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Performance of Three-Parameters Dirichlet Universal Portfolio During COVID-19 Pandemic

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ABSTRACT

Stock returns are often the primary objectives for investors, financial analysts as well as the politicians with the intention to make a right investment decision. In this paper, we study the performance of the three-parameters Dirichlet universal portfolio on selected stocks during the COVID-19 pandemic. Some empirical results are obtained based on some selected data sets from the local stock exchange. The period of trading of the stocks are selected from 2nd January 2020 to 18th August 2021 consisting of 400 trading days. The empirical results seem to indicate the three-parameters Dirichlet universal portfolio performs well during the COVID-19 pandemic by a proper choice of parameters. Also, this study provides evidence that the capital achievement at the end of the 400th trading days is influenced by the arrangement of the stocks within each selected data set. Besides, the performance of the homogeneous datasets, particularly, main data set from healthcare sector, is better than heterogeneous datasets during the COVID-19 pandemic.

1. Introduction

Anticipation and forecast of the financial time series, for example stock returns, are often the primary objectives for investors, financial analysts as well as the politicians with the intention to make an accurate and good investment decisions. However, the nature of the stock returns would change and alter as a result of catastrophic events, specifically, a financial crisis brought by the pandemic in 2020. The investment strategy we discussed here is free of any distribution of stock prices, yet it depends on past stock price data. As a result, this "universality" characteristic of model-free make it a "universal" portfolio. Dirichlet $(\alpha_1, \alpha_2, \ldots, \alpha_m)$ universal portfolio attempted to improve by varying the parameter vectors periodically after a fixed trading period, and this finding has been proven by Tan and Pang [1], where m is the number of stocks in the market. By changing the parameters of the Dirichlet universal portfolio periodically, investors may achieve higher investment returns as this time-varying investment strategy seems reasonable to meet the ever-changing company stock prices, thereby overcoming the effect of any sudden downturn in the stock market, which can cause severe financial loss to investors.

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Since we realized that the Cover-Ordentlich Universal Portfolio solely emphasized the Dirichlet (1,1,…1) and Dirichlet (0.5,0.5,…,0.5) universal portfolios, there was no study on the general Dirichlet $(\alpha_1, \alpha_2, \dots, \alpha_m)$ universal portfolio until the theoretical findings of Tan [2] (as cited by Tan and Pang, 2012). According to the research of Tan and Pang [1], the performance of the Dirichlet $(\alpha_1, \alpha_2, \dots, \alpha_m)$ universal portfolio can be enhanced by varying the parameter vector regularly after a fixed trading period as compared to the constant parameter universal portfolio. After a trading period, a new optimum parametric vector is chosen using a cyclic constrained-search algorithm that improves the investment return from the previous period. Through iteration, Tan and Pang [1] found a new parametric vector used in the kth period by using the formula as follows:

$$\alpha_k = \left(\alpha_{k1}^{(i)}, \dots, \alpha_{k(j-1)}^{(i)}, \alpha_{kj}^{(i-1)}, \alpha_{k(j+1)}^{(i-1)}, \dots, \alpha_m^{(i-1)} \right)$$

Lee et al [3] studied the impact of COVID-19 pandemic on the Malaysian stock market and they found out that there are the weakest correlations between healthcare and plantation sectors, which has the correlation coefficient of 0.323. It is followed by the finance and healthcare sectors with 0.38 correlation coefficient. As stated by Abuoliem, Kalyebara and Ibrahim [4], shariah-compliant portfolios tend to have a better performance than the conventional rivals in the Malaysian stock market during the times of economic instability, such that as in the COVID-19 pandemic period. This can be explained because the shariah-compliant portfolio of securities did not expose themselves in the highly volatile investments as they need to comply with the Shariah principles that stipulated by Islamic Law. This is also supported by Haseeb, Mahdzan and Ahmad [5], in which they revealed that the firm's Shariah compliance is less prone to the stock price crash risk as well as less likely to assemble bad news. Consequently, the company stocks with Shariah principles outperforms other traditional stocks even though the Malaysian marker performance is in a diminishing trend and a volatile stage during the spread of COVID-19. Other than that, Subekti et al. [6] proposed that their modified Black-Litterman (BL) model was able to mitigate the implications of the COVID-19 pandemic to the Shariah-complaint stock market in Indonesia by comparing the Sharpe ratio of their proposed portfolio model with the two reference models which are the Mean-Variance (MV) Method and the Black-Litterman Capital Asset Pricing Model (BL-CAPM). It can be proved that the Sharpe ratio of the modified BL model managed to generate more favorable risk-adjusted returns by reducing the portfolio losses.

In this study, we selected six data sets of stock with each set consisting of three public-listed companies chosen randomly from the main market of Bursa Malaysia, ranging from 2nd January 2020 to 18th August 2021 (during COVID-19 pandemic) consisting of 400 trading days. This paper aimed to improve the performance of the three-parameters Dirichlet universal portfolio by varying and finding the optimum values of the parametric vectors $(\alpha_1, \alpha_2, \alpha_3)$. The sectors we are interested to investigate in this study encompass the healthcare, finance, and plantation sector. Furthermore, under each six main data sets, there are a permutation arrangement in the position of the company stocks, in which each data sets of stock consists of an addition six subsets. For an illustration, in set A which includes the stocks from healthcare sector such as Top Glove, Hartalega and Supermax, there are another six subsets generated from the permutation arrangement, namely from Set A1 to Set A6 which were demonstrated more precisely under Table 1. In this case, by using the modified algorithms proposed by Chan [7], we apply the Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ universal portfolio, which is also known as the three-parameters Dirichlet universal portfolio, to evaluate the portfolio vector as well as investment capital during the volatile period of COVID-19 by selecting the publicly available capital value data. In addition, this study also has a motivation to examine whether there is a significant effect on the investment wealth obtained when the position of the company stocks within the data sets are permuted.

2. Material and Methodology

2.1. Data

This study extracted the daily stock price data of the period from 2nd January 2020 to 18th August 2021 (during-pandemic period) consisting of 400 trading days. The daily closing stock prices were collected from Yahoo Finance. This study employed the daily data from the three particular sectors which are healthcare, finance and plantation. Under each industry, three companies are being randomly chosen from the main market of Bursa Malaysia, thus nine company stocks are involved in this study. Table 1 shows the six main data sets and each consisting of three company stocks, which is denoted from Set A to Set F. It is clearly to examine that sets A, B and C are the company stocks involved belong to their own sectors, that is, the combinations of the company stocks are within their own sectors. To illustrate, set A consists of the stocks from the healthcare sector, set B has the stocks from the finance sector, and set C has the stocks from the plantation sector. On the other hand, for sets D, E, and F, the company stocks involved come from inter-industry. In other words, the combinations of company stocks are randomly assigned across the healthcare, finance, and plantation sectors. For example, in set D, it encompasses stocks from the healthcare sector (Top Glove), the finance sector (Maybank), and the plantation sector (IOI). Owing to fulfill one of the objectives of this study, we also interested in determining whether the permutation arrangement of the position of the company stocks within each data sets will affect the investment wealth obtained at the end of 400th day by using three-parameters Dirichlet universal portfolio, therefore, another 36 subsets are proposed in this study. A clearer picture of the proposed data sets had listed in Table 2.1.

Table 1. List of Companies in the Main Data Sets A, B, C, D, E and F

Sets	Company Stocks	Subsets	Arrangement of the Position of the Company Stocks	
Set A (Healthcare)	Top Glove Hartalega Supermax	Set A1	(Top Glove, Hartalega, Supermax)	
		Set A2	(Top Glove, Supermax, Hartalega)	
		Set A3	(Hartalega, Top Glove, Supermax)	
		Set A4	(Hartalega, Supermax, Top Glove)	
		Set A5	(Supermax, Top Glove, Hartalega)	
		Set A6	(Supermax, Hartalega, Top Glove)	
Set B (Finance)	Maybank Public Bank CIMB	Set B1	(Maybank, Public Bank, CIMB)	
		Set B2	(Maybank, CIMB, Public Bank)	
		Set B3	(Public Bank, Maybank, CIMB)	
		Set B4	(Public Bank, CIMB, Maybank)	
		Set B5	(CIMB, Maybank, Public Bank)	Homogeneous Sets
		Set B6	(CIMB, Public Bank, Maybank)	
Set C (Plantation)	Sime Darby IOI KLK	Set C1	(Sime Darby, IOI, KLK)	
		Set C2	(Sime Darby, KLK, IOI)	
		Set C3	(IOI, Sime Darby, KLK)	
		Set C4	(IOI, KLK, Sime Darby)	
		Set C5	(KLK, Sime Darby, IOI)	
		Set C6	(KLK, IOI, Sime Darby)	
Set D (Mixed)	Top Glove Maybank IOI	Set D1	(Top Glove, Maybank, IOI)	
		Set D2	(Top Glove, IOI, Maybank)	
		Set D3	(Maybank, Top Glove, IOI)	
		Set D4	(Maybank, IOI, Top Glove)	

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Sets	Company Stocks	Subsets	Arrangement of the Position of the Company Stocks	
		Set D5	(IOI, Top Glove, Maybank)	
		Set D6	(IOI, Maybank, Top Glove)	
Set E (Mixed)	Hartalega Public Bank Sime Darby	Set E1	(Hartalega, Public Bank, Sime Darby)	Heterogeneous Sets
		Set E2	(Hartalega, Sime Darby, Public Bank)	
		Set E3	(Public Bank, Hartalega, Sime Darby)	
		Set E4	(Public Bank, Sime Darby, Hartalega)	
		Set E5	(Sime Darby, Hartalega, Public Bank)	
		Set E6	(Sime Darby, Public Bank, Hartalega)	
Set F (Mixed)	Supermax CIMB KLK	Set F1	(Supermax, CIMB, KLK)	
		Set F2	(Supermax, KLK, CIMB)	
		Set F3	(CIMB, Supermax, KLK)	
		Set F4	(CIMB, KLK, Supermax)	
		Set F5	(KLK, Supermax, CIMB)	
		Set F6	(KLK, CIMB, Supermax)	

2.2. General Algorithms

a. Consider the market for m stocks. The price relative ratio of a stock is the ratio of the closing price at the end of the n trading day to the closing price at the end of the $(n-1)$ trading day. That is,

$$x = \frac{Closing\ Price\ of\ ith\ stock\ at\ nth\ trading\ day}{Closing\ Price\ of\ ith\ stock\ at\ (n-1)th\ trading\ day} \tag{1}$$

b. **b** is a portfolio vector where $b = (b_1, b_2, \dots, b_m)$ where $b_i \geq 0, i = 2,3, \dots m$ and $\sum_{i=1}^{m} b_i = 1$ .The component b_i indicates the proportion of the current wealth invested in the ith stock for $i = 1,2,3, \dots m$. The simplex B_m is the set of all portfolio vectors **b.**

$$B_m = \{b = (b_1, b_2, \dots, b_m): b_i \geq 0\ for\ \textstyle\sum_{i=1}^{m} b_i = 1 \tag{2}$$

Note: The specific portfolio vector is $b = (b_1, b_2, b_3)$. The component b_i for $i = 1, 2, 3$ particularly indicates the proportion of current wealth we invested in healthcare, finance, and plantation stocks respectively.

c. The Dirichlet $(\alpha_1, \alpha_2, \dots, \alpha_m)$ universal portfolio is a universal portfolio where the sequence of the portfolio vectors $\{\hat{b}_k\}$ is said to be a μ-weighted universal portfolio.

d. Since the portfolio vector $\hat{b}_k$ depends on the past price relative vectors $x_1, x_2, \dots, x_{k-1}$, therefore the universal capital $\hat{S}_n(x^n)$ achieved at the end of the n trading day is the following.

$$\hat{S}_n(X^n) = \textstyle\prod_{k=1}^{n} \hat{b}_n^t X_k \tag{3}$$

where x^n is the sequence of price relative vectors $(x_1, x_2, \dots, x_n)$ and the initial investment capital S_0 is assumed to be 1 unit.

2.3. Modified Algorithms on the 3-stock Universal Portfolio

We described the modified algorithm proposed by Chan (2002) [7] for computing the three-stocks universal portfolio generated by the Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ where $\alpha_i > 0$, for $i = 1,2,3$.

$$d\mu(b) = \frac{\Gamma(a_1 + a_2 + a_3)}{\Gamma(a_1)\Gamma(a_2)\Gamma(a_3)} b_1^{a_1 - 1} b_2^{a_2 - 1} b_3^{a_3 - 1} db_1 db_2 \tag{4}$$

Next, we define three recursive functions $X_n(l_1, l_2)$, $C_n(l_1, l_2)$ and $Q_n(l_1, l_2)$.

a. Firstly, we define $X_n(l_1, l_2)$

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Letting

$$X_n(l_1, l_2) = \sum_{j^n \epsilon T_n(l_1,l_2)} \prod_{i=1}^{n} x_{ij_i} \quad (5)$$

b. Secondly, we define $C_n(l_1, l_2)$
The accrual investment capital of the universal portfolio at time *n* can be redefined as

$$\hat{S}_n = \sum_{l_1=0}^{n} \sum_{l_2=0}^{n-l_1} Q_n(l_1, l_2) \quad (6)$$

c. Thirdly, we define $Q_n(l_1, l_2)$

$$Q_n(l_1, l_2) = X_n(l_1, l_2) C_n(l_1, l_2) \quad (7)$$

d. The universal portfolio $\{\hat{b}_n\}$ can be computed as follow:

$$\hat{b}_n = \frac{1}{\sum_{l_1=0}^{n} \sum_{l_2=0}^{n-l_1-1} Q_{n-1}(l_1,l_2)} \begin{bmatrix} \sum_{l_1=0}^{n} \sum_{l_2=0}^{n-l_1-1} \frac{(l_1+a_1)}{(n+a_1+a_2+a_3-1)} Q_{n-1}(l_1, l_2) \\ \sum_{l_1=0}^{n-1} \sum_{l_2=0}^{n-l_1-1} \frac{(l_2+a_2)}{(n+a_1+a_2+a_3-1)} Q_{n-1}(l_1, l_2) \\ \sum_{l_1=0}^{n-1} \sum_{l_2=0}^{n-l_1-1} \frac{(n-l_1-l_2+a_3-1)}{(n+a_1+a_2+a_3-1)} Q_{n-1}(l_1, l_2) \end{bmatrix} \quad (8)$$

e. The universal capital $\{\hat{S}_n\}$ can be computed as follow:

$$\hat{S}_n = \sum_{l_1=0}^{n} \sum_{l_2=0}^{n-l_1} Q_n(l_1, l_2) \quad (9)$$

Next, we give the recursive relationships of the functions $X_n(l_1, l_2)$, $C_n(l_1, l_2)$, $Q_n(l_1, l_2)$ and their end-point conditions. The recursive function of $X_n(l_1, l_2)$ is provided as follows:

for $1 \leq l_1 \leq n-1$ and $1 \leq l_2 \leq n - l_1 - 1$,

$$X_n(l_1, l_2) = x_{n1} X_{n-1}(l_1 - 1, l_2) + x_{n2} X_{n-1}(l_1, l_2 - 1) + x_{n3} X_{n-1}(l_1, l_2) \quad (10)$$

The recursive function of $X_n(l_1, l_2)$ with the endpoint conditions are provided as follows:

When $l_1 = 0$,

$$X_n(0, l_2) = x_{n2} X_{n-1}(0, l_2 - 1) + x_{n3} X_{n-1}(0, l_2) \quad (11)$$

When $l_2 = 0$,

$$X_n(l_1, 0) = x_{n1} X_{n-1}(l_1, 0) + x_{n3} X_{n-1}(l_2, 0) \quad (12)$$

The recursive function of $C_n(l_1, l_2)$ is provided as follows:

a. for $1 \leq l_1 \leq n$ and $0 \leq l_2 \leq n - l_1$

$$C_n(l_1, l_2) = \frac{l_2+a_2-1}{n+a_1+a_2+a_3-1} C_{n-1}(l_1, l_2 - 1) \quad (13)$$

b. for $0 \leq l_1 \leq n-1$ and $0 \leq l_2 \leq n - l_1 - 1$.

$$C_n(l_1, l_2) = \frac{l_2+a_2-1}{n+a_1+a_2+a_3-1} C_{n-1}(l_1, l_2 - 1) \quad (14)$$

c. for $0 \leq l_1 \leq n-1$ and $0 \leq l_2 \leq n - l_1 - 1$.

$$C_n(l_1, l_2) = \frac{n-l_1-l_2+a_3-1}{n+a_1+a_2+a_3-1} C_{n-1}(l_1, l_2) \quad (15)$$

The initial condition is as follows:

$$C_0(0,0) = \int d\mu(b) = 1 \quad (16)$$

The recursive function of $Q_n(l_1, l_2)$ is provided as follows:

a. for $0 \leq l_1 \leq n-1$ and $0 \leq l_2 \leq n - l_1 - 1$.

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$$Q_n(l_1, l_2) = x_{n1}\frac{(l_1+a_1-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(l_1-1, l_2) + x_{n2}\frac{(l_2+a_2-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(l_1, l_2-1) + x_{n3}\frac{(n-l_1-l_2+a_3-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(l_1, l_2) \quad (17)$$

The recursive function of $Q_n(l_1, l_2)$ with the endpoint conditions are provided as follows:

a. for $1 \le l_1 \le n-1$ and $1 \le l_2 \le n - l_1 - 1$

$$Q_n(l_1, 0) = x_{n1}\frac{(l_1+a_1-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(l_1-1,0) + x_{n3}\frac{(n-l_1+a_3-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(l_1, 0) \quad (18)$$

b. for $1 \le l_1 \le n-1$,

$$Q_n(0, l_2) = x_{n2}\frac{(l_2+a_1-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(0, l_2-1) + x_{n3}\frac{(n-l_2+a_3-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(0, l_2) \quad (19)$$

c. for $1 \le l_2 \le n - l_1 - 1$.

$$Q_n(l_1, l_2) = x_{n1}\frac{(l_1+a_1-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(l_1-1, l_2) + x_{n2}\frac{(l_2+a_2-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(l_1, l_2-1) \quad (20)$$

d. for $1 \le l_1, 1 \le l_2$ and $l_1 + l_2 = n$.

$$Q_n(n, 0) = x_{n1}\frac{(n+a_1-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(n-1,0) \quad (21)$$

$$Q_n(n, 0) = x_{n2}\frac{(n+a_1-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(0, n-1) \quad (22)$$

$$Q_n(0,0) = x_{n3}\frac{(n+a_3-1)}{(n+a_1+a_2+a_3-1)}Q_{n-1}(0,0) \quad (23)$$

Note: The initial condition is as follows.

$$Q_0(0,0) = \int d\mu(b) = 1 \quad (24)$$

The computation of the universal portfolio vectors $\hat{b}_n$ and the universal capital $\hat{S}_n$, as formulated in (8) and (9) respectively, can be achieved by using the recursive function of $X_n(l_1, l_2)$ and $C_n(l_1, l_2)$ from (10) to (16) or by figuring out the values of $Q_n(l_1, l_2)$ recursively through (17) to (24).

3. Results and Discussion

3.1. Results

This section discusses the results obtained by analyzing the performance of the three-parameters Dirichlet universal portfolio during the COVID-19 pandemic, both within and among the six main data sets. Under each main data sets, it consists of six subsets respectively, thus with a total of 36 subsets. The Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ universal portfolio with a sampling period of 400 trading days from 2nd January 2020 to 18th August 2021 (during the COVID-19 pandemic) are selected. Nine sets of company stock price data, namely Top Glove, Hartalega, Supermax, Maybank, Public Bank, CIMB, Sime Darby, IOI and KLK, are collected from the Yahoo Finance Website. Under this study, we focus on investigating the performance of the three-parameters Dirichlet universal portfolio during the COVID-19 pandemic. Other than that, this study has an initiative to investigate whether the investment wealth obtained at the end of the 400th trading days will be affected by the permutation arrangement of the position of the company stocks within the data set. We used the modified algorithms proposed by Chan (2002) [1] to compute the Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ universal portfolio where $\alpha_j > 0$ for $j = 1,2,3$. We assume the initial capital S_0 to be 1 unit. We compare the performance of the three-parameters Dirichlet universal portfolio by varying the Dirichlet parametric vectors $(\alpha_1, \alpha_2, \alpha_3)$ for every subset of data with an initial $\alpha_0 = (0.1, 0.1, 0.1)$. The wealth obtained at the end of the 400th trading days, S_{400} for each subset with a parametric-varying Dirichlet universal portfolio is listed in Fig. 1 until Fig. 6, respectively.

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3.1.1. Performance of Main Data Set A (Top Glove, Hartalega, Supermax)

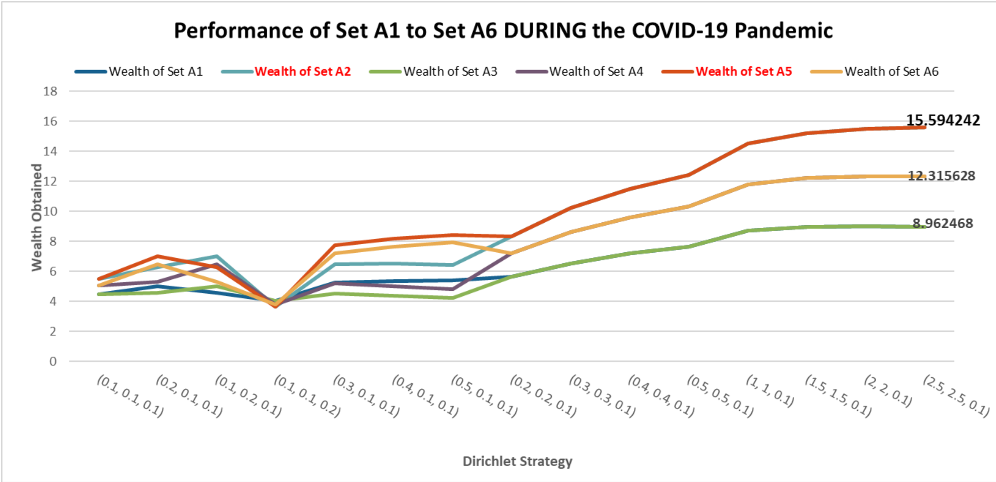

Fig. 1 Performance of Set A1 to Set A6 under various Dirichlet strategies during the COVID-19 pandemic.

The investment returns achieved in Sets A1 to A6 after 400 trading days with 15 universal portfolio strategies generated by Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ distribution based on the stock price data of Top Glove, Hartalega, and Supermax during the volatile period from 2nd January 2020 to 18th August 2021 are demonstrated in Fig. 1. The 15 sets of parametric vectors are being used in the data sets during the COVID-19 pandemic for generating different capital amounts. It is clear to notice that the permutation arrangement of the position of the company stocks within the main data set A will affect the investment wealth obtained at the end of the 400th trading day. For example, under the same Dirichlet (2.5, 2.5, 0.1) universal portfolio strategy, Set A2 and Set A5 achieved the same optimum wealth of 15.594242 units for this period, which was followed by Set A4 and Set A6 with 12.315628 units of wealth, together with Set A1 and Set A3 with a return of 8.962468 units. Performance of **Set A2 and Set A5** during the COVID-19 pandemic surpassed the other four subsets by using the Dirichlet (2.5, 2.5, 0.1) universal portfolio strategy, yielding an optimal universal investment capital of $\boldsymbol{\hat{S}_{400} = 15.59424}$ **units** with portfolio vectors of $\boldsymbol{\hat{b}} = \boldsymbol{(0.455241, 0.502659, 0.042101)}$. Consequently, it is recommended to invest 45.52% in Top Glove, 50.27% in Supermax, but with a little of 4.21% in Hartalega in order to earn a better investment return during the COVID-19 pandemic.

3.1.2. Performance of Main Data Set B (Maybank, Public Bank, CIMB)

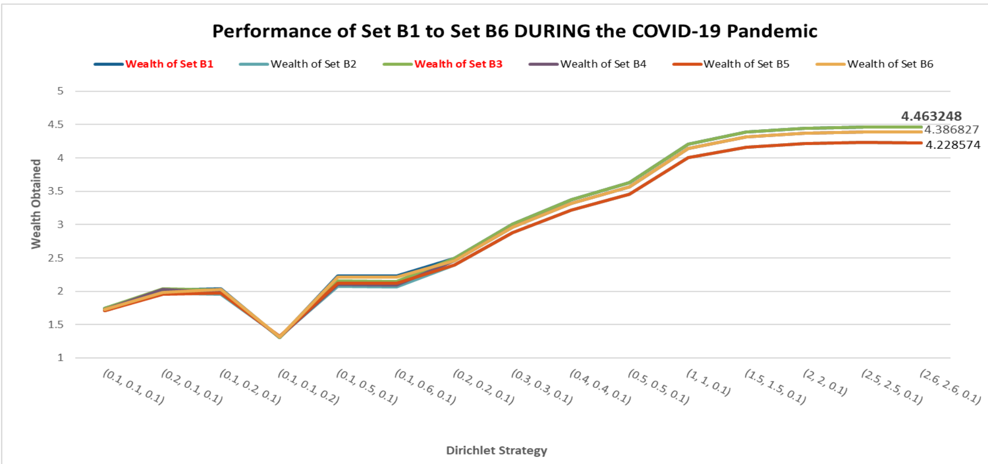

Fig 2. Performance of Set B1 to Set B6 under various Dirichlet strategies during the COVID-19 pandemic.

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The investment returns achieved in Sets B1 to B6 after 400 trading days with 15 universal portfolio strategies generated by Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ distribution based on the stock price data of Maybank, Public Bank and CIMB during the volatile period from 2nd January 2020 to 18th August 2021 are demonstrated in Fig. 2. The 15 sets of parametric vectors are being used in the data sets during the COVID-19 pandemic for generating different capital amounts. It is clear to notice that the permutation arrangement of the position of the company stocks within the main data set B will affect the investment wealth obtained at the end of the 400th trading day. For example, under the same Dirichlet (2.6, 2.6, 0.1) universal portfolio strategy, Set B1 and Set B3 achieved the same optimum wealth of 4.463248 units for this period, which was followed by Set B4 and Set B6 with 4.386827 units of wealth, together with Set B2 and Set B5 with a return of 4.228574 units. Similar to the performance before the COVID-19 pandemic, the performance of **Set B1 and Set B3** during the COVID-19 pandemic surpassed the other four subsets by using the Dirichlet (2.6, 2.6, 0.1) universal portfolio strategy, yielding an optimal universal investment capital of $\widehat{\boldsymbol{S}}_{\mathbf{400}} = \mathbf{4.463248}$ **units** with portfolio vectors of $\widehat{\boldsymbol{b}} = (\mathbf{0.474571}, \mathbf{0.480112}, \mathbf{0.045316})$. Consequently, it is recommended to invest 47.46% in Maybank, 48.01% in Public Bank, but with a little of 4.53% in CIMB in order to earn a better investment return during the COVID-19 pandemic.

3.1.3. Performance of Main Data Set C (Sime Darby, IOI, KLK)

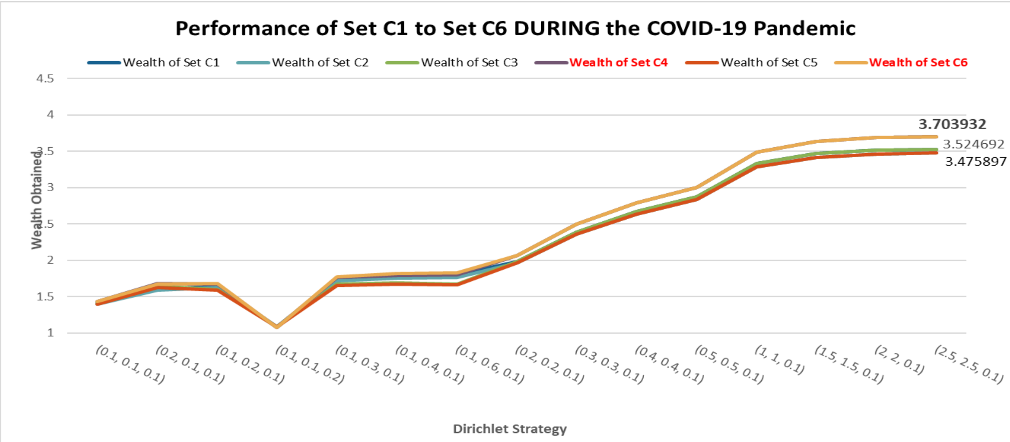

Fig. 3 Performance of Set C1 to Set C6 under various Dirichlet strategies during the COVID-19 pandemic.

The investment returns achieved in Sets C1 to C6 after 400 trading days with 15 universal portfolio strategies generated by Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ distribution based on the stock price data of Sime Darby, IOI and KLK during the volatile period from 2nd January 2020 to 18th August 2021 are demonstrated in Fig. 3. The 15 sets of parametric vectors are being used in the data sets during the COVID-19 pandemic for generating different capital amounts. It is clear to notice that the permutation arrangement of the position of the company stocks within the main data set C will affect the investment wealth obtained at the end of the 400th trading day. For example, under the same Dirichlet (2.5, 2.5, 0.1) universal portfolio strategy, Set C4 and Set C6 achieved the same optimum wealth of 3.703932 units for this period, which was followed by Set C1 and Set C3 with 3.524692 units of wealth, together with Set C2 and Set C5 with a return of 3.475897 units. Similar to the performance before the COVID-19 pandemic, the performance of **Set C4 and Set C6** during the COVID-19 pandemic surpassed the other four subsets by using the Dirichlet (2.5, 2.5, 0.1) universal portfolio strategy, yielding an optimal universal investment capital of $\widehat{\boldsymbol{S}}_{\mathbf{400}} = \mathbf{3.703932}$ **units** with portfolio vectors of $\widehat{\boldsymbol{b}} = (\mathbf{0.4792}, \mathbf{0.474855}, \mathbf{0.045945})$. Consequently, it is recommended to invest 47.92% in Sime Darby, 47.49% in IOI, but with a little of 4.59% in KLK in order to earn a better investment return during the COVID-19 pandemic.

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3.1.4. Performance of Main Data Set D (Top Glove, Maybank, IOI)

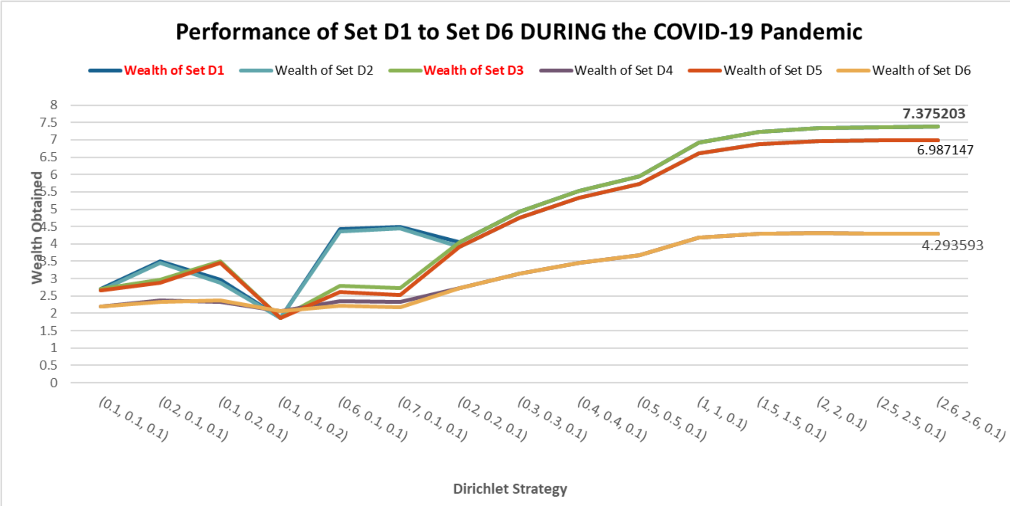

Fig. 4 Performance of Set D1 to Set D6 under various Dirichlet strategies during the COVID-19 pandemic.

The investment returns achieved in Sets D1 to D6 after 400 trading days with 15 universal portfolio strategies generated by Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ distribution based on the stock price data of Top Glove, Maybank and IOI during the volatile period from 2nd January 2020 to 18th August 2021 are demonstrated in Fig. 4. The 15 sets of parametric vectors are being used in the data sets during the COVID-19 pandemic for generating different capital amounts. It is clear to notice that the permutation arrangement of the position of the company stocks within the main data set D will affect the investment wealth obtained at the end of the 400th trading day. For example, under the same Dirichlet (2.6, 2.6, 0.1) universal portfolio strategy, Set D1 and Set D3 achieved the same optimum wealth of 7.375203 units for this period, which was followed by Set D2 and Set D5 with 6.987147 units of wealth, together with Set D4 and Set D6 with a return of 4.293593 units. Different from the performance before the COVID-19 pandemic, the performance of **Set D1 and Set D3** during the COVID-19 pandemic surpassed the other four subsets by using the Dirichlet (2.6, 2.6, 0.1) universal portfolio strategy, yielding an optimal universal investment capital of $\hat{\boldsymbol{S}}_{400} = \mathbf{7.375203}$ **units** with portfolio vectors of $\hat{\boldsymbol{b}} = (\mathbf{0.512292}, \mathbf{0.445169}, \mathbf{0.042540})$. Consequently, it is recommended to invest 51.23% in Top Glove, 44.52% in Maybank, but with a little of 4.25% in IOI in order to earn a better investment return during the COVID-19 pandemic.

3.1.5. Performance of Main Data Set E (Hartalega, Public Bank, Sime Darby)

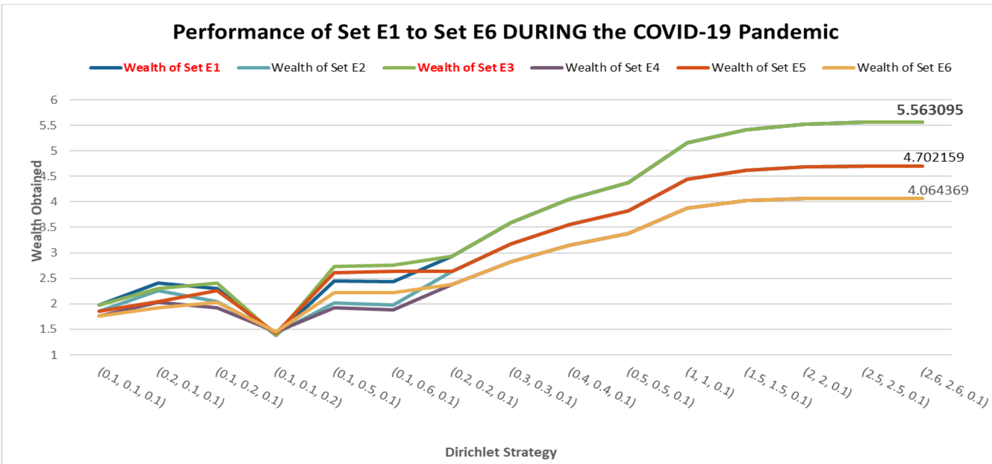

Fig. 5 Performance of Set E1 to Set E6 under various Dirichlet strategies during the COVID-19 pandemic.

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The investment returns achieved in Sets E1 to E6 after 400 trading days with 15 universal portfolio strategies generated by Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ distribution based on the stock price data of Hartalega, Public Bank and Sime Darby during the volatile period from 2nd January 2020 to 18th August 2021 are demonstrated in Fig. 5. The 15 sets of parametric vectors are being used in the data sets during the COVID-19 pandemic for generating different capital amounts. It is clear to notice that the permutation arrangement of the position of the company stocks within the main data set E will affect the investment wealth obtained at the end of the 400th trading day. For example, under the same Dirichlet (2.6, 2.6, 0.1) universal portfolio strategy, Set E1 and Set E3 achieved the same optimum wealth of 5.563095 units for this period, which was followed by Set E2 and Set E5 with 4.702159 units of wealth, together with Set E4 and Set E6 with a return of 4.064369 units. Similar to the performance before the COVID-19 pandemic, the performance of **Set E1 and Set E3** during the COVID-19 pandemic surpassed the other four subsets by using the Dirichlet (2.6, 2.6, 0.1) universal portfolio strategy, yielding an optimal universal investment capital of $\boldsymbol{\hat{S}_{400} = 5.563095}$ **units** with portfolio vectors of $\boldsymbol{\hat{b} = (0.486963, 0.469766, 0.043271)}$. Consequently, it is recommended to invest 48.70% in Hartalega, 46.98% in Public Bank, but with a little of 4.33% in Sime Darby in order to earn a better investment return during the COVID-19 pandemic.

3.1.6. Performance of Main Data Set F (Supermax, CIMB, KLK)

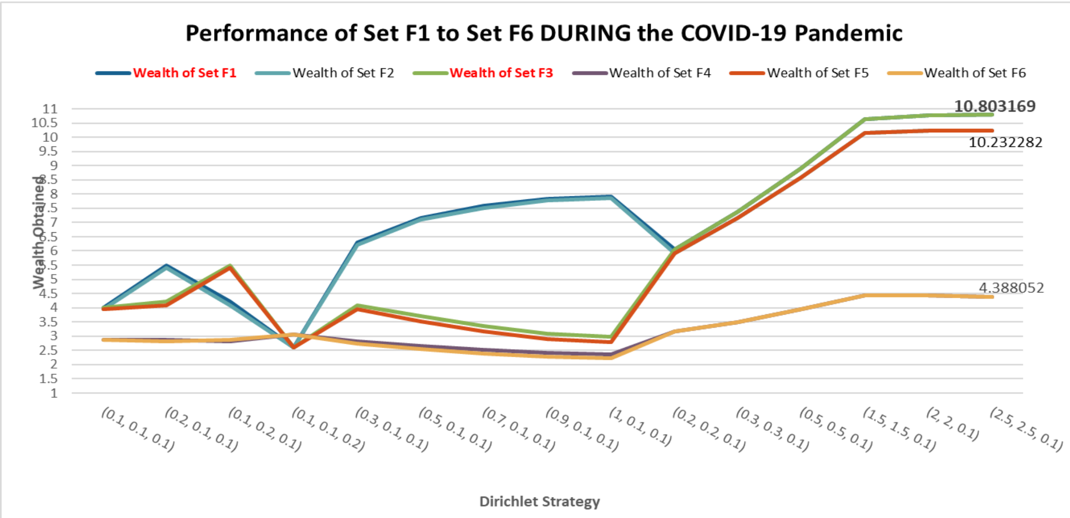

Fig. 6. Performance of Set F1 to Set F6 under various Dirichlet strategies during the COVID-19 pandemic.

The investment returns achieved in Sets F1 to F6 after 400 trading days with 15 universal portfolio strategies generated by Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ distribution based on the stock price data of Supermax, CIMB and KLK during the volatile period from 2nd January 2020 to 18th August 2021 are demonstrated in Fig. 6. The 15 sets of parametric vectors are being used in the data sets during the COVID-19 pandemic for generating different capital amounts. It is clear to notice that the permutation arrangement of the position of the company stocks within the main data set F will affect the investment wealth obtained at the end of the 400th trading day. For example, under the same Dirichlet (2.5, 2.5, 0.1) universal portfolio strategy, Set F1 and Set F3 achieved the same optimum wealth of 10.803169 units for this period, which was followed by Set F2 and Set F5 with 10.232282 units of wealth, together with Set F4 and Set F6 with a return of 4.388052 units. Unlike the performance before the COVID-19 pandemic, the performance of **Set F1 and Set F3** during the COVID-19 pandemic surpassed the other four subsets by using the Dirichlet (2.5, 2.5, 0.1) universal portfolio strategy, yielding an optimal universal investment capital of $\boldsymbol{\hat{S}_{400} = 10.803169}$ **units** with portfolio vectors of $\boldsymbol{\hat{b} = (0.538097, 0.42048, 0.041423)}$. Consequently, it is recommended to invest 53.81% in Supermax, 42.05% in CIMB, but with a little of 4.14% in KLK in order to earn a better investment return during the COVID-19 pandemic.

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4. Conclusion

Table 2. The Outperforming $\hat{S}_{400}$ Obtained for Main Data Sets A, B, C, D, E, and F During the COVID-19 Pandemic

Homogeneous Sets	**Main Data Set A**	**Set A2 and Set A5**	**15.594242**
	Main Data Set B	Set B1 and Set B3	4.46325
	Main Data Set C	Set C4 and Set C6	3.703932
Heterogeneous Sets	Main Data Set D	Set D1 and Set D3	7.375203
	Main Data Set E	Set E1 and Set E3	5.563095
	Main Data Set F	Set F1 and Set F3	10.803169

During the **pandemic period**, as demonstrated in Table 2, **subsets A2 and A5,** under the main data set A, has better performance in yielding **15.594242 units** of wealth via the Dirichlet (2.5, 2.5, 0.1) strategy. This is because the COVID-19 pandemic has had an extremely good effect on the healthcare sector, resulting in the return of main data set A, which all stocks come from the healthcare sector, having a significant increase of **155%** recorded under Table 2. To sum up, the three-parameters Dirichlet universal portfolio outperforms during the volatile period rather than during the non-volatile period. Although there are a lot of fluctuations and uncertainties in the Malaysian stock market, investors will still be able to generate profit from the financial market as well as prevent substantial financial losses by utilizing the Dirichlet $(\alpha_1, \alpha_2, \alpha_3)$ universal portfolio.

So far, the research of the parameter-varying Dirichlet universal portfolio has been limited to the three company stocks of Malaysia. Therefore, it is recommended to extend the Dirichlet (α_1, α_2, α_3) universal portfolio to include even more parameter values. In other words, increase the three company stocks involved in this study to four or five company stocks of Malaysia, resulting in forming the Dirichlet $(\alpha_1, \alpha_2, \alpha_3, \alpha_4)$ universal portfolio and Dirichlet $(\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5)$ universal portfolio, respectively. Since we focus on the Malaysian stock market in this study, it is also recommended to investigate the performance of the three-parameters Dirichlet universal portfolio before and during the COVID-19 pandemic in other foreign countries as well. For example, it is important and critical to analyse the wealth obtained by investors when the Dirichlet universal portfolio is used in the European stock market such as the United States.

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