agent-Based Modeling

A simple Ising-like model [2] is used to generate the price series. Previous studies have suggested that many critical behaviors of systems are related to the hierarchical structure of the components [3]. Therefore, the heterogeneity of the agents in our study is not only reflected in the trading behaviors, but also in their influences on others and their capacities of gathering the others' opinions. Different kinds of lattices have been implemented in the model to investigate the crash dynamics and pre-crash patterns.

3. Results and Discussion

We use a consistent quantitative criterion to detect the market crashes in simulations (Fig.1a). On the hierarchical network, we find that not only the LPPL patterns can be well reproduced in the simulation (Fig.1b), other kinds of crash and pre-crash patterns which cannot be well fitted by the LPPL law, can also be generated. Generally, the pre-crash patterns fall into three categories: the LPPL pattern (Fig.2a), the weak oscillating pattern (Fig.3a) and the energy decaying pattern (Fig.4a). While the JLS model can give a good forecast on the critical point of the LPPL pattern, for the other two kinds of patterns, other technical methods such as momentum indicators are needed to get helpful diagnoses and predictions. It is interesting to note that all the three kinds of pre-crash patterns can be found in the real financial markets (Fig.2b, 3b, 4b).

The classification of pre-crash patterns suggests that to better detect and predict the market crashes before it really happens, one needs to employ different methods and work in collaborative way.

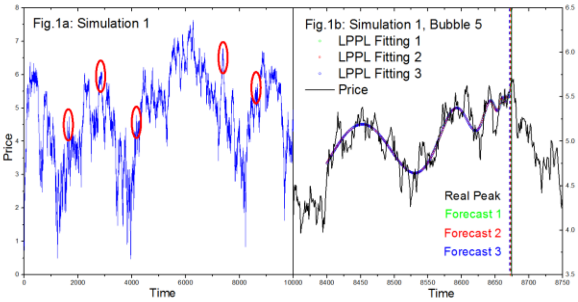

Fig.1 Filtering out the bubbles and reproducing the LPPL pattern with the synthetic data.

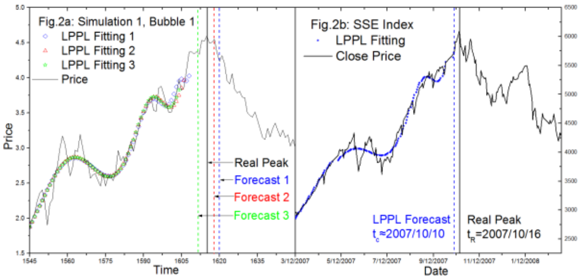

Fig.2 The LPPL pattern found in ABM simulation and in real financial market.

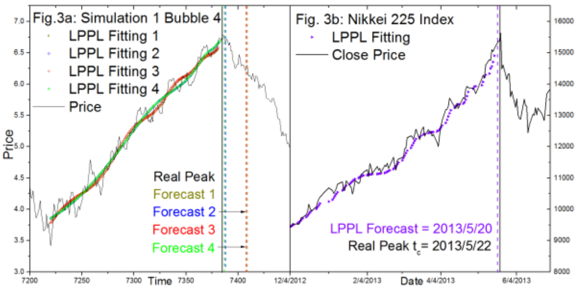

Fig.3 The weak oscillating pattern found in ABM simulation and in real financial market.

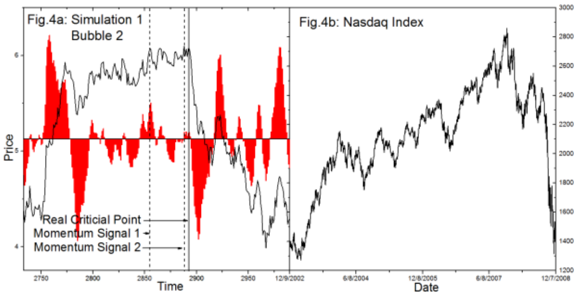

Fig.4 The energy decaying pattern found in ABM simulation and in real financial market.

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