Multi-Asset Artificial Market Simulation: Test of Market-wide Circuit Breaker Regulation

Takuma TORII[1,*], Kiyoshi IZUMI[1,2], and Kenta YAMADA[1]

[1]The University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo, 113-8656 Japan
[2]CREST, JST, Kawaguchi Center Building, 4-1-8 Honcho, Kawaguchi, Saitama, 332-0012 Japan

E-mail: *tak.torii@sys.t.u-tokyo.ac.jp

Abstract

Together with the evolution of financial markets and crises, market regulations have also been updated. However this revision does not have enough empirical supports. We developed a multi-asset artificial market simulation to test the impact of this revised rule of market-wide circuit breakers. We discuss two scenarios, single-asset circuit breakers vs market-wide circuit breakers, by exploiting artificial markets of index futures and spot markets composed of multiple assets, in which multi-asset traders by trading some alternatives attempt to compensate for unavailable assets under a trading halt in operation.

Keyword: Multi-Asset Artificial Market, Circuit Breaker, Financial Engineering

Introduction

Together with the evolution of financial markets and crises, market regulations have also been updated. Circuit breaker (CB) is such a financial regulation consisting of two major components, trading halt and price limit. A trading halt is activated when a market price exceeds predetermined bounds. Proponents believe that CBs can reduce market volatility and panic selling, and so CBs can protect traders and encourage price discovery. Last year, reflecting the 2010 Flash Crash in which CBs were not activated, SEC announced the revision of market regulations. This revision included the trading halt applied to the entire market, so-called market-wide circuit breaker (MWCB), using the S&P 500 Index, rather than the Dow Jones Industrial Average.

Recent updates of market regulations show the change of focus from single-asset regulations to entire market-wide regulations. Research on financial markets with multiple assets and/or multiple markets is earning more interest with the practical needs [3, 6]. Empirical studies on different samples of financial crises however may often yield controversial arguments due to the limitation and difficulty of studying non-reproducible events [1]. The revised MWCB has not been empirically tested even against the hypothesized causes of the 2010 Flash Crash. Agent-based simulations have been developed as an approach to overcoming this potential barrier. In financial engineering, agent-based simulations have been exploited to design new market regulations [4]. Agent-based simulations typically have a large parameter space, which is hard to be exhausted. To the end of resolving this problem, in recent years, an exploratory software for computer simulations, including agent-based simulations, has been developed [5].

We developed a multi-asset artificial market model to test the impact of market-wide circuit breakers, in comparison with single-asset circuit breakers. In this presentation, we focus on the effect of "event-trigger trading," such as risk hedge and panic selling, which is said to have initiated and accelerated the 2010 Flash Crash.

Multi-Asset Artificial Market

The artificial market model we developed consists of two markets, a spot market with multiple assets and an average index futures market that the assets of the spot market underlie. Both the spot and index futures markets use a continuous double auction mechanism. A market price is given by the price if any trade occurs. If no trade the price is given by the average of the best bid and ask prices. Otherwise, the price remains unchanged. The index is a weighted sum of prices of underlying assets, $I_t = \sum_s m^s\, p_t^s$, where $m^s = M_s / \sum_z M_z$ is a proportion of a market capitalization of asset s, M_s, which is defined here to be the product of fundamental value and the total volume of the asset s in the market. We assume the fundamental prices of the spot assets, p_t^{s*} ($s = 1, 2, \ldots$), follow a multivariate geometric Brownian motion, $\Delta p_t^{s*} = \mu_{s*}\, p_t^{s*} + \sigma_{s*}\, p_t^{s*}\, \Delta W_t^{s*}$, where ΔW_t^{s*} is a correlated Wiener process such that $\mathrm{E}[\Delta W_t^{s*}\, \Delta W_t^{z*}] = \rho_{s*,z*}$. We describe two sorts of traders, local and global agents, and the rules for circuit breakers below.

Local Agent A local agent can buy or sell a specific asset in the spot market or the index futures. At time t, a local agent i uses a combination of fundamentalist and chartist rules, F_t^i and C_t^i, with a noise term, N_t^i, to make expectations on market returns of asset s [2]:

$$\hat{r}_t^{i,s} = \frac{1}{w_F^i + w_C^i + w_N^i}(w_F^i F_t^{i,s} + w_C^i C_t^{i,s} + w_N^i N_t^{i,s})$$

where $w_F^i,\ w_C^i,\ w_N^i \geq 0$ are weights. The fundamentalist component $F_t^{i,s} = (1/\tau^{s*})\ln(p_t^{s*}/p_t^s)$ is a divergence of fundamental value p_t^{s*} and market price p_t^s, where τ^{s*} is the mean-reversion time constant of p_t^{s*}. The chartist component $C_t^{i,s} = (1/\tau^i)\sum_{j=1}^{\tau^i}\ln(p_{t-j}^s/p_{t-j-1}^s)$ is a trend calculated from a time-series of market price p_t^s over agent i's time horizon τ^i. The noise component $N_t^{i,s}$ follows a normal distribution with zero mean and variance $(\sigma_e^s)^2$. Local agents are risk averse [2], and they decide order prices and volumes based on market volatility and the amount of assets and cash they hold. Under a trading halt in operation on asset s, local agents who are predetermined to trade the asset s try to find alternative assets by taking correlations of market prices and volatility into account.

Global Agent A global agent we designed is a spot-futures arbitrageur, who buys (sells) the index futures and sells (buys) the assets in the spot market at the same time. Arbitrageurs exploit the difference between the spot index and the price of the index futures. Under a trading halt in operation on the index futures, global agents do nothing because of no alternatives available. Under a trading halt in operation on some of the assets in the spot market, global agents attempt to compensate for unavailable assets due to the trading halts by trading some of available assets to compensate for the lack of unavailable ones. Technically this behavior of arbitrageurs is as follows. Consider a situation where some of the assets is under the trading halt in operation, and so arbitrageurs cannot buy or sell these assets. In the face of this situation arbitrageurs attempt to buy or sell some of the other assets available to trade. Since the co-movement of market prices is an underlying idea of arbitrage-like trading strategies, we employed for agent i the proportions of correlation coefficients $r_{s,z}$ among market prices, which are calculated over agent i's time horizon τ^i, to choose alternatives of assets unavailable.

Circuit Breakers (Trading Halts) Trading halts in our simulation are specified with two parameters: market halt threshold and halt time. The halt threshold is tied to the change rate from a market price at a specific time point as a baseline, e.g., the initial price of corresponding asset of that day. We set the threshold in reference to a real market regulation, and set the time length relative to the average time horizon of all agents. We examined several settings for both the threshold and the time length. A single-asset circuit breaker, for an asset in the spot market or the index futures, takes its baseline in market price of corresponding asset. The market-wide circuit breaker takes its baseline in the index futures, while it applies to all the assets of all the markets, both the spot and index futures.

Simulation

In this presentation, we discuss two scenarios, single-asset circuit breakers vs market-wide circuit breakers, by exploiting the new artificial market model. Based on the results of simulation and analysis focusing on the effect of event-trigger trading by arbitrageurs under trading halts, we discuss when single-asset circuit breakers would not work to protect market stability and when market-wide circuit breakers work well. Implications for creating new market regulations would also be discussed.

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