

Combinatorial Portfolio Selection with the ELECTRE III method: Case study of the Stock Exchange of Thailand (SET)

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Abstract—Various techniques of portfolio selection are applied to interpret the status of the market and predict the market's future trend, but they are not beneficial to small investors because these techniques should be administered by an expert. In addition, these techniques desire accumulation of data about the market and complicated calculations, which is too much effort for individual small investors. Therefore, portfolio selection with two significant financial ratios using the ELECTRE III method is proposed for these investors to make trading decisions. In order to demonstrate the effectiveness of this new method, it is compared to the situation where a fix percentage allocation existed and data was collected from the Stock Exchange of Thailand (SET).

I. INTRODUCTION

The Stock Exchange of Thailand (SET) is the national stock exchange of Thailand. Retail investors in Thailand have long been a majority of players. They account for approximately 41%, whereas foreigner and institution flows are 36% and 21% of daily trading value respectively [13]. Since many factors (such as political and economic factors) are likely to influence the trend of the market [3], forecasting the trend requires various market analysis techniques [2, 5, 10, 11, 19, 22]. In addition, there are a number of machine learning techniques proposed as a solution to the problem such as reinforcement learning [17, 18, 20], neural networks [9, 12], genetic algorithms [1, 15, 16], decision trees [24], support vector machines [4, 14, 23], and boosting and expert weighting [6, 7, 8]. Arthur Samuel in 1959 defined machine learning as the “field of study that gives computers the ability to learn without being explicitly programmed”. Such techniques build a model from an example training set of input observations in order to make data-driven predictions or decisions expressed as outputs. Although machine learning techniques are applied to interpret the status of the market and predict the market's future trend, but they are not beneficial to small investors because these techniques desire both accumulation of training data set about the market and complicated calculations to make data-driven predictions, which is too much effort for an individual small investor. Therefore, portfolio selection with only two significant financial ratios using the ELECTRE III method is proposed for those investors to make trading decisions. The two significant financial ratios are net profit margin and dividend

yield. The Net profit margin is a ratio of profitability calculated as after-tax net income (net profits) divided by sales (revenue) and displayed as a percentage; whereby consideration focuses on stocks with high net profit margin. Dividend yield is the amount that a company pays to its shareholders annually for their investments; whereby consideration focuses on stocks with high dividend yield. It is expressed as a percentage and indicates attractiveness of investing in a company's stocks. The ELECTRE III method [21] is the most popular one of the outranking methods in Multi Criteria Decision Making (MCDM). Its performance of alternatives on each criterion in outranking is compared in pairs. An alternative a is said to outrank an alternative b if it performs better on some criteria and at least as well as b on all others. The outranking relation in the ELECTRE III is a fuzzy binary relation. It uses three distinct thresholds (indifference, preference, and veto) to incorporate the uncertainties that are inherent in most influence valuations. In addition, the ELECTRE III method is less of a complex than the machine learning techniques because it follows strictly static program instructions.

This report proceeds as follow. In the next section, previous related literatures are reviewed. Then the research methodology and data used are discussed. Empirical results found in the study are then presented and analyzed. Lastly, conclusion, implications, and limitations together with suggestion for further study are presented.

II. BACKGROUNDS

An **ELECTRE** is a family of multi-criteria decision analysis methods (Roy, B. (1978)). The ELECTRE is working on the concrete, multiple criteria, and real-world problem of how firms can decide on new activities and had encountered problems using a weighted sum technique. It uses several mathematical functions to indicate the dominant degree of one alternative over the remaining ones. Additionally, it also facilitates comparisons between alternative schemes by using a weighted sum technique. The outranking relationships between alternatives are constructed and exploited eventually.

In order to be consistent with the basic concept of similarity in case based reasoning, different terminologies from the classical ELECTRE is used.

Let the distance between case a_k and case a_l on the j feature be denoted by $|a_{kj} - a_{lj}|$ or d_{lkj} . Let w_j express the weight of the feature.

Definition 1: The indifferent threshold of criterion j q_j : a_k and a_l are indifferent if $|a_{kj} - a_{lj}| < q_j$.

Definition 2: The strict preference threshold of criterion j p_j : a_k is strictly preferred to a_l if $|a_{kj} - a_{lj}| < p_j$.

Definition 3: The weak preference threshold of criterion j p_j : a_k is weakly preferred to a_l if $|a_{kj} - a_{lj}| \leq p_j$.

Definition 4: The veto threshold of criterion j v_j : reject the hypothesis of outranking of a_k over a_l if $|a_{kj} - a_{lj}| > v_j$.

The Index of Concordance and Discordance

Definition 5: The degree of concordance with the judgmental statement that a_k outranks a_l under the j the criterion $cr_j(k, l)$ is defined as

$$cr_j(k, l) = \begin{cases} 1 & \text{if } q_j \geq a_{lj} - a_{kj}, \\ 0 & \text{if } p_j \leq a_{lj} - a_{kj}, \\ \frac{p_j - (a_{lj} - a_{kj})}{p_j - q_j} & \text{otherwise} \end{cases}$$

Definition 6: A concordance index of each ordered pair (a_k, a_l) of alternatives $cr(k, l)$ is defined as

$$cr(k, l) = \frac{\sum_{j=1}^r w_j cr_j(k, l)}{\sum_{j=1}^r w_j}$$

Where w_j is the weight determining the relative importance of j th criterion.

Definition 7: The degree of discordance with the judgmental statement that a_k outranks a_l under the j the criterion $d_j(k, l)$ is defined as

$$d_j(k, l) = \begin{cases} 0 & \text{if } a_{lj} - a_{kj} \leq p_j, \\ 1 & \text{if } a_{lj} - a_{kj} \geq v_j, \\ \frac{(a_{lj} - a_{kj}) - p_j}{v_j - p_j} & \text{otherwise} \end{cases}$$

The Degree of Outranking

Definition 8: The degree of credibility of outranking with the judgmental statement that a_k outranks a_l is defined as

$$s(k, l) = \begin{cases} cr(k, l) & \text{if } J(k, l) = \emptyset, \\ cr(k, l) \prod_{j \in J(k, l)} \frac{1 - d_j(k, l)}{1 - cr(k, l)} & \text{otherwise} \end{cases}$$

where $J(k, l)$ is defined as the set of criterion for which $d_j(k, l) > cr(k, l)$. If $J(k, l) = \emptyset$, we have $d_j(k, l) > cr(k, l)$ for any criterion, then $s(k, l)$ is the same as $cr(k, l)$.

Definition 9: The ranking of the alternatives is defined as

$$\delta_k = \sum_{l=1}^n s(k, l) - \sum_{l=1}^n s(l, k), k = 1, 2, \dots, n$$

III. THE ELECTRE III MODEL FOR SELECTING STOCKS

A. The ELECTRE III Method

Let $A = \{a_1, a_2, \dots, a_n\}$ be a set of stock alternatives, P_{purchase} be prices of the purchased stocks in any year, P_{sell} be prices of the sold stocks in any year, and $C = \{c_1, c_2\}$ be a set of criteria in this research which are net profit margin and dividend yield. $W = \{w_1, w_2\}$ is a set of weights of influence on criteria net profit margin and dividend yield, a_{kj} is the performance values of criterion c_j of stock alternative a_k , and (a_k, a_l) is any ordered pair of stock alternatives. Net Profits of any stocks are the difference between the price of the purchased stocks and their sold stocks. Total profit is summation of Net Profits and their Dividend yields.

In this section, Combinatorial Portfolio selection with the ELECTRE III method is described. There are three steps as follows:

Table 1: The ELECTRE III method for Selecting Stocks

<p><i>Input:</i> a list A of stock alternatives, P_{purchase} is prices of the purchased stocks in any year, P_{sell} is prices of the sold stocks in any year, C is a set of criteria: net profit margin and dividend yield, W is a set of weights of influence on criteria net profit margin and dividend yield, Percent of ranking allocation</p> <p><i>Output:</i> Total profit of each allocation</p> <ol style="list-style-type: none"> 1. Ranking the stocks. The results are ranking based on the ELECTRE III method. 2. Allocating percentage of top ranking stocks. 3. Calculating total profit from each allocation.

B. Description of the Scenario

In this section, we present an application of the ELECTRE III method to select any stocks. Suppose that Somsri want to select stocks of any company. Table 2 shows all stocks that she wants to purchase. Criteria that are considered in selecting each stock are their weights, their preference threshold, their indifference index, and their veto threshold are defined for this application, as in Table 3. The criteria net profit margin and dividend yield are to be maximized. The last price and dividend yield of stocks from 2011 to 2014 are shown in Table 4 and 5 respectively. Finally, the final ranking of the ELECTRE-III methods is shown in Table 6.

Table 2: Stock alternatives

Stock alternatives	Description
A1	BTS: BTS GROUP HOLDINGS PUBLIC COMPANY LIMITED
A2	PTT: PTT PUBLIC COMPANY LIMITED
A3	SPALI: SUPALAI PUBLIC COMPANY LIMITED
A4	SCB: THE SIAM COMMERCIAL BANK PUBLIC COMPANY LIMITED
A5	AHC: AIKCHOL HOSPITAL PUBLIC COMPANY LIMITED

Table 3: Indifference, preference, and veto thresholds values

Criteria	Description	Units	Indifference Threshold (q)	Preference Threshold (p)	Veto Threshold (q)	Weight
C1	Net Profit Margin (%)	%	5	10	20	0.6
C2	Dividend Yield (%)	%	0.5	3	5	0.3

Table 4: Price of stocks of any company in any years

Alternatives	Last Price(Baht)			
	30/12/2011	28/12/2012	27/12/2013	30/12/2014
A1: BTS	0.7	7.15	8.70	9.65
A2: PTT	318	332	286	324
A3: SPALI	14.30	17.70	14.6	24.10
A4: SCB	116.5	181.5	143.5	182.0
A5: AHC	77.50	21.40	19.40	28.50

Table 5: Dividend yields of stocks of the company in any years

Alternatives	Dividend Yield (%)			
	30/12/2011	28/12/2012	27/12/2013	30/12/2014
A1: BTS	5.03	3.55	4.21	6.2
A2: PTT	3.21	3.91	4.55	4.01
A3: SPALI	4.2	3.67	4.45	2.9
A4: SCB	2.57	1.93	3.14	2.88
A5: AHC	3.23	1.64	2.58	2.25

Table 10: Results of the fixed-percentage allocation evaluation

Stocks	Ranking	Percentage	Budgets	P _{purchased}	Units	P _{sold}	Profits	Total
A1: BTS	3	20	20000	0.7	28571	9.65	8.95	798285.7
A2: PTT	5	20	20000	318	62.89	324	6	1363.52
A3: SPALI	2	20	20000	14.3	1398.6	24.18	9.88	35,104.9
A4: SCB	1	20	20000	116.5	171.67	182	65.5	13,050.64
A5: AHC	4	20	20000	77.5	258.06	28.5	-4.9	-10,141.9
Total								837,662.86

To evaluate the performance of the ELECTRE-III method allocation the above algorithms were run 100 times for various simulation parameters and the average values of the profits were calculated. Table 11 shows various parameters used in the experiment.

Table 11: Simulation parameters used in both scenarios

Parameters	Range of values used for simulation
Fixed percentages	20%
Budgets	100000 baths
Years	2 – 4 years
Alternatives	5

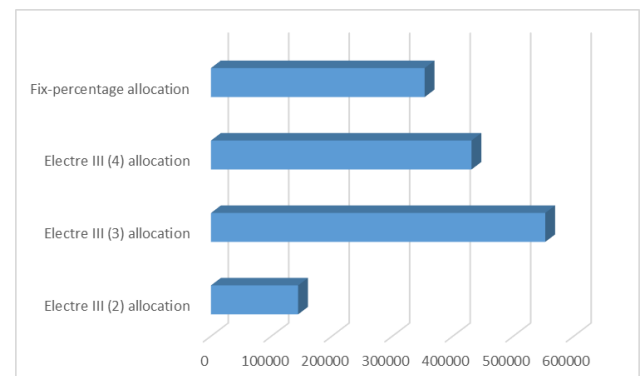
In Table 11, there are four parameters. Fixed percentage of a fixed-percentage allocation scheme is 20%. Budget means the budget for all stocks or alternatives. Years mean the number of years that the stocks are hold from 2011 to 2014. Alternatives mean the number of stocks.

B. Results

The above results (Table 7, 8, and 9) show the total profits under the proposed scheme with different top-n choices. Figure 1 compares these results with a fixed-percentage allocation scheme (Table 10). In Figure 1, the vertical axis represents mean of total profit.

In these simulations, the total profits of the alternative ELECTRE-III (3) is higher than of the fixed-percentage allocation. To determine whether a significant difference exists between the total profits of the two groups, an independent t-test and a Wilcoxon signed rank statistic used with a significance level of $\alpha = 0.05$ were applied to the results of these simulations. The test results reject the hypotheses: the total profit of the ELECTRE-III (3) is equal

to of the fixed-percentage allocation. It implies that the total profit of the ELECTRE-III (3) is not equal to that of the fixed-percentage allocation comparisons. Additionally, the ELECTRE-III (4) method gives the same results as the ELECTRE-III (3) method. However, the ELECTRE-III (2) method gives the results opposite from the ELECTRE-III (3) because the number of stocks is not much to guarantee a risk from investment.

**Figure 1: Results of satisfaction evaluation**

V. CONCLUSION, LIMITATIONS, AND FUTURE WORKS

Portfolio selection with two significant financial ratios using the ELECTRE III method is proposed for small investors to make trading decisions. We have presented fundamental principles of the ELECTRE III method in detail. In this research, we use a veto indicator deriving from non-veto relations, weak veto relations, and strong veto relations to enhance the mechanism of similarity measure between two cases. 100 times is employed to assess ranking performance of various ELECTRE III methods. From the results of the experiment, we find that the new offer a viable approach for investment advisory ranking. Empirical results show that they offer significantly better ranking performance than the fix-

percentage allocation method. Our proposed prototype using the ELECTRE III method has been successfully validated. This was demonstrated in Figure 1. Such results illustrate that user can get not vague information from application of the ELECTRE III method allocation to help he/she in investment planning and then it could lead to a growing total profits of retail investors in Thailand. Limitations of our study is that it doesn't considered situations with vary alternatives and percentages of ranking stocks.

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