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Scaling and correlations in foreign exchange market

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Abstract

We observe that the distribution of the relative return, describing the variation of a certain currency, of 74 global currencies obeys a power-law. By using the random matrix theory we find that the distribution of eigenvalues of correlation matrix of relative return also follows a power-law. Using a scaled factorial moment we investigate the distribution of correlation coefficients of the relative return and observe intermittence phenomenon. Furthermore, we define the influence strength for a certain currency, which reflects the influence of its price change to the community interested. By doing that, we find that the distribution of influence strength is again a power-law. Beyond that, we compare the influence strength of Chinese Yuan (RMB) to those of other seven important currencies, which may have some interesting indications.

Keywords: Relative return; Correlations; Scaled factorial moment; Influence strength

1. Introduction

During the last few decades, scientists have applied methods and models in statistical physics to study economic phenomena [1–4]. This tendency has been enhanced recently by enormous interest in economic networks. Specifically, the analysis of financial market has been found to exhibit some universal characteristics similar to those observed in physical systems with a large number of interacting units [5]. For example, the distribution of financial return (the logarithmic change of the market price) has been observed to be non-Gaussian and exhibit fat-tails [6,7]. Several models have also been put forward to show the fat-tail distribution, and a fluctuating temperature was found that leads to intermittent behavior of price changes [8].

Economic systems consist of many constituents such as individuals, companies, countries, etc. and exhibit cooperative and adaptive phenomena through diverse interactions between them. In particular, the foreign exchange market is one of the most important constituents in economic markets. As the exchange rate changes of individual currencies are mutually influenced, the research of the interactions between different currencies is of great necessity. Along this orientation, several models have been proposed. Based on inverse statistic analysis on intra-day foreign exchange time series, a new type of stylized fact has been found by Jensen et al. [9]. Mizuno et al.'s study [10], on the basis of the correlation among currencies, led to the conclusions that

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there is a time delay of order less than a minute between two currency markets having a strong correlation, whereas the correlation between exchange rates is lower in shorter time scale in any case.

At present, there have been some efforts to research the correlations in the stock price changes using random matrix theory (RMT), where large eigenvalues are located far away from the rest part [11–13]. However, to our best knowledge, little has been done in the study of the distribution of the correlation of the return. This is the main focus of this paper.

This paper is organized as follows. In Section 2, we investigate the correlation on the exchange rate changes of 74 currencies in the world listed on the foreign exchange market from 2002 to 2006. In Section 3, the concept of scaled factorial moments is used to analyze the distribution of the correlation coefficients. In Section 4, influence strength for a certain currency is defined. The distribution of the influence strength is also presented. The last section is a summary.

2. Correlation of relative return

Let $P_i(t)$ be the price notion of one currency i ($i = 1, 2, \ldots, N$) (US dollar as base currency) at time t. Then the return of one currency's price after a time interval Δt is defined as

$$R_i(t) = \ln P_i(t + \Delta t) - \ln P_i(t), \tag{1}$$

which gives exactly the geometrical change of $P_i(t)$ during the interval Δt. We can take Δt 1 month, 1 week, or 1 day. In order to reduce the influence of external economic environments, such as bank interest, inflation index, etc. on the correlation coefficient, we make a modification on $R_i(t)$:

$$G_i(t) = R_i(t) - \frac{1}{N}\sum_j R_j(t), \tag{2}$$

where $G_i(t)$ indicates the relative return of one currency i to its mean value over the entire 74 currencies at time t. Then the correlation between individual currencies can be studied in terms of a matrix C, whose elements are given by

$$c_{i,j} = \frac{\langle G_i G_j \rangle - \langle G_i \rangle \langle G_j \rangle}{\sqrt{(\langle G_i^2 \rangle - \langle G_i \rangle^2)(\langle G_j^2 \rangle - \langle G_j \rangle^2)}}, \tag{3}$$

where the brackets mean a temporal average over the period of interest. The values of the $c_{i,j}$ are varied from -1 to 1; $c_{i,j} = 1$ (-1) means that currencies i and j are completely correlated (anti-correlated), while $c_{i,j} = 0$

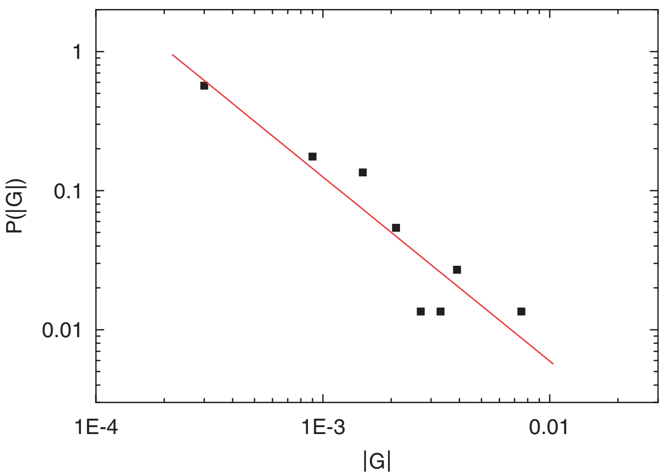

Fig. 1. Plot of the distribution of relative return $P(|G|)$ versus the absolute magnitude of the relative return $|G|$ in double-logarithmic scales, linear fitting (solid line), with slope -1.32.