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Scaling behavior in ranking mobility of Chinese stock market

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HIGHLIGHTS

- A mobility index is introduced to measure the ranking variations of stocks in Chinese market.
- The relation between ranking mobility and sampling time scale demonstrates a scaling property.
- Evidences of long memory in the stock ranking orders are found.

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ABSTRACT

As an aggregate measure of the variations in individuals, the analysis of mobility provides a substantial and comprehensive perspective into the complexity of socio-economic systems. In this paper, we introduced the ranking mobility index to measure the ranking variations of the stocks in Chinese stock market over time. Using the daily data of 837 constituent stocks of the Shanghai A-Stock Composite Index from January 1, 2002 to December 31, 2012, we examined respectively the dependence of ranking mobility with respect to the absolute return, trading volume and turnover ratio on the sampling time interval. The scaling property is observed in all three relations. The fact of long relaxation times gives evidence of long memory property in the stock ranking orders.

1. Introduction

One focus of the researches on complex systems is to explore the characteristics of various size distributions and their formation mechanisms [1–5]. It is common that in the level of the whole system, there exists a stable distribution while in the level of individuals, relentless changes and motions are observed. One example is the personal wealth distribution. Pareto found that it is true in all time periods that 20% of the population possesses 80% of the whole wealth of the society no matter how dramatic gains and losses an individual may experience [1]. Similar phenomenon that intensive fluctuations of individuals are hidden behind stable macro distributions are also reported in other socio-economic systems spanning from families to firms, from cities to nations [6–9].

In order to understand the dynamics behind the perplexing distributions, the notion of mobility is introduced to describe and measure the variations in individuals from an aggregate perspective. Initiated by welfare economists, mobility is firstly used to measure the changes in individual income status from one period to another [10,11]. Instead of the static measurements of the degree of inequality in a society, the mobility analysis focuses on the variations of individual incomes over time [12,13]. It is proved in a wide range of studies that the mobility analysis is potent in describing the dynamics of multi-agent systems. For instance, Guo et al. found that the revenue distribution of top 500 Chinese enterprises is

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strongly stable, but there is a great variation when it comes to individuals [7]. Batty discovered that even though the distribution of populations in the biggest 100 cities is nearly unchanged over time, the population and ranking of each city are constantly changing [8]. The income of all countries in the world in terms of GDP per capita is found following an exponential distribution over several decades, the aggregate variations of both income and the ranking of all nations are significant over this time period [9].

Comprised of a large number of units, the financial market is an appropriate target to use mobility to measure the degree of variations in relative ranking of stocks. Currently, the prevailing approach employed to characterize the dynamics of the whole financial market is to study the time series of the market stock indexes. Being an averaged value of selected stocks, the market stock index represents the price level of all stocks in the whole market. Thus the change of the stock index over time reflects the price volatility of the whole market [14–16]. However, it fails to reflect the relative changes among stocks from an aggregate perspective whereas the introduction of mobility can be an easy solution. According to anyone of the absolute return, trading volume, and turnover ratio in each day, we can obtain a corresponding order of the stocks in the market. It is frequently observed that a stock with a high ranking will suffer a dramatic drop in another day. To provide an all-round perspective of the changes among stocks, we study the ranking mobility of the absolute return, trading volume and turnover ratio. With different ranking rules, the three mobilities reflect different market information: the variation in the stock rankings with respect to the absolute return relates to the shifts in traders' expectation of future returns; the variation in the stock rankings with respect to the trading volume mirrors the transfers in capitals attracted by a certain stock; the variation in the stock rankings with respect to the turnover ratio reflects the changes of the vitality of stock transactions.

The measurement of mobility depends on the sampling time scale. Some economists have noticed this relation and put forward a measurement of income mobility called time-dependence based on the notion that the present incomes are determined by past incomes [6,17–19]. These studies describe the time-dependence of mobility at an individual level, mainly providing probabilistic information regarding individuals switching from one category to another during the base-year and the final-year. Recently, Huang and Wang theoretically and empirically demonstrated how the mobility of the whole system depends on the sampling time interval at an aggregate level [20]. They found that the relative mobility will initially increase with the sampling time interval and then approach a constant value.

In this paper, we apply the ranking mobility index to the financial market and investigate the dependence of the ranking mobility with respect to absolute return, trading volume and turnover ratio on the sampling time scale respectively using daily data from Chinese stock market. The scaling property is discovered in all these relations and the corresponding power law exponents are presented.

Our paper is organized as follows. In Section 2, the dataset we used in this work is specified and the methods we use to measure ranking mobility are described. Then, in Section 3, we show how the ranking mobility changes with the sampling time scale with respect to absolute return, transaction volume, and turnover ratio respectively. We conclude in Section 4.

2. Data and methodology

Having enjoyed tremendous growth since 1990, Chinese stock market has attracted considerable attention. Many literature show that most stylized facts observed in developed financial markets, such as the absence of autocorrelations, heavy tails, multifractality, intermittency, volatility clustering, and leverage effect are also presented in China [21–26]. However, as an emerging market, Chinese stock market has a number of idiosyncratic features, such as institutional segmentation between the domestic and foreign investors, different purchasing costs, high transfer rate, and high investment risk [27]. These tricky terms and differences give rise to the uniqueness of Chinese market and make it exceptionally significant to investigate its underlying dynamics.

The dataset is comprised of the daily closing prices, trading volume and turnover ratios of 837 constituent stocks of the Shanghai A-Stock Composite Index from January 1, 2002 to December 31, 2012. We obtain Chinese data from GTA database covering 2769 days [28].

Our purpose is to measure the ranking mobility with respect to absolute return, trading volume and turnover ratio. The data of the last two are available directly, while the absolute return must be calculated from the closing prices. The daily return of stock i on day t, $r_i(t)$, is computed as follows,

$$r_i(t) = \frac{p_i(t) - p_i(t-1)}{p_i(t-1)}, \quad (1)$$

where $p_i(t)$ denotes the daily closing price of stock i on day t.

Many measurement indexes of mobility have been proposed by economists, including absolute mobility and relative mobility [11,13,29–31], here we employ the relative one which takes the form of Euclidean distance as follows:

$$RM(t) = \frac{1}{N^2}\sum_{i=1}^{N} |x_i(t+\Delta t) - x_i(t)|, \quad (2)$$

where N is the number of stocks, and $x_i(t)$, $x_i(t+\Delta t)$ denotes the variable ranking of stock i at time t and $t+\Delta t$ respectively. Δt is the sampling time scale. This index measures the average variations of the stock variable rankings between two selected