ARTICLE IN PRESS

Physica A ▮ (▮▮▮▮) ▮▮▮–▮▮▮

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

The price momentum of stock in distribution

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HIGHLIGHTS

- We give a random appearance for price momentum of stock at the first time.
- It proposes the cost distribution of holders and delivers a computation procedure to estimate it.
- An empirical statistical analysis is made to compare the new price momentum with others.
- It discusses the entropy of stock and shows that the entropy can provide a reserve signal of the market tendency.

ARTICLE INFO

Article history:
Received 20 October 2016
Received in revised form 19 November 2017
Available online xxxx

Keywords:
Price momentum
Momentum/contrarian strategy
Cost distribution
Entropy

ABSTRACT

In this paper, a new momentum of stock in distribution is proposed and applied in real investment. Firstly, assuming that a stock behaves as a multi-particle system, its share-exchange distribution and cost distribution are introduced. Secondly, an estimation of the share-exchange distribution is given with daily transaction data by 3σ rule from the normal distribution. Meanwhile, an iterative method is given to estimate the cost distribution. Based on the cost distribution, a new momentum is proposed for stock system. Thirdly, an empirical test is given to compare the new momentum with others by contrarian strategy. The result shows that the new one outperforms others in many places. Furthermore, entropy of stock is introduced according to its cost distribution.

1. Introduction

Recently econophysics has attracted a lot of attention in financial area. Many physical principles have been applied to financial analysis. For example, Mantegna and Stanley [1] studied the power law of stock market. Ilinski [2] proposed a physical consideration for stock dynamics. Baaquie [3] gave a quantum representation for option pricing. Jegadeesh and Titman [4] studied momentum effect of stock market in 1993. They used momentum/contrarian strategy to get an abnormal profit. After that, many scholars applied this strategy in different markets to find arbitrage chances [5–11]. Schiereck and Weber [12] got that momentum/contrarian strategy produced excess returns in Germany. Joseph Kang and Ming-Hua Liu et al. [13] found abnormal profit for momentum/contrarian strategy in the Chinese stock market. Carlos Forner, Abeyratna Gunasekarage and Mark T. Hon et al. discovered that momentum effect existed in the Spanish [14], the New Zealand [15], the Australia [16] and the U.K. [17] stock markets respectively.

In physics, momentum represents motion direction of an object such as going forward or moving backward. Recently, Choi [18] further discussed the momentum effect of stock market and defined ten kinds of momentum for stock in a view of classical physics. He considered log price of a stock as its position. Then he gave two kinds of velocity, raw return and log return, and proposed three kinds of mass for a stock, i.e., transaction volume, daily transaction value and inverse of

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https://doi.org/10.1016/j.physa.2017.11.154
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the return volatility. And momentum is defined as mass times velocity. He utilized ten kinds of momentums as ranking criterion to investigate the profitability in American and South Korea stock markets. He pointed out that most momentum strategies that he proposed were efficient for stock market and much better than the traditional momentum strategy in [4]. This investigation indicates that momentum of stock plays an extremely important role on portfolios.

But there exists a defect in Choi's consideration that a kind of momentum behaving well in one country's market may perform badly in other market. In U.S. equity market, the momentum $p^{(3)}$ outperforms others. Otherwise in South Korea stock market, the momentum $p^{(3)}$ is the worst. This difference tells us that there may exist more scientific definition for momentum of stock.

In fact, there are many holders and many implicit buyers for a stock. And their standpoints of buying or selling and psychological prices are quite different. So treating a stock as a particle may be too simple. Here we consider each share of a stock as a particle and its all shares constitute a multi-particle system as in thermodynamics or statistical physics. In this system, different particles may have different positions, different velocity and different momentum. And the position chosen is not log price but its holding cost. The target of this paper is to discuss the momentum of stock in distribution or statistical physics view. To describe thermodynamics property of a stock, a share-exchange distribution and a cost distribution will be proposed. And a new momentum is deduced out based on these distributions for a stock. Especially an empirical test is done to compare the new momentum with other old ones by momentum/contrarian strategy. It is pleasing that the performance of the new one is better than others in many places.

The main difference between ours and Choi's is that Choi thinks a stock as an object as in classic physics. A stock has its position, velocity and momentum. But in our paper we consider a stock as a particle system. A share is a particle. And every particle has its position, velocity and momentum respectively. Another difference is that in Choi's view, the position of a stock is its price or log price, but in our paper, the position is the cost of share. In one word, the Choi's result can be considered as the version of classic mechanics and our paper is a version of statistics mechanics.

This paper is organized as follows. In Section 2, the share-exchange distribution and the cost distribution of stock are introduced. And a new momentum is deduced out based on its cost distribution for a stock. In Section 3, some empirical analyses and applications of momentum in portfolios are given to compare old momentums with new one. In Section 4, Boltzmann entropy of stock market based on cost distribution is proposed. In Section 5, a summary is given for this paper.

2. Theoretical background

As mentioned above, a stock can be seen as a system. It consists of 'many particles'. In real trade, each trade only involves part particles(shares). It is obvious that the shares fractionally exchanged could not represent the whole shares. That implies that prices cannot explain everything. In order to measure a stock system more exactly, it is better to estimate its all shares' information. To that end it, two concepts are proposed, the share-exchange distribution and cost distribution. Here each share of a stock is thought as a sample point ω and all shares constitute a sample space Ω. In a given exchange time interval $[t_1, t_2]$, the set E of shares exchanged is a subset of Ω. As usual, price in the following means log price.

For a stock, let Z be exchange state of its shares in time interval $[t_1, t_2]$. It is defined as follows:

$$Z = \begin{cases} 1, & \text{if the share is exchanged in time interval } [t_1, t_2]; \\ 0, & \text{else .} \end{cases} \tag{1}$$

In Chinese stock market, the exchange rule asks that the shares bought in one day cannot be sold again in the same day. That rule is also said "$T+1$". So Let Z denote its exchange state of a stock in one day. Then $P(Z = 1) = \frac{Q}{N}$ and $P(Z = 0) = 1-\frac{Q}{N}$, where N is the number of the outstanding shares and Q is total transaction volume in one day. The probability $P(Z = 1)$ is also said turnover rate.

The exchange price X of a stock in $[t_1, t_2]$ is a random variable defined on event set $\{Z = 1\}$. Its distribution is called as share-exchange distribution of the stock. So share-exchange distribution illustrates how many percentage of shares have been exchanged at a certain price p in a certain time interval $[t_1, t_2]$. Different holders generally have different costs in some time t because they would have different buying prices and different holding time. For a stock, the distribution of its cost $C(t)$ is called as cost distribution. Here $C(t)$ represents the holding cost on different shares. Usually, different shares have different costs even for the same holder. Therefore the cost distribution means the percentage of shares whose cost is c in a certain time t for different shares.

Let p denote a exchange price of stock in time interval $[t_1, t_2]$ and $q(p)$ is the transaction volume at price p in this time interval. Q is the sum of transaction volume $q(p)$ in $[t_1, t_2]$, i.e., $Q = \sum_p q(p)$. Then the share-exchange distribution in time interval $[t_1, t_2]$ is $P(X = p) = \frac{q(p)}{Q}$.

For example, we use data of ShenWanke(000002) in Shenzhen stock market on 6th Jan. 2011. The total transaction volume Q in this day is 77189390 shares and at price $p = \ln(8.72) = 2.1656$, the exchange volume $q(p)$ is 2052074 shares. So the value of the share-exchange distribution at price p is $2052074/77189390 = 0.0266$.

For a given stock, let c be its cost of a stock and $F(c, t)$ represent the total number of shares whose cost is c at time t. Assume that N is its total number of outstanding shares at that moment. Then the cost distribution of this stock at time t is $P(C(t) = c) = \frac{F(c,t)}{N}$.

For example, if a holder bought a stock at price $p = 2.1656$ per share and the holding time is $T = 1$ year, then his cost is $p + \delta \cdot T = 2.1656 + 0.01 \cdot 1 = 2.1756$ per share, where δ is the risk-free interest effect. Furthermore, if there are 10% shares that they have a common cost c, then the value of cost distribution is 0.1 at c.

Please cite this article in press as: H. Liu, L. Wang, The price momentum of stock in distribution, Physica A (2017), https://doi.org/10.1016/j.physa.2017.11.154.