Resource allocation neural network in portfolio selection

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Abstract

Portfolio selection is a resource allocation problem in a finance market. The investor’s asset optimization requires the distribution of a set of capital (resources) among a set of entities (assets) with the trade-off between risk and return. The ANN with nonlinear capability is proven to solve a large-scale complex problem effectively. It is suitable to solve NP-hard resource allocation problem. However, the traditional ANN model cannot guarantee the summation of produced investment weight always preserves 100% in output layer. This article introduces a resource allocation neural network model to optimize investment weight of portfolio. This model will dynamically adjust the investment weight as a basis of 100% of summing all of asset weights in the portfolio. The experimental results demonstrate the feasibility of optimal investment weights and superiority of ROI of buy-and-hold trading strategy compared with benchmark Taiwan Stock Exchange (TSE).

Keywords: Resource allocation; Neural network; Portfolio; Investment; Optimization

1. Introduction

The resource allocation problem is a process of allocating a set of resources among a set of entities or activities. It is a complex problem encountered in a variety of areas in operations economics and operation researches, such as portfolio selection, production planning, and computer scheduling. In general, the resource allocation is NP-complete if considering a variety of constrains and limitations which are common trade-offs. The intelligent computational techniques such as artificial neural networks (ANNs) would be more suitable to improve the resource allocation problem. ANNs had attracted much more efforts from both academic scholars and industrial practitioners since Rosenblatt first applied single-layer perceptron to pattern classification learning in the late 1950s. Recently, a growing interest researches had been focused on using ANNs in finances and economics because they are powerful to imitate flexible nonlinear modeling relationship capabilities.

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results show that the ANNs outperform the benchmark for financial performance prediction. The experimental algorithm to integrate fundamental and technical analysis is a popular issue in business failure prediction (Ahn, Cho, & Kim, 2000; Plikynas, Salalauskas, & Poliakova, 2005). It is also a significant issue in asset allocation framework according to a value-at-risk adjusted profit criterion for making asset allocation decisions. Both the forecasting and decision models are significantly outperforming the benchmark market performance. Eakins and Stansell (2003) examine whether superior investment returns can be earned by using ANNs to perform forecasts based on a set of financial ratio and determine the intrinsic value of assets to enter the property portfolio. They find that the ratio value provides useful information that permits the selection of portfolio with superior investment returns than DJIA and S&P500.

Kryzanowski, Galler, and Wright (1993) applied Boltzmann machine for ANNs to discriminate stock return as positive, neutral and negative. They found the correct classification rate from results is more than 70% of all unseen data. Dropsy (1996) uses ANNs as a nonlinear prediction tool to forecast international equity risk premia. Both linear and nonlinear forecasts’ results outperform than random work. Lam (2004) applied the back-propagation algorithm to integrate fundamental and technical analysis for financial performance prediction. The experimental results show that the ANNs outperform the benchmark. The criteria factor selection is an issue in ANNs. Qi and Zhang (2001) investigate the model selection criteria for ANNs time series forecasting. They discover Akaike and Bayesian information criterion as well as several extensions have been examined through time serial of S&P500. The hybrid evolutionary approach with ANNs is popular issue in business failure prediction (Ahn, Cho, & Kim, 2000; Plikynas, Salalauskas, & Poliakova, 2005). Ko and Lin (2006) proposed an evolutionary modularized evaluation functions with ANNs to forecast financial distress, which allows using any evolutionary algorithm to extract the set of critical financial ratios and integrates more evaluation function modules to achieve a better forecasting accuracy by assigning distinct weights. This approach effectively helps improving final forecasting accuracy.

In portfolio applications, using ANNs to portfolio management has gained interest in recent years. Hung, Liang, and Liu (1996) integrate the arbitrage pricing theory (APT) and ANNs to extracting risk factors and generating individual in portfolio. The empirical results indicate the integrated method beats the benchmark and ARIMA model. Chapados and Bengio (2001) demonstrated the success of ANNs with asset allocation framework according to a value-at-risk adjusted profit criterion for making asset allocation decisions. Both the forecasting and decision models are significantly outperforming the benchmark market performance. Eakins and Stansell (2003) examine whether superior investment returns can be earned by using ANNs to perform forecasts based on a set of financial ratio and determine the intrinsic value of assets to enter the property portfolio. They find that the ratio value provides useful information that permits the selection of portfolio with superior investment returns than DJIA and S&P500. Hung, Cheung, and Xu (2003) present an extended adaptive supervised learning decision EASLSD trading system to enhance the portfolio management. Their research results take a balance between the expected returns and risks. Plikynas et al. (2005) use ANNs to control nonlinear dynamics of heterogeneous foreign investment impact on national capitalization structure. Their research results are better than multidimensional linear regression forecasting performance. Ellis and Wilson (2005) applied ANNs to the Australian property sector stocks to construct a variety of value portfolios. Their risk-adjusted performances show the value portfolios outperform the benchmark by as much as 7.14%.

However, the traditional ANN model cannot produce reasonable allocation ratios generally, i.e. the summation of produced allocation ratios cannot retain 100% in the target portfolio during the training period. Most of them use additional correction steps, such as, division the output vector by its sum to fit constrains of problems. This extra fixing step would possibly mislead the final trained neural network. Therefore, it is an important issue to propose a novel resource allocation neural network (RANN) model. The aim of this paper is to introduce an allocated learning based neural network model to optimize the assets allocation in portfolio. This approach proposes a dynamic synaptic weight modification as a basis of 100% of summing all of allocation ratios in the portfolio. Through the examination of final experimental results, our model would outperform the market performance.

This paper is organized as follows. Section 2 presents our resource allocation ANNs model for asset allocation. Then, we will conduct some experiments to compare its performance with benchmark market in Section 3. Finally, we draw some conclusions in Section 4.

2. Multi-layer resource allocation neural network (RANN)

In this section, an allocated learning algorithm applied to multi-layer resource allocation neural network (RANN)
are negative, they are also higher than the corresponding ROI\_TSE (−10.19%) and (−8.97%). These results are also shown in Fig. 5. It demonstrates that RANN obtain better asset allocations effectively.

Table 3 is the summary of various asset allocation ratios in each sliding window. Let $R_{AV,x}$ denote the average allocation ratio for asset code $x$. It is reasonable that $R_{AV,2002} = 0.24$ (Catcher Technology, the automobile industry) and $R_{AV,2201} = 0.22$ (China Steel, Iron & Steel Industry) possess higher allocating ratio because of their higher ROI\_YM,2002 = 15.5% and ROI\_YM,2201 = 33.3%, where ROI\_YM,x refers to the annual ROI for asset code $x$. Even though ROI\_YM,1326 = 15.6% and ROI\_YM,2002 = 15.5% have similar values, $R_{AV,1326}$ (0.16) is smaller because of its higher risk $\sigma^2$ (0.12). It means that the MLRANN model suggests increasing investing ratio with high return and low risk; otherwise, it will decrease its allocation ratio.

4. Conclusions

The best asset allocation of portfolio is concerned with good performance of investment. The well-known mean variance method requires predetermined expected return to calculate the investing ratios of portfolio that becomes much more difficult and unrealistic forecasting securities investment strategies in the future. This approach uses specific linear relationship and limitation to calculate the risk factor such as covariance metric. The neural network with nonlinear characteristics may be more suitable to improve the asset allocation of portfolio. However, the traditional ANN model could not produce fitness investment weight based on summation of these weight retain one.

This paper introduces a novel allocated learning based resource allocation neural network model to optimize investment weight of portfolio that will outperform the market. This model proposes a dynamic weight modification as a basis of 100% of summing all of asset weights in the portfolio. Results on 21 companies selected to be our testing targets from Taiwan 50 Index Constituents demonstrate the feasibility of optimal investment weights and superiority of ROI based on buy-and-hold trading strategy. Through the experimental results, the complex portfolio asset allocation management would be solved effectively by our model. From our experiments, it appears that using allocated learning based neural network model will converge to two dimensions (the highest expected return and the lower RMSE), simultaneously. Using resource allocation neural network model produces better return of investment than TSE in each sliding window. Our resource allocation neural network model recommends increasing/decreasing investment weight of optimistic/pessimistic prospects of assets effectively.

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References


