International Review of Financial Analysis 23 (2012) 35–40

Contents lists available at ScienceDirect

International Review of Financial Analysis

Mixed time scale strategy in portfolio management

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ARTICLE INFO

Article history:
Received 13 November 2010
Received in revised form 25 April 2011
Accepted 30 June 2011
Available online 12 July 2011

Keywords:
Portfolio management
Mean variance analysis
Risk control
Trading strategy

ABSTRACT

The fluctuation in the prices in a stock market can be separated into two time scales: a long term trend guided by financial principles and a short term trend governed by the specific trading mechanisms used. We proposed a mixed strategy for managing stock portfolios in which the long term trend is tracked by Markowitz's theory of mean variance analysis, and the short term fluctuation in stock price is monitored by a trading threshold. This strategy is tested in a two-stock portfolio formed from twenty four selected stocks in the Hang Seng Index from July 10 2007 to July 21 2009, which covers the financial Tsunami in 2008. In our mixed strategy, the test is based on a periodic trading with a period of ten trading days. At the beginning of each trading period, a two-stock portfolio that has the optimal Sharpe ratio among all the possible combination of 24 chosen stocks from the Hang Seng Index is selected using mean variance analysis. This is accomplished through a two steps process that involves a maximization of the Sharpe ratio for each pair with an implementation of the worst scenario hypothesis and a threshold that control the activation of trading. Then we examine the price fluctuation of the chosen stocks to determine the trading action. A trading threshold is proposed to facilitate the trading decision so as to ensure that the price of the selected portfolio will likely follow a rising trend on the decision day. The yield of the portfolio based on this mixed strategy is compared to the Hang Seng Index and the averaged price of the 24 stocks over the same period. The results show that this strategy of portfolio management yields a factor of 1.6 of the initial value, whereas the corresponding yield of the Hang Seng Index is a decrease in value by a factor of 0.8. Over the period of two years for the comparison, the investment using our mixed strategy in portfolio management maintains a positive return for a wide range of trading threshold, from a few days to one month. Our choice of a trading period of 10 days reduces the transaction frequency in order to avoid the penalty of transaction fee. Our strategy therefore allows higher flexibility in the trading scheme for investors of different trading habits. An important observation of our strategy is that it preserves the assets over the Tsunami in 2008, which is important to conservative investors who prefer protection in the worst situation.

1. Introduction

The problem of financial resource allocation in portfolio management has been of research interest since the seminal work on the mean variance analysis by Markowitz (1952, 1959). The mean variance analysis, which is a mathematical formation of the concept of diversification, suggests that the selection of two or more assets for investment can lower the risk involved in the investment of any individual asset, thereby providing a guideline in risk control in portfolio management. Markowitz's theory provides a simple and elegant solution for resource allocation, such as in the fraction of money invested in each constituent stock in the two-stock portfolios by specifying the investment frontier and the risk tolerable by the investor. In practice, however, one does not have a static picture of the mean nor the variance as they are time dependent. To handle this problem, pattern recognition (Fukunaga, 1990; Zemke, 1999), genetic algorithm (Szeto et al., 1997; Szeto & Cheung, 1997, 1998), neural network (Froehlinghaus & Szeto, 1996), and fuzzy rule (Fong & Szeto, 2001; Szeto & Fong, 2000) are some of the approaches that have been applied in real application. In this paper, we introduce two different time scales into the mean variance analysis. First of all, we assume that the long term behavior provides guidance to the trend of the stock in the near future. This point of view on the importance of long term behavior in resource allocation is very different from the point of view on time series forecasting, where the predictive power of a forecast relies heavily on an intelligent data-mining algorithm, applied not on the long or medium term data, but on the news and fluctuation of the market in the past few days.

In order to accommodate the fluctuation in stock price in the short term, it will be desirable to incorporate these two points of view, so that we have a general platform to construct a resource allocation algorithm, with the definition of the long time scale and short time scale given by the user. Recently, we have investigated a multi-agent system of stock traders, each making a two-stock portfolio using the

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doi:10.1016/j.irfa.2011.06.015

mean variance analysis (Chen et al., 2008). The results of this work show that there exists portfolio with low risk and high return, in spite of the random nature of the stock price and the unknown mechanism between the price variations of individual stock. Indeed, in all the works on portfolio management involving stocks, a common goal is to pursue high return, low risk and consistent performance. On the other hand, we are also aware of the short term nature of the correlation of the stock price, which can be as short as 1–2 days (Chen & Szeto, 2011). Therefore, it is desirable to extend our previous works by considering both the long term and short term conditions for portfolio management. Furthermore, we perform the portfolio selection and trading over a fixed period, thereby reducing the frequency of trading in order to avoid the penalty of the transaction fees. This constraint on the trading period also provides more flexibility in the trading scheme for investors of different trading habits in practical application. The final result should produce an algorithm that avoid frequent trading, while providing a good guidance for selecting stock combination that yield good profit with low risks. Such algorithm is ideal for conservative investors who can regularly enjoy consistent yield with low risk.

2. Investment strategy

2.1. Mean variance analysis for the long time scale

We first consider the resource allocation problem of a portfolio consisting of two stocks and cash. Let's denote the expected return $U(t)$ and variance $Var(t)$ by

$$U(t) = \frac{1}{Sample\ Size} \sum_{k=t-Sample\ \ Size+1}^{t} p(k) \tag{1}$$

$$Var(t) = \frac{1}{Sample\ Size-1} \sum_{k=t-Sample\,Size+1}^{t} (p(k)-U(t))^2 \tag{2}$$

where $p(t)$ is the daily closing price of the stock. The sample size is chosen to be 30 days, which we consider to be sufficiently long so that the mean and variance are rather smooth function of time. In our study of a two-stock portfolio, we take the expected return and variance for stock pair (1,2) as follows (Markowitz, 1952, 1959):

$$U_{12}(t,x) = U_1(t)x(t) + U_2(t)y(t) \tag{3}$$

$$Var_{12}(t,x) = Var_1(t)x^2(t) + Var_2(t)y^2(t) + 2Cov_{12}(t)x(t)\cdot y(t) \tag{4}$$

where $x(t)$and $y(t)$are the fraction of the portfolio invested in stock 1 and in stock 2, respectively. Note that the constraint $x(t)+y(t)=1$, with $x(t)$, $y(t)\in(0,\,1)$ implies that these quantities are function of t and x only. The time dependent covariance $Cov_{12}(t)$ of the two stocks is

$$Cov_{12}(t) = \frac{1}{Sample\ \ Size-1} \sum_{k=t-Sample\ \ Size\ +\ 1}^{t} (p_1(k)-U_1(t))(p_2(k)-U_2(t)) \tag{5}$$

and the standard deviation of the two-stock portfolio is:

$$\sigma_{12}(t,x) = \sqrt{Var_{12}(t,x)} \tag{6}$$

To analyze this two-stock portfolio, we make use of a version of the Sharpe ratio (Roy, 1952; Sharpe, 1966) defined as:

$$F_{12}(t,x) = \Delta p_{12}(t,x)\,/\,\sigma_{12}(t,x) \tag{7}$$

where $\Delta p_{12}(t,\ x)=(p_1(t)-p_1(t-Sample\ \ Size))\cdot x+(p_2(t)-p_2(t-Sample\ \ Size))\cdot(1-x)$ is the weighted price change of the stock combination. Note that this ratio is a function of x, so that we can find its maximum in the range of $x\in(0,\,1)$. Thus, for a chosen combination of stock, for example, the pair (1,2), we can achieve maximum return per unit risk, by maximizing $F_{12}(t,x)$ with respect to x and denote this maximum value as $F^*_{12}(t)$ and the corresponding resource allocation at time t as $(x(t),\ y(t))=(x^*,\ y^*=1-x^*)$. One may use exhaustive search with preset precision to obtain this value of $(x^*,\ 1-x^*)$ where the maximum of $F_{12}(t,\ x)$ occurs. In real application, one should use some efficient search algorithm to obtain this time dependent optimal resource allocation value $\{x^*_{ij}(t)|i=1,\ \ldots\ N, j>i\}$ for all possible pair of stocks. Note that this resource allocation of the portfolio refers to time t and a particular pair of stock (i,j).

2.2. Short term trading criterion

With the selected portfolio according to the long term analysis, we introduce a trading criterion based on the short term condition. Since the averaged correlation length of the stock price in terms of date is approximately 1.5 days in our previous analysis (Chen & Szeto, 2011), we define the short term fluctuation of the portfolio as the price change over two days: the trading day (t) and the day before the trading day $(t-1)$. We set the first day of trading to be July 10, 2007 and denote it by time $t_1$and denote the previous trading day by t_0. At t_1, we carry cash and have to decide on that day whether we convert cash into a two-stock portfolio by properly selecting a pair of stocks with allocation chosen at an optimal combination according to the Markowitz theory. The algorithm therefore involves two steps. The first step is to decide the pair of stocks to be invested. The second step is to decide if the chosen pair of stock should be bought.

Now, we discuss the implementation of the first step. The selection of pairs is divided into two parts. The first part involves the optimization of the Sharpe ratio given a two-stock portfolio. The second part involves the selection of the pair of stock using the worst scenario hypothesis.

1) Optimization of portfolios of stock pairs according to mean variance analysis
   We first compute the long term optimal two-stock portfolio using Eq. (7) for all pairs of stocks chosen among the 24 selected stocks from Heng Seng Index (Table 1). (There are 276 (=24*23/2) distinct pair of stocks). In order to use the Markowitz theory, we set the sample size for long term trend as 30 and compute the maximized Sharpe ratio $F^*_{i(t_1)j(t1)}(t)$using the 30 data points on and before $t_1$for each of the 276 combination of the pair $(i(t_1), j(t_1))$ of stock, and the associated optimal fraction for this pair at$(x^*_{ij}(t_1),\ y^*_{ij}(t_1))$. This process follows Eqs. (1–7).
2) Selection of portfolio for investment based on the Sharpe ratio and the worst scenario hypothesis
   Among the 276 pairs of stocks $\{(i, j)\}$, following the optimization process in Section 2.2 1), we have 276 best Sharpe ratios that maximize Eq. (7). Then, we select the stock pair $\left(\hat{i}(t_1), \hat{j}(t_1)\right)$with the minimal $F^*_{i(t_1)j(t1)}(t_1)$ among the 276 best Sharpe ratios optimized with respect to the x_{ij}. That is:

$$\left(\hat{i}(t_1),\ \hat{j}(t_1)\right) = \ \arg\min_{i,j}\left\{F^*_{ij}\left(x^*_{ij}(t_1),t_1\right)\middle|i,j=0,\ldots,23;\,i<j\right\} \tag{8}$$

Note that we choose among all 276 pairs the one which best Sharpe ratio is minimum. This is the worst scenario choice since if this stock pair$\left(\hat{i}(t_1),\hat{j}(t_1)\right)$ satisfies our short term trading criterion, then

Table 1
The 24 stocks used in this study.

0001.HK	0002.HK	0003.HK	0004.HK	0005.HK	0006.HK	0011.HK	0012.HK
0013.HK	0016.HK	0019.HK	0023.HK	0066.HK	0101.HK	0144.HK	0267.HK
0291.HK	0293.HK	0330.HK	0494.HK	0762.HK	0883.HK	0941.HK	1199.HK