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Dynamics of bid–ask spread return and volatility of the Chinese stock market

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ABSTRACT

The bid–ask spread is taken as an important measure of the financial market liquidity. In this article, we study the dynamics of the spread return and the spread volatility of four liquid stocks in the Chinese stock market, including the memory effect and the multifractal nature. By investigating the autocorrelation function and the Detrended Fluctuation Analysis (DFA), we find that the spread return is the lack of long-range memory, while the spread volatility is long-range time correlated. Besides, the spread volatilities of different stocks present long-range cross-correlations. Moreover, by applying the Multifractal Detrended Fluctuation Analysis (MF-DFA), the spread return is observed to possess a strong multifractality, which is similar to the dynamics of a variety of financial quantities. Different from the spread return, the spread volatility exhibits a weak multifractal nature.

1. Introduction

Financial dynamics has attracted a central interest of physicists in recent years [1–8]. The financial market has accumulated a large amount of historical data in the past years, which provides an abundant data resource for the empirical study. Some scaling behaviors have been revealed to be universal for different markets [1–3], e.g., the well known "inverse cubic law" of the probability distribution of the price return. Recently, in Ref. [9], new similar inverse cubic law and universality for different markets have been reported in the probability distribution of the trading volume changes supporting similarity between price dynamics and trading volume dynamics. The so-called "volatility clustering" is also found for a variety of financial markets [10,11], which refers to the long-range time correlation of the absolute value of the price return. Different from those universal behaviors, unique characteristics are found for several emerging markets [12]. A typical example is the "anti-leverage effect" of the Chinese stock market [13], which indicates an anti-effect from the "leverage effect" of most mature financial markets in the return-volatility correlation [14]. On the other hand, the financial markets can be taken as a complex system composed of many elements, with the scaling behavior emerging from the many-body interactions. Different models and theoretical approaches have been developed to describe financial markets [15–20].

Within this framework, the so-called bid–ask spread is served as an important indicator to quantify the financial market liquidity and efficiency. Most modern financial markets are order-driven markets, which adopt the continuous double auction mechanism. There are two basic types of orders, the market order and the limit order. For the market order, trade is carried out immediately after the system receives the order. For the limit order, order is stored, and it waits for a best

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price for trading. The buy limit order is called bid, and the sell limit order is called ask. The bid–ask spread refers to the price difference between the lowest ask price and the highest bid price. Generally speaking, the lower the spread, the smaller the transaction cost, and also a higher liquidity of the market.

So far, statistical properties of the bid–ask spread of the limit-orders have been widely studied [21–24]. Empirical study shows that, the probability distribution of the bid–ask spread obeys a power law behavior, with the exponent around 3.0 [22,23]. Long-range time correlation of the bid–ask spread is also revealed for different markets, including the Chinese stock market [22,24]. In addition, different from the multifractality of a variety of financial quantities, the bid–ask spread is reported to be mono-fractal for the Chinese stock market [24]. On the other hand, a lot of work contributes to the order flow dynamics, and the microscopic mechanism of price formation [21–23,25–30]. However, the dynamics of the spread return and the spread volatility has not been analyzed or reported in detail, to our knowledge. The spread return is defined as the logarithm change of bid–ask spread between two successive time points, and the spread volatility is defined as the magnitude of the spread return. In fact, in finance, one concerns more on the price return or the price volatility, rather than the price itself. Similarly, it is essential to investigate the bid–ask spread return and the spread volatility dynamics.

With this incentive, in this paper, we study the dynamics of the spread return and the spread volatility. Based on the tick-by-tick data of four liquid stocks in the Chinese stock market, we investigate the memory effect of the spread return and the spread volatility by applying the autocorrelation function and the Detrended Fluctuation Analysis (DFA). Multifractal nature of the spread return and the spread volatility is also revealed, by employing the Multifractal Detrended Fluctuation Analysis (MF-DFA).

The remainder of this paper is organized as follows. In the next section, we present the datasets we analyzed. In Section 3, we introduce the definition of the bid–ask spread, the spread return, and the spread volatility, and then we focus on the memory effect of the spread return and the spread volatility in Section 4. In Section 5, we emphasize the multifractal nature of the spread return and the spread volatility. Finally comes the conclusion.

2. Datasets

The Chinese stock market is an order-driven market based on the continuous double auction [24,31,32]. Before July 1, 2006, only limit orders were permitted to submit in the order placement. The Chinese stock market is composed of two stock exchanges, the Shanghai Stock Exchange (SHSE) and the Shenzhen Stock Exchange (SZSE). The SHSE was established on November 26, 1990, and the SZSE was established on December 1, 1990. The dataset we analyzed is based on the tick-by-tick data of 4 liquid stocks listed on the SHSE and the SZSE, i.e., the Shenzhen Development Bank Co., Ltd (SDB) stock, the Guangdong Electric Power Development Co., Ltd. (GEP) stock, the Datang Telecom Co., Ltd (DTT) stock, and the Shanghai Lujiazui Finance and Trade Zone Co., Ltd (SLFT) stock. The time scale of the datasets covers 3 whole year from 2004 to 2006, and the time resolution of the data record is about 15 s on average.

3. Definition of the spread return and the spread volatility

Different definitions of the bid–ask spread have been proposed [21,23,27,33–38]. In our study, we define the bid–ask spread $\widetilde{S}$ as the price difference between the lowest ask price and the highest bid price, which reads,

$$\widetilde{S}(t') = a(t') - b(t'), \tag{1}$$

where $a(t')$ and $b(t')$ are the lowest ask price and the highest bid price at time t', respectively. To quantify the spread $\widetilde{S}$ at a same time scale, we define a rescaled spread S in a time interval Δt as [21],

$$S(t') = \frac{1}{N}\sum_{i=1}^{N}\widetilde{S}_i(t'), \tag{2}$$

where N is the total number of transactions in the time interval Δt. In this article, we study the time scale $\Delta t = 1$ minute. The original spread return is defined as the logarithm change between two consecutive values of the rescaled spread,

$$\widetilde{R}(t') = \ln\left(\frac{S(t')}{S(t'-1)}\right). \tag{3}$$

The original spread volatility is then defined as the absolute value of the original spread return, i.e., $\widetilde{V}(t') = |\widetilde{R}(t')|$.

It has been reported that the bid–ask spread shows similar characteristics as a number of financial quantities, such as the long-range time-correlation of the spread series. However, the spread is also found to present some unique feature. For example, the spread exhibits a mono-fractal characteristic [24], which is different from the multifractality of most financial quantities. What feature could the spread return and the spread volatility present? In the following section, we then investigate the memory effect of the spread return and the spread volatility.