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Strategic Decision Making in Portfolio Management with Goal Programming Model

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Abstract: Enhanced index tracking is a popular type of portfolio management which aims to construct the optimal portfolio in order to generate higher portfolio mean return than the benchmark index mean return. Enhanced index tracking is a dual objective optimization problem which can be represented by a goal programming model to determine the trade-off between maximizing the portfolio mean return and minimizing the tracking error. The objective of this paper is to apply the goal programming model in constructing the optimal portfolio to track the Technology Index in Malaysia. In this study, the data consists of weekly return of the companies from technology sector in Malaysia stock market. The results of this study indicate that the optimal portfolio is able to outperform Technology Index by generating weekly excess mean return 0.3798% at minimum tracking error 2.0980%. The significance of this study is to identify and apply the goal programming model as a strategic decision-making tool for the fund managers to track the benchmark Technology Index effectively in Malaysia stock market.

Keywords: Goal Programming Model, Enhanced Index Tracking, Optimal Portfolio, Mean Return, Tracking Error

1. Introduction

At the operational level, many decisions are made in order to achieve the desired outcome that contribute to the achievement of a company's overall strategic goal. In operations management, there are quantitative models, optimization models and other techniques available which help the managers to make better decisions scientifically. In portfolio management, the fund managers have to determine the optimal portfolio which can generate higher return at minimum risk of loss. Enhanced index tracking is a popular type of portfolio management which aims to construct the optimal portfolio in order to generate higher portfolio mean return than the benchmark index mean return at minimum tracking error [1]. Tracking error is a risk measure of how closely the portfolio return follows the benchmark index return [2].

Tracking the sectorial index is important because the index represents the overall performance of the economic sectors in a country such as technology sector, construction sector and industrial product sector. In tracking the benchmark index, the

optimization model with goal programming approach has been developed to determine the trade-off between minimizing the tracking error and maximizing the mean return of the portfolio [3]. The optimization model has been studied by different researchers as a strategic decision-making tool in portfolio management [4-9]. Tracking error and mean return of the optimal portfolio are two elements in enhanced index tracking problem [10, 11]. The objective of this paper is to apply the optimization model with goal programming approach in constructing the optimal portfolio to track the Technology Index in Malaysia. The performance of the optimal portfolio is then compared with the benchmark Technology Index. The rest of the paper is organized as follows. The next section describes the materials and methods used in this study. Section 3 presents the empirical results of this study. Section 4 concludes the paper.

2. Materials and Methods

2.1. Data

In this study, the data consists of weekly return of the

stocks from technology sector which are listed on the Malaysia stock market as shown in Table 1 [12].

Table 1. List of Stocks from Technology Sector on Malaysia Stock Market.

Stocks
CUSCAPI
D&O
DATAPRP
DIGISTAR
DNEX
GHLSYS
GPACKET
GTRONIC
MPI
MSNIAGA
NOTION
OMESTI
PANPAGE
PENTA
THETA
TRIVE
UNISEM

The study period is from January 2012 until December 2015. This data is applied in the optimization model with goal programming approach for portfolio construction to track the Technology Index in Malaysia. In portfolio construction with the goal programming model, the decision variables represents the optimal portfolio composition that can be determined by solving the model [3]. The return of the stocks is determined as below [1].

$$R_{jt} = \ln\left(\frac{P_{j,t}}{P_{j,t-1}}\right) \qquad (1)$$

R_{jt} is the return of stock j at time t,

$P_{j,t}$ is the closing price of stock j at time t,

$P_{j,t-1}$ is the closing price of stock j at time t-1.

The return of the benchmark index is determined as below [4].

$$R_{It} = \ln\left(\frac{I_t}{I_{t-1}}\right) \qquad (2)$$

R_{It} is the return of index at time t,

I_t is the index value at time t,

I_{t-1} is the index value at time t-1.

The mean return of the stock j is calculated as below [13].

$$r_j = \frac{1}{T}\sum_{t=1}^{T} R_{jt} \qquad (3)$$

r_j is the mean return of stock j,

R_{jt} is the return of stock j at time t,

T is the number of observations.

Figure 1 shows the construction process of the optimal portfolio in tracking the benchmark Technology Index with an optimization model [14].
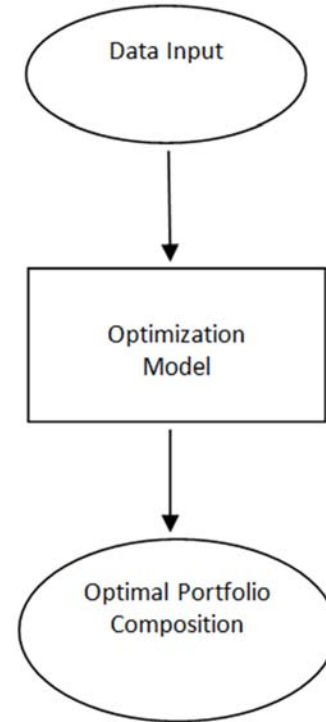

Figure 1. Construction Process of the Optimal Portfolio Composition with Optimization Model.

In this study, the optimization model with goal programming approach is solved with LINGO software [15].

2.2. Goal Programming Model

In enhanced index tracking, there are two goals to be achieved, which are minimizing the tracking error and maximizing the mean return of the optimal portfolio. Reference [3] proposed the dual objective optimization model for enhanced index tracking problem which is formulated as follow.

Minimize

$$T = \sum_{j=1}^{N} T_j x_j \qquad (4)$$

Maximize

$$R = \sum_{j=1}^{N} r_j x_j \qquad (5)$$

subject to

$$\sum_{j=1}^{N} x_j = 1 \qquad (6)$$

$$x_j \geq 0 \qquad (7)$$

r_j is the mean return of stock j in the optimal portfolio,

N is the number of stocks,

x_j is the weight of stock j in the optimal portfolio,

T_j is the tracking error of stock j,

T is the portfolio tracking error,
R is the portfolio mean return,

Equation (4) is the first goal which minimizes the portfolio tracking error. Equation (5) is the second goal which maximizes the portfolio mean return. Constraint (6) ensures that the total weights of stocks invested equal to one. Constraint (7) ensures that the weight of each stock j in the optimal portfolio are positive.

The dual objective optimization model above is solved with goal programming approach [3]. Goal programming is able to handle decision problems that involve multiple goals [16]. The goal programming model is formulated as follow.

Minimize

$$z = d_1^+ + d_2^- \qquad (8)$$

subject to

$$T + d_1^- - d_1^+ = m \qquad (9)$$

$$R + d_2^- - d_2^+ = n \qquad (10)$$

$$\sum_{j=1}^{N} x_j = 1 \qquad (11)$$

$$x_j \geq 0 \qquad (12)$$

d_1^- is the extent of underachievement for tracking error,

d_1^+ is the extent of overachievement for tracking error,

d_2^- is the extent of underachievement for portfolio mean return,

d_2^+ is the extent of overachievement for portfolio mean return,

T is the portfolio tracking error,
R is the portfolio mean return,
m is target value for portfolio tracking error,
n is target value for portfolio mean return,
N is the number of stocks,

x_j is the weight of stock j in the optimal portfolio,

Equation (8) is the objective function of the model which minimizes the sum of deviations of all decision goals. Equation (9) is the first goal which minimizes the portfolio tracking error. Equation (10) is the second goal which maximizes the portfolio mean return. Constraint (11) ensures that the total weights of stocks invested equal to one. Constraint (12) ensures that the weight of each stock j in the optimal portfolio are positive.

2.3. Portfolio Performance

Tracking error and mean return of the optimal portfolio are two elements in enhanced index tracking problem [10, 11]. Tracking error is the standard deviation of the difference between the returns of the portfolio and the returns of the benchmark index [17-19]. The formula for tracking error is as follows.

$$TE = \sqrt{\frac{1}{T} \sum_{i=1}^{T} (R_{Pt} - R_{It})^2} \qquad (13)$$

TE is the tracking error,
T is the number of periods,
R_{Pt} is the mean return of the optimal portfolio at time t,
R_{It} is the mean return of the benchmark index at time t.

The mean return of the optimal portfolio is formulated as follow [14, 20].

$$r_P = \sum_{i=1}^{N} r_j x_j \qquad (14)$$

r_P is the mean return of the optimal portfolio,

x_j is the weight of stock j in the optimal portfolio,

r_j is the mean return of stock j in the optimal portfolio.

Excess return is defined as the difference between the portfolio mean return and benchmark index mean return which is formulated as follow [3, 10].

$$\alpha = r_P - r_I \qquad (15)$$

α is the excess return,
r_P is the mean return of the optimal portfolio,
r_I is the mean return of the benchmark index.

The performance of the optimal portfolio is measured with information ratio [10, 21]. The information ratio is defined as the ratio of portfolio's excess mean return to the portfolio's tracking error which is formulated as below.

$$IR = \frac{\alpha}{TE} \qquad (16)$$

IR is the information ratio,
α is the excess mean return of the optimal portfolio over the mean return of the benchmark index return,
TE is the tracking error.

Higher information ratio indicates higher performance of the optimal portfolio.

3. Empirical Results

Table 2 displays the summary statistics of the stocks returns in this study.

Table 2. Summary Statistics of the Stocks Returns.

Stocks	Mean	Standard Deviation
CUSCAPI	-0.0052	0.0723
D&O	0.0035	0.0660
DATAPRP	-0.0034	0.0526
DIGISTAR	-0.0035	0.0540
DNEX	-0.0009	0.0549
GHLSYS	0.0059	0.1426
GPACKET	-0.0042	0.0682
GTRONIC	0.0106	0.0393
MPI	0.0063	0.0460
MSNIAGA	-0.0036	0.0343
NOTION	-0.0081	0.0625
OMESTI	-0.0018	0.0513
PANPAGE	-0.0013	0.0357
PENTA	0.0051	0.0590
THETA	-0.0031	0.0958
TRIVE	-0.0061	0.1091
UNISEM	0.0035	0.0543

As reported in Table 2, the stocks returns show that the values of mean and standard deviation are different for each stock in this period of study. GTRONIC gives the highest mean return at 0.0106 whereas GHLSYS gives the highest standard deviation at 0.1426.

Table 3 presents the stock selection in optimal portfolio which is constructed by solving the goal programming model.

Table 3. Stock Selection in Optimal Portfolio.

Stocks	Weights (%)
CUSCAPI	0.32
D&O	1.81
DATAPRP	0.48
DIGISTAR	0.00
DNEX	4.21
GHLSYS	2.68
GPACKET	0.00
GTRONIC	29.24
MPI	21.20
MSNIAGA	0.00
NOTION	0.00
OMESTI	0.00
PANPAGE	0.00
PENTA	14.53
THETA	0.00
TRIVE	1.65
UNISEM	23.88

As shown in Table 3, the list of stocks with positive weights indicate that those stocks are selected by the goal programming model in constructing the optimal portfolio to track the Technology Index in Malaysia. The optimal portfolio consists of 10 stocks with different weights in tracking the Technology Index. DIGISTAR, GPACKET, MSNIAGA, NOTION, OMESTI, PANPAGE and THETA are not selected in the optimal portfolio because these stocks give the weights of 0.00%.

Figure 2 presents the optimal portfolio composition with goal programming model.
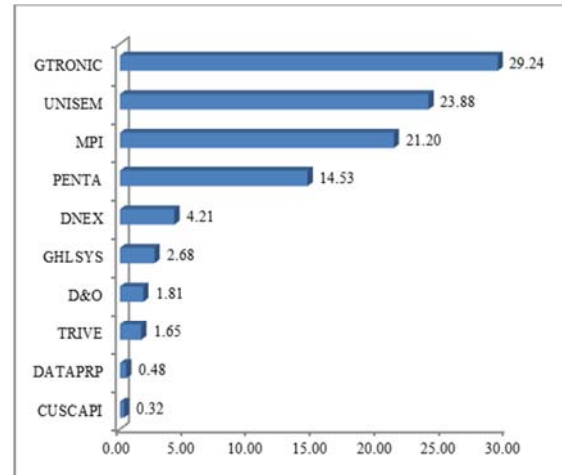
Figure 2. Optimal Portfolio Composition with Goal Programming Model.

As shown in Figure 2, the optimal portfolio consists of CUSCAPI (0.32%), D&O (1.81%), DATAPRP (0.48%), DNEX (4.21%), GHLSYS (2.68%), GTRONIC (29.24%), MPI (21.20%), PENTA (14.53%), TRIVE (1.65%) and UNISEM (23.88%). This implies that the optimal portfolio composition are the optimal solution of the goal programming model. GTRONIC is the most dominant stock in the optimal portfolio with 29.24% of the allocated fund. On the other hand, CUSCAPI is the smallest stock in the optimal portfolio with 0.32% of the allocated fund.

Table 4 and Figure 3 present the summary statistics and return distribution of the optimal portfolio of the goal programming model respectively.

Table 4. Summary Statistics of the Optimal Portfolio.

Goal Programming Model	Summary Statistics
Portfolio Mean Return	0.006068
Portfolio Standard Deviation	0.033702
Portfolio Skewness	-0.259044
Portfolio Kurtosis	1.356789
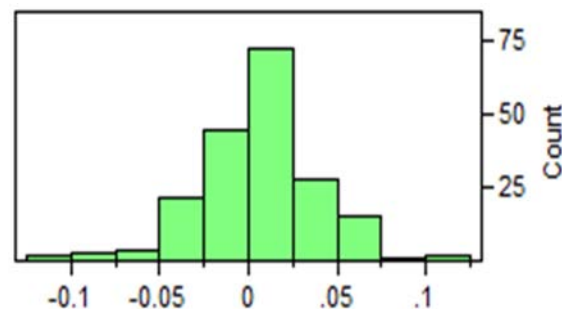
Figure 3. Portfolio Return Distribution of the Goal Programming Model.

Based on Table 4 and Figure 3, the optimal portfolio of goal programming model gives the mean return 0.006068 (0.6068%) with standard deviation 0.033702. Besides that, the skewness and kurtosis value of the optimal portfolio are -0.259044 and 1.356789 respectively.

Table 5 displays the performance of the optimal portfolio constructed using the goal programming model.

Table 5. *Performance of the Optimal Portfolio of Goal Programming Model.*

Portfolio	Technology Index	Goal Programming Model
Mean Return (%)	0.2270	0.6068
Excess Return (%)	-	0.3798
Tracking Error (%)	-	2.0980
Information Ratio	-	0.1810

As shown in Table 5, the weekly mean return for Technology Index is 0.2270% based on the study period. The optimal portfolio tracks the Technology Index with weekly mean return 0.6068% which is higher than the mean return of Technology Index. This implies that the optimal portfolio constructed by the goal programming model is able to outperform the Technology Index with weekly excess mean return 0.3798% at minimum tracking error 2.0980%. Besides that, the information ratio 0.1810 indicates that the optimal portfolio can generate weekly excess mean return 0.1810% over the mean return of Technology Index at 1% tracking error. Therefore, the goal programming model is suitable to be used as a strategic decision-making tool for the fund managers and investors in Malaysia.

4. Conclusion

This paper discusses about the strategic decision-making tool in portfolio management by using the goal programming model to track the Technology Index in Malaysia. In conclusion, the optimal portfolio constructed by the goal programming model is able to outperform Technology Index by generating weekly excess mean return 0.3798% at minimum tracking error 2.0980%. The significance of this study is to identify and apply the goal programing model as a strategic decision-making tool for the fund managers and investors to track the benchmark Technology Index effectively in Malaysia.

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