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Dynamic multi-criteria evaluation of co-evolution strategies for solving stock trading problems

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ABSTRACT

Risk and return are interdependent in a stock portfolio. To achieve the anticipated return, comparative risk should be considered simultaneously. However, complex investment environments and dynamic change in decision making criteria complicate forecasts of risk and return for various investment objects. Additionally, investors often fail to maximize their profits because of improper capital allocation. Although stock investment involves multi-criteria decision making (MCDM), traditional MCDM theory has two shortfalls: first, it is inappropriate for decisions that evolve with a changing environment; second, weight assignments for various criteria are often oversimplified and inconsistent with actual human thinking processes.

In 1965, Rechenberg proposed evolution strategies for solving optimization problems involving real number parameters and addressed several flaws in traditional algorithms, such as their use of point search only and their high probability of falling into optimal solution area. In 1992, Hillis introduced the co-evolutionary concept that the evolution of living creatures is interactive with their environments (multi-criteria) and constantly improves the survivability of their genes, which then expedites evolutionary computation. Therefore, this research aimed to solve multi-criteria decision making problems of stock trading investment by integrating evolutionary strategies into the co-evolutionary criteria evaluation model. Since co-evolution strategies are self-calibrating, criteria evaluation can be based on changes in time and environment. Such changes not only correspond with human decision making patterns (i.e., evaluation of dynamic changes in criteria), but also address the weaknesses of multi-criteria decision making (i.e., simplified assignment of weights for various criteria).

Co-evolutionary evolution strategies can identify the optimal capital portfolio and can help investors maximize their returns by optimizing the preoperational allocation of limited capital. This experimental study compared general evolution strategies with artificial neural forecast model, and found that co-evolutionary evolution strategies outperform general evolution strategies and substantially outperform artificial neural forecast models. The co-evolutionary criteria evaluation model avoids the problem of oversimplified adaptive functions adopted by general algorithms and the problem of favoring weights but failing to adaptively adjust to environmental change, which is a major limitation of traditional multi-criteria decision making. Doing so allows adaptation of various criteria in response to changes in various capital allocation chromosomes. Capital allocation chromosomes in the proposed model also adapt to various criteria and evolve in ways that resemble thinking patterns.

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1. Introduction

The booming Taiwan stock market has attracted numerous amateur investors. Because of their limited professional knowledge and limited access to information, these unprofessional investors often resort to their own personal experience or to media reports when making investment decisions [6].

However, scholars pointed out in the past that Taiwan's stock market still provided effective strength for the ethnic groups of investment, which indicates that investors can still apply historical data for profit and stock prices to enhance their return on investment [22]. Thus, optimizing the capital allocation of investment portfolios is a major concern of many investors [12,26].

In the environment, the decision making problem often faced by investors is the interaction between various goals and criteria. Given the incomplete information available and the subjectivity in judging value, traditional single-goal decision making approaches are no longer applicable. Accordingly, multiple criteria should be considered, and decision-makers must perform multi-criteria decision making to find optimal solutions given varying goals and multiple criteria [31]. The numerous analytical tools applied for stock market forecasting and abroad include genetic algorithms, evolution strategies, artificial neural networks, ant colony system, fuzzy logic, or integration of genetic algorithms with artificial neural network, etc. [2,3,6,8–10,17–21,23,24,28,29]. No matter technical perspective or basic perspective, few reports have investigated methods of quickly and accurately analyzing an investment portfolio to determine the optimal capital allocation for the external environment. Thus, investors often resort to personal experience and limited information when allocating limited capital, which inevitably results in poor capital allocation and profit loss [17]. Instead of the simplified evaluation model adopted by general evolution computation tools, which are inappropriate for highly variable investment environments, this research integrated evolution strategies into the co-evolutionary criteria evaluation model to identify the optimal capital allocation ratio. Because artificial neural networks enable investors to observe the complicated non-linear relationships among different stock prices and because of their excellent forecasting performance [3], this study compared the proposed model with an artificial neural network benchmark and general evolution strategies.

2. Literature review

2.1. Stock investment portfolio

The investment portfolio means as the allocation of capital among more than one investment, given limited capital. Investors generally allocate capital among many investments in order to avoid large losses from a single investment. They consider how the independent characteristics of each investment can diversify risk. Doing so necessarily dilutes overall investment risk. The sharpe ratio is a widely used tool for performance comparisons of investment portfolios under similar risk conditions and is also used to compare their returns [30].

$$\text{Sharpe ratio} = \frac{\text{Asset return} - \text{Risk free return}}{\text{Standard deviation returns}}.$$

The traditional measure of risk in the finance industry is asset return fluctuation (σ) [27], and a riskless interest rate is a fixed-term deposit interest rate. In an investment portfolio (P) that includes n kinds of stocks and where w_i represent the capital allocation for an i group of stocks, $\sum_{i=1}^{N}\omega_i = 1$. Eq. (1) gives the return for the portfolio, and Eq. (2) gives the risk.

$$E(R_P) = \sum_{i=1}^{n} w_i E(r_i), \tag{1}$$

$$\sigma_P^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij}. \tag{2}$$

2.2. Multi-criteria decision making model

The four elements of a multi-criteria decision making Problem [15,31] are the alternative set, the criterion set, the performance values of the alternative, and the preference structure of the decision-maker. These four basic elements correspond to the key elements in the process of evolution strategies. For example, alternative sets correspond to the initial population in evolution strategies. The evolution strategies process constantly generates new chromosomes, which can be viewed as new solutions for new choices. This corresponds to the changing of new alternatives constantly generated by multi-criteria decision making process. The criteria set also correspond to the limit equations in evolution strategies. Multi-criteria decision making uses criteria to determine whether a solution choice is good or bad whereas evolution strategies use various limit equations to evaluate the pros and cons of various chromosomes. Performance values of alternatives correspond to the fitness value of each chromosome in the evolution strategies. The evaluation value in multi-criteria decision making