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Phase transition of dynamical herd behaviors for Yen–Dollar exchange rates

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Abstract

We study the herd behavior and the phase transition for the yen–dollar exchange rate in the Japanese financial market. It is obtained that the probability distribution of returns satisfies the power-law behavior $P(R) \simeq R^{-\beta}$ with scaling exponents $\beta = 3.11$, 2.81, and 2.29 at time intervals $\tau = 1$ min, 30 min, and 1 h. The crash region in which the probability density increases with the increasing return appears, when the herding parameter h satisfies $h \geqslant 2.33$ for the case of $\tau < 30$ min. We especially obtain that no crash occurs $\tau > 30$ min and that the probability distribution of price returns occurs in the phase transition at $\tau = 30$ min.

Keywords: Herd behavior; Returns; Herding parameter; Yen–dollar exchange rate

1. Introduction

The microscopic models in financial markets have recently received considerable attention [1–4]. Of the many crucial models, the main concentration is on the herding multiagent model [5,6] and the related percolation models [7,8], the democracy and dictatorship model [9], the crowd–anticrowd theory, the self-organized dynamical

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model [10], the cut and paste model, and the fragmentation and coagulation model [11]. One of microscopic models in the self-organized phenomena is the herding model [12,13], in which some degree of coordination among a group of agents shares the same information or the same rumor and makes a common decision in order to create and produce the returns. There are three important reasons for inducing the herd behavior: first, a crash model exists where the herds may be occurring by the biased information between investors. Second, the return structure of fund managers may be sensitive to the herd behavior, since bank and stock company influence investors powerfully. Thirdly the fund manager and market analyst may play a crucial role to essentially determine the investment, in order to maintain their reputation and credit. It is particularly of interest for the herd model to search for the bubbles and crashes in econophysical system. The probability distribution of returns shows a power-law behavior for the herding parameter below a critical value, but the financial crashes yield an increase in which the probability of large returns exists for the herding parameter larger than the critical value.

The theoretical and numerical analysis for the volume of bond futures transacted at Korean futures exchange market has been presented in the previous work [14]. This is mainly treated by the number of transactions for two different delivery dates and found the decay functions for survival probabilities [15,16] in the Korean bond futures. We also argued tick dynamical behaviors of the yen–dollar exchange rate using the range over standard deviation or the R/S analysis in financial exchange markets [17]. It has recently been found that the empirical tick data on different delay times can be regarded as a stochastic Markoff process and estimated Kramers–Moyal coefficients in financial exchange markets [18]. The numerical analysis based on multifractal Hurst exponent and the price–price correlation function has been used for the long-run memory effects. The crash region for the yen–dollar exchange rate appears, when the herding parameter h satisfies $h \geqslant 2.33$ for the case of one time lag $= 1$ h [19]. Our purpose of this paper is to investigate the herd behavior and the phase transition for the yen–dollar exchange rate in the Japanese financial market. Our obtained result will be compared with other numerical calculations. In Section 2, the phase transition of crash regions for the yen–dollar exchange rate is mainly discussed, and we conclude with some results in Section 3.

2. Crash regions of the yen–dollar exchange rate

First of all, we introduce the yen–dollar exchange rate for two delivery dates of tick data: One minutely analyzes tick data for the period 1st March–8th March 2002, while the other analyzes daily tick data for the period Jan/1971–June/2003. We show the minute time series of the price return for the yen–dollar exchange rate in Fig. 1. The price return $R(t)$ can be defined as

$$R(t) = \ln \frac{P(t+\tau)}{P(t)} , \tag{1}$$

where τ denotes the time interval, i.e., the average time between ticks.