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FORMATION OF AN OPTIMAL PORTFOLIO OF LQ45 SHARES USING MARKOWITZ METHOD

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Abstract
Currently, there are still many investors who do not realize that stock management strategies are important. Therefore, as a practitioner, through this research, it is hoped that authors can help overcome this problem so that it can calculate maximum profits in-stock selection. This research aims at understanding stock management strategies by forming a Markowitz portfolio with the help of the K-Means grouping method. The population in this research included stock companies listed on the Indonesian Stock Exchange. The sample selection method used was the targeted sampling method. The sample data used was daily stock returns from LQ45 stock companies. The research results showed that based on data processing, stock grouping using the k-Means method and the Markowitz method was proven to produce maximum profits and low risk. Therefore, the method used in this research can be useful in the world of finance, especially to help investors.

INTRODUCTION

Investment is an agreement on a certain amount of funds or other resources made at this time, to obtain a certain amount of profit in the future. Everyone is faced with various choices in determining the proportion of funds or resources they have for current and future consumption. The term investment can relate to various activities of investing a certain amount of funds in real assets (land, gold, machinery or buildings) or financial assets (shares, deposits or bonds) which are investment activities that are commonly carried out (Tandelilin, 2010). One type of investment that can be made is investment in financial assets, including shares. Investing in shares requires the ability to manage assets effectively. Management of these assets is very important for investors who want to generate positive profits while minimizing risk. Because share price conditions are very fluctuating and cannot be predicted with certainty, asset management must be carried out. One of the things that investors can consider when determining their investment decisions is the financial position of each investor. Due to this information imbalance, it was very difficult for investors to be able to objectively differentiate groups between good-quality companies (Seong K & Jong Min, 2017) and poor-quality companies (Priyo et

al., 2023). Asset management in shares is the main focus for every investor who invests their shares in the stock market. Management of stock assets is influenced by making decisions based on a person's perception. So it will happen that each investor's choice will always be different from another investor's. Because each investor's perception will be different, this will cause problems in managing assets, especially for novice investors. Therefore, to overcome this, there is a method that can help investors in determining stock selection, namely the K-Means clustering method.

Asset management in shares is the main focus for every investor who invests their shares in the stock market. Management of stock assets is influenced by decision-making based on a person's perception. So it will happen that each investor's choice will always be different from other investor's. This will cause problems in managing share assets, especially for novice investors. Apart from that, because share companies in the capital market continue to grow and become more numerous, it will become increasingly difficult for investors to choose shares. So the more experienced investors are in selecting stock companies, the greater the chances of profit they will get. Experience in selecting a company was closely related to the intellectual capital of an investor. According to Putra et al., (2019) Intellectual capital was an intangible asset that played an important role in increasing competitiveness and can be used effectively to increase profits.

Intellectual capital, which means that knowledge is required. One of the sciences that can be used to help investors analyze the right choice of stock companies is statistics. In statistics, some methods function to process large amounts of data into data groupings. This method can group data to make it simpler and easier to understand. This method was called the AS method, Nourahmadi & Sadeqi (2023) explained that one of the most important investment problems faced by investors was choosing an optimal investment portfolio and balancing risk and profit to maximize investment returns and minimise investment risk. Therefore, to overcome this, there was a method that can help investors in managing assets, specifically in determining stock selection, namely the K-Means clustering method.

Clustering analysis is a multivariate technique whose main goal is to classify objects based on their characteristics. The K-means method is a method for searching and grouping data that has almost the same characteristics between one data and another. The K-means method is a method that can help classify stock companies based on the desired stock return data characteristics and minimum risk. Apart from that, the K-means method can also help investors diversify by forming a stock portfolio. Because the more diverse stock companies are included in the portfolio, the smaller the risk the investor accepts. The advantage of the K-Means algorithm is that it can determine groups of data flexibly according to user needs. Therefore, according to research of Bhoomi et al., (2013), the advantages of the K-means method were: (1) In implementing problem-solving, the K-Means algorithm was very simple and flexible. This meant that the computational calculations were not too complicated and this algorithm could be implemented in all fields. (2) The K-Means algorithm was very easy to understand, especially in implementing very large data and could reduce the complexity of the data it had.

In the process, apart from grouping shares using k means clustering, determining stock selection was also assisted by forming a stock portfolio so that profits were maximized and risks were minimized. Through the process of forming an optimal portfolio, the level of profit (return) and risk of each portfolio would be reviewed. Portfolio optimization had become a popular approach for investors, with the mean-variance (MV) model proposed by Harry (2011) being a successful example. Although there had been progress in portfolio optimization (Wang & Aste, 2023), the application of machine learning models can further improve performance. By leveraging predictive models to select assets and predict returns during the optimization process, investors can improve portfolio performance. Incorporating advanced methods offered the opportunity to achieve effective financial asset management.

Harry (2011) introduced a saying in the investment sector, namely "Don't put your eggs in one basket" because if the basket falls all the eggs in it will break. Likewise, don't invest all your funds in just one stock, because if that stock experiences a loss then all the funds invested will also experience a loss. This adage became the basis for the formation of Markowitz's portfolio theory which has developed to this day. It is proven from research conducted by Juniar et al., (2020) using the Markowitz method in forming an optimal portfolio of Sharia-based shares that the Markowitz method can reduce the risk accepted by investors. Based on all the explanations above, it can be seen that the aim of this research, especially in the fields of finance and accounting, is to assist investors in analyzing all selected stock companies so that they can classify shares using the K-Means method, then proceed by calculating the optimal weight of each selected share through K-means grouping. This means forming a portfolio using the Markowitz method. So that later the opportunity for investors to gain greater profits by considering the risks.

METHODS

The research design used in this research was descriptive. The aim was at finding out which stocks were eligible to be included in determining the optimal portfolio using the Markowitz method in the period January 2, 2020, to January 27, 2022. Because the period 2020 to 2022 was the highest market capitalization level achieved by the JCI, IDX (2022). The data source used was secondary data taken from www.investing.com

The population used in this research was stock companies listed on the Indonesian Stock Exchange (IDX) stock market. Therefore the selected sample was the stock that was incorporated in the LQ45 stock. Because LQ45 shares had high liquidity and large market capitalization and were supported by good company fundamentals (IDX, 2022). Then, the sample used a purposive sampling technique by eliminating stock companies that were members of the LQ45 stock which produced a negative expected return value.

Table 1. Stock List Lq45

1.	Ace Hardware Indonesia Tbk. (ACES)
2.	Adaro Energy Tbk. (ADRO)
3.	AKR Corporindo Tbk. (AKRA)
4.	Aneka Tambang (Persero) Tbk. (ANTM)
5.	Astra Internasional Tbk. (ASII)
6.	Bank Central Asia Tbk. (BBCA)
7.	Bank Negara Indonesia (Persero) Tbk. (BBNI)
8.	Bank Rakyat Indonesia (Persero) Tbk. (BBRI)
9.	Bank Tabungan Negara (Persero) Tbk. (BTN)
10.	Bank Mandiri (Persero) Tbk. (BMRI)
11.	Bumi Serpong Damai Tbk. (BSDE)
12.	Bank Tabungan Pensiunan Syariah Tbk. (BTPS)
13.	Charoen Pokphand Indonesia Tbk. (CPIN)
14.	Ciputra Development Tbk. (CTRA)
15.	Erajaya Swasembada Tbk. (ERAA)
16.	XL Axiata Tbk. (EXCL)
17.	Gudang Garam Tbk. (GGRM)
18.	H. M. Sampoerna Tbk. (HMSP)
19.	Indofood CBP Sukses Makmur Tbk. (ICBP)
20.	Vale Indonesia Tbk. (INCO)
21.	Indofood Sukses Makmur Tbk. (INDF)
22.	Indah Kiat Pulp & Paper Tbk. (INKP)
23.	Indocement Tunggal Prakarsa Tbk. (INTP)
24.	Indo Tambangraya Megah Tbk. (ITMG)
25.	JAPFA Comfeed Indonesia Tbk. (JPFA)
26.	Jasa Marga (Persero) (JSMR)
27.	Kalbe Farma Tbk. (KLBF)
28.	Merdeka Copper Gold Tbk. (MDKA)
29.	Mitra Keluarga Karyasehat Tbk. (MIKA)
30.	Media Nusantara Citra Tbk. (MNCN)
31.	Perusahaan Gas Negara (Persero) Tbk. (PGAS)
32.	Tambang Batubara Bukit Asam Tbk. (PTBA)
33.	PP (Persero) Tbk. (PTPP)
34.	Pakuwon Jati Tbk. (PWON)
35.	Surya Cipta Media Tbk. (SCMA)
36.	Semen Indonesia (Persero) Tbk. (SMGR)
37.	Summercon Agung Tbk. (SMRA)
38.	Sri Rejeki Isman Tbk. (SRIL)
39.	Tower Bersama Infrastructure Tbk. (TBIG)
40.	Pabrik Kertas Tjiwi Kimia Tbk. (TKIM)
41.	Telekomunikasi Indonesia (Persero) Tbk. (TLKM)
42.	Sarana Menara Nusantara Tbk. (TOWR)
43.	United Tractors Tbk. (UNTR)
44.	Unilever Indonesia Tbk. (UNVR)
45.	Wijaya Karya Tbk. (WIKA)

Source: data processed from www.Investing.com

The Data used in this research was in the form of closing prices of shares listed in lq45 Stock Company members totalling 45 shares with each daily closing price data of 508 shares. Then, because the need for data in this research was stock return data, a calculation was made to obtain the daily stock return value.

Table 2.The Expected Return Calculation Results, The Mean-Variance of LQ45 Shares

NO.	Stock Name	Expected Return	Mean-Variance
1.	ACE	0.0000471	0.000694
2.	ADRO	0.001787825	0.001041086
3.	AKRA	0.000418663	0.00091345
4.	ANTM	0.002265427	0.00162
5.	BBCA	0.000564365	0.000383
6.	BBNI	0.000302638	0.000765227
7.	BBRI	0.000340307	0.000718
8.	BMRI	0.000460059	0.000699251
9.	BTPS	0.000308319	0.001411663
10.	CPIN	0.000428222	0.00083106
11.	CTRA	0.00029748	0.00120
12.	ERAA	0.001399257	0.00120
13.	EXCL	0.000485973	0.000970
14.	INCO	0.001091174	0.001100236
15.	INKP	0.000697377	0.00143376
16.	ITMG	0.002140162	0.000986552
17.	JPFA	0.000737081	0.00104
18.	KLBF	0.000467671	0.000623
19.	MDKA	0.002932824	0.001070
20.	MIKA	0.000149451	0.000773
21.	PTBA	0.000973543	0.000889309
22.	SCMA	0.000640263	0.00123
23.	TBIG	0.002272105	0.00109
24.	TKIM	0.0000378	0.001665361
25.	TLKM	0.000620939	0.000513334
26.	TOWR	0.000879291	0.000569
27.	UNTR	0.000733924	0.000828678
28.	ASII	-4.60E-06	6.46E-04
29.	BBTN	-9.94E-05	1.05E-03
30.	BSDE	-0.00019	0.00105
31.	GGRM	-0.00067	0.000603
32.	HMSP	-0.00099	0.000609
33.	ICBP	-0.00021	0.000373
34.	INDF	-1.28E-05	4.93E-04
35.	INTP	-0.00035	0.000983
36.	JSMR	-0.00052	0.000792
37.	MNCN	-0.00081	1.29794E-09
38.	PGAS	-0.00018	0.001136
39.	PTPP	-0.00036	0.00139
40.	PWON	-0.0001	0.000994
41.	SMGR	-0.00064	0.000981
42.	SMRA	-0.00019	0.001306
43.	SRIL	-0.00077	0.000705
44.	UNVR	-0.0011	0.000526
45.	WIKA	-0.00057	0.001445

Source: Processed data

Variables used in this research were response variables. Response variables were 45 kinds of return data derived from the daily stock price index with its scale ratio. The data structure in this research was presented in Table 3 where the notation J indicated the period to – J, while Ri was the daily stock return Banking time to-J and MV was the mean-variance of the stock.

Table 3. Research Data Structure

Stock to - i	Period to - j						E(Ri)	MVi
	1	2	3	4	...	m		
1	R11	R12	R13	R14	...	R1m	E(R1m)	MV1m
2	R21	R22	R23	R24	...	R2m	E(R2m)	MV2m
3	R31	R32	R33	R34	...	R3m	E(R3m)	MV3m
...	...	...	...	...	...	...	...	....
n	Rn1	Rn2	Rn3	Rn4	...	Rnm	E(Rnm)	MVnm

Source: processed data

The analysis steps were divided into 2 stages. Phase I explained related lq45 stock grouping using K-means. Then Phase II explained how to get the weight of each selected stock in the formation of a stock portfolio with the Markowitz method. Henceforth, the steps in this research were as phase I was grouping stocks using K-Means : (1) Find the expected return value and mean-variance of each stock incorporated into LQ 45 shares, (2) Choosing a positive expected return value of stocks so that the optimal stock portfolio formation strategy can be achieved, (3) Select the number of K groups to be formed, (4) Determination of the centre of the initial K Group. Can be done using random, (5) Perform the calculation of the distance of each data expected return and mean-variance shares with the centre of the initial group using Euclidian distance, (6) Place each stock's expected return and mean-variance data to the nearest starting group Center, (7) Perform an iteration to renew the group Center based, (8) Repeat steps 5 through Step 7 until none of the group members had moved and the group centre value had not changed, (9) After obtaining the optimal value of K, the calculation of the distance between intra-group objects, (10) Calculated the inter-group distance between one group member and another group member, (11) Then to obtain the value of the Silhouette Coefficient, first calculated the Silhouette Score, Finally, after getting the value Silhouette Score, calculated the value Silhouette Coefficient.

Phase II was the formation of an investment portfolio Markowitz method : (1) Calculated stock covariance to determine the relationship between two stocks used to diversify, (2) Calculated the optimal stock weight, (3) Calculated the expected return and risk of a stock portfolio with the weight of each stock for each stock. The expected return of the portfolio was the maximum profit and the minimum portfolio risk.

RESULTS

The research that had been carried out showed that by grouping K-Means and forming a portfolio using the Markowitz method, it was possible to obtain a greater expected return portfolio than the method of forming a portfolio with the same stock weight in each selected stock and being able to consider the risks involved. Therefore, this research emphasized the importance of portfolio formation analysis using K-Means and Markowitz in determining the amount of stock weight in selected stocks into the portfolio composition owned by investors.

The findings from the results of this research supported previous research such as (Faizal et al., 2020), (Aminda, 2019) and (Simorangkir, 2021) which proved that the use of the K-Means and Markowitz methods can produce greater portfolio returns compared to other methods.

Then related to the analysis steps carried out in this research were as follows: Optimal Weighting Results Of Markowitz Portfolios. In this section, the calculation of the daily stock return of each stock incorporated in the lq45 stock was carried out. Using the formula in equation 2, for example, calculated the daily stock return of BBNI shares. Known stock closing price S1 = 7,353 and S2 = 7,377. Then get the return result as follows:

$$R_1 = \frac{S_2 - S_1}{S_1}$$

$$R_1 = \frac{7.377 - 7.353}{7.353} = 0{,}0032$$

Based on the stock return calculation data above, the calculation of expected return and mean-variance for BBNI shares was as follows:

Stock Expected Return of BBNI :

$$\mu_1 = E(R) = \frac{\sum_{i=1}^{508} R_i}{508}$$

$$\mu_1 = \frac{0{,}1535}{508} = 0{,}000302$$

Stock Mean-variance of BBNI :

$$\mu_1 = E(R) = \frac{\sum_{i=1}^{508} (R_i - \mu_1)^2}{508}$$

$$\sigma^2_1 = \frac{0{,}000765}{508} \; 0.000765227$$

In this section, stock grouping was explained by using the K-Means algorithm and Silhouette Coefficient calculation. The k-means algorithm that was carried out was referred to in sub-chapter 2.6 using data that can be seen in the appendix, and assisted by R program programming. Then after the calculation related to the required attributes, especially on the ECX expected return attribute, stocks that had a positive expected return were selected. So, the 45 shares that are merged into LQ 45 shares, had a positive expected return of 27 shares. The k-means algorithm began by determining k as the number of groups formed. Furthermore, with the help of the R Program, the results of grouping with K-Means validated using the Silhouette Coefficient are found in Figure 1 below :

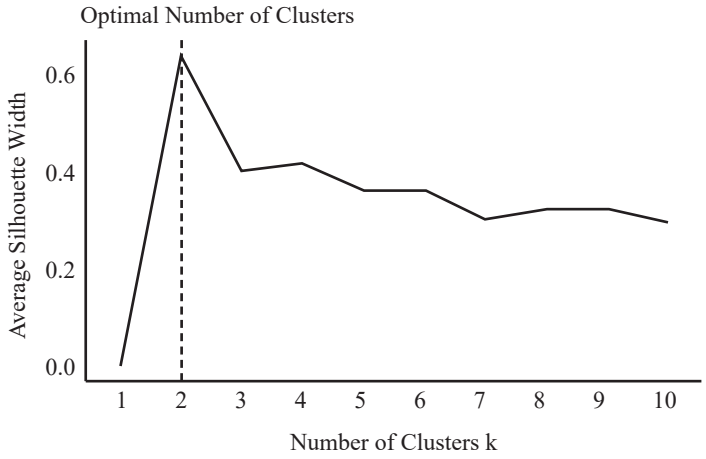

Figure 1. K - means Optimal with the Silhouette coefficient

Figure 1 presented the most optimal K-Means formed in this research were 2 groups with an average value of Silhouette Coefficient above 0.6. But because what was needed at the next stage was the formation of a portfolio with the Markowitz method that required a combination of stocks more than 2 groups of stocks, then the selected is the average value of the nearest silhouette Coefficient of 2 groups of 4 groups. Figure 1 showed that 4 groups had a Silhouette Coefficient of 0.4 and the average value of the second largest Silhouette Coefficient of the various groups formed.

Table 4. Results of clustering with K-Means

Group	Members of Group	Numbers of Member
1	BTPS,CTRA,INCO,INKP,JPFA,SCMATKIM	7
2	PTBA,AKRA,EXCL,BMRI,CPIN,UNTR,BBCA,KLBF,TLKM, TOWR,BBRI	11
3	ACE, BBNI, MIKA	3
4	ANTM,ERAA,ADRO,ITMG,MDKA,TBIG	6

Source: Processed Data

Furthermore, this section discussed the selection of stocks based on the results of the K-Means grouping and the formation of an investment portfolio with the Markowitz method. The stock selection criteria used were stocks that had the largest expected positive return from each group. Based on the results of the K-Means grouping in Table 4, the stocks that met the selection criteria for the formation of an investment portfolio can be seen in Table 2.

Table 2 explained as many as 4 selected stocks where these stocks had the largest expected positive return among other stocks in the group. Next was to calculate the stock covariance of 4 selected stocks. Covariance between stocks based on k-means grouping can be found for example INCO shares with BBNI shares as follows:

$$\sigma_{Rj,Rk} = \sum_{i=1}^{n} \frac{[R_{ji}\text{-}E(R).(R_{ki}\text{-}E(R_k))]}{m}$$

$$\sigma_{INCO,BBNI} = \frac{[0{,}5534 \text{ X } 0{,}1532]}{508} \; 0.000167$$

The calculation of covariance of other stocks can be calculated according to the example above. The following were the results of the covariance matrix between the selected stocks :

$$\sigma_{Rj,Rk} = \begin{bmatrix} 0{,}000985197 & 0{,}000537851 & 0{,}000166918 & 0{,}001619856 \\ 0{,}000537851 & 0{,}000943055 & 0{,}000148935 & 0{,}001445339 \\ 0{,}000166918 & 0{,}000148935 & 0{,}000918547 & 0{,}000448551 \\ 0{,}001619856 & 0{,}001445339 & 0{,}000448551 & 0{,}000979511 \end{bmatrix}$$

The largest covariance value was found in INCO shares with MDKA at 0.001619856, while the smallest covariance was found between PTBA shares and BBNI at 0.000148935. Furthermore, the covariance value that was formed, can be used to find the optimal stock weight using the formula in equation 11, as follows:

$$w_i = \frac{\sum_{b=1}^{n}(\sum_{c=1}^{n}\sigma_{bc})}{\sum_{i=1}\sigma_{Ri}^{n}}$$

$$w_{INCO} = \frac{0{,}00331}{0{,}012561} = 0{,}263495498$$

The next step was the formation of an investment portfolio carried out by an optimization process based on the Markowitz model which aims at providing a certain level of profit at minimum risk with the help of Microsoft Excel to obtain the optimal weight of each stock by calculating the expected return and portfolio standard deviation as in equations 12 and 13 :

Portfolio Expected return :

$$E(R_p) = \sum_{i=1}^{n}(w_i \,.\, E(R))$$

$E(R_p)$ = (0,263495498×0,001091174+0,244815553×0,000973543 +0,133980036×0,000303+0,357708913×0,002933)

$E(R_p)$ = 0,001615503

Portofolio variance :

$\sigma_p = \sum_{i=1}^{n}\sum_{j=1}^{n} w_i \,.\, w_j \,.\, \sigma_{ij}$ = 0,00346222 or

Portfolio standard deviation :

$\sigma_p = \sqrt{\sum_{i=1}^{n}\sum_{j=1}^{n} w_i \,.\, w_j \,.\, \sigma_{ij}}$ = 0,018607039

Based on the analysis steps conducted in this research had the results that group 1 had 7 members consisting of BTPS, CTRA, INCO, INKP, JPFA, SCMA and TKIM. Group 2 has 11 members namely PTBA, AKRA, EXCL, BMRI, CPIN, UNTR, BBCA, KLBF, TLKM, TOWR and BBRI. Then for Group 3 had 3 members, namely ACE, BBNI and MIKA. Group 4 had 6 members, namely ANTM, ERAA, ADRO, ITMG, MDKA and TBIG. The results of the grouping showed that each group had different characteristics. After obtaining

the group from the process through the K-Means grouping, the stock selection strategy for optimal portfolio formation was done by choosing one stock from each group that had the largest expected positive return. Stock selection based on K-Means grouping produced 4 stocks, namely INCO, PTBA, BBNI and MDKA as in Table 5 below:

Table 5. Results of grouping shares by K-Means

Group	Stock Name	Expected Return	Mean-Variance
1	INCO	0.001091174	0.001100236
2	PTBA	0.000973543	0.000889309
3	BBNI	0.000302638	0.000765227
4	MDKA	0.002932824	0.001070

Source: Processed data

The formation of an investment portfolio was carried out by determining the optimum weight for each selected combination of shares using the Markowitz method. The results obtained for the optimum weight were INCO shares weight of 0.263495498, PTBA shares weight of 0.244815553, BBNI shares weight of 0.133980036 and MDKA shares weight of 0.357708913. The results of the expected return of the portfolio obtained were 0.001615503, portfolio variance of 0.000346222 and the standard deviation to see the portfolio risk obtained by 0.018607039 as in Table 6 below:

Tabel 6. Optimal Weighting Results Of Markowitz Portfolios

Stock Name	INCO	PTBA	BBNI	MDKA
Stock Weight	0.263495498	0.244815553	0.133980036	0.357708913
Expected Return Portfolio		0.001615503		
Variance Portfolio		0.000346222		
Standard Deviation Portfolio		0.018607039		

Source: Processed data

DISCUSSION

Based on the results of the analysis that had been carried out, to formulate the first problem related to stock grouping based on expected return and standard deviation using the K-Means grouping method, the results of stock grouping consisted of 4 groups. Group 1 had 7 members consisting of BTPS, CTRA, INCO, INKP, JPFA, SCMA and TKIM. Group 2 consisted of 11 people, namely PTBA, AKRA, EXCL, BMRI, CPIN, UNTR, BBCA, KLBF, TLKM, TOWR and BBRI. Then group 3 had 3 members, namely ACE, BBNI and MIKA. Group 4 had 6 members, namely ANTM, ERAA, ADRO, ITMG, MDKA and TBIG. The grouping results showed that each group had different characteristics.

Of the 4 groups of shares, 4 shares were selected based on the most positive expected return and the lowest risk, namely for the first group INCO, for the second group namely PTBA, for the third group BBNI and the fourth group namely MDKA. From the results of stock grouping using k-means, the results were the same as research conducted by Nourahmadi & Sadeqi (2023) that recommendations for grouping shares using k-means grouping were more profitable than the random stock selection method. Because with the means grouping, the Markowitz method was also used to weight the selected stock portfolio, and the expected return was 0.00162. The expected return results were greater than the random stock selection method which, if an equal weighting was used, namely 0.25 for the four selected stocks, was 0.00133. According to research of Nourahmadi & Sadeqi (2023), the results of grouping shares using the clustering method and portfolio formation were better than the random share management method.

Based on the research results, it was also in line with the research results of D. Wu (2022) stated that with the help of the K-means grouping method, it was possible to reduce risk and increase profits in the selected portfolio. Stock selection by selecting based on the maximum expected return value of each group can fix the shortcomings of stock selection which only used the mean variance method. So this can influence the maximum level of profit return and reduce the risk obtained. Then, research that was also relevant to the results of this research was the one conducted by S. Wu (2020) who examined the use of cluster analysis on the stock market in the United States showing that the results of the proposed investment strategy based on K-means clustering had a higher level of excess return during a bullish market, and declined in sync with the S&P500 index during bearish markets. Therefore, grouping shares using the K-means method was very helpful in selecting shares for investors.

Furthermore, relevant research regarding the use of Markowitz to form an optimal portfolio can be found in research conducted by Chen (2022) which proved that forming an optimal portfolio with Markowitz was better used by investors to form a stock portfolio that had high-risk to get maximum profits than with using a single index model. Then, research conducted by Irfani (2023) also proved that portfolio optimization using Markowitz provided a systematic approach to forming an optimal investment portfolio. By taking into account expected profits, risks, and correlations between different assets, Markowitz aims at determining the portfolio with the highest expected return for a certain level of risk or the lowest risk for a certain level of return. Based on the results of subsequent relevant research, the optimal portfolio associated with Markowitz had the results that this method was more promising and could add value to investors' portfolios, especially those who would invest in the forex stock market (Mba et al., 2022).

CONCLUSIONS

Stock selection strategy based on K-means grouping and Markowitz portfolio formation to get maximum profits with minimal risk. So this method can be useful in finance, especially for investors who would invest capital in selected stock companies. The K-means clustering method divided stock companies into several groups that had the same characteristics and selected the stocks closest to the centre of the group to build an optimal portfolio. In the process, stock companies were grouped based on the largest and most positive expected return to measure the size of the profit opportunity and the smallest standard deviation to measure the risk of loss. Then, after successfully obtaining the stock group results, an optimal portfolio formation analysis was carried out with Markowitz to determine the weight of investment shares invested in the selected stock companies. If this method produced greater profits than the method of dividing shares into equal weights, then the Markowitz portfolio formation method could be concluded to be successful. But if the profit results were the same or lower, this meant that a review of the company's stock selection was needed.

This research was carried out to the best of the researcher's ability, but due to limited research resources, this research had several shortcomings. To begin with, the number of stock companies analyzed should be greater so that investors could gain greater profits and more stock companies should be selected so that they were not only focused on one type of stock company sector. In addition, a comparison method for grouping shares was needed to more accurately result in the profits obtained by investors. In conclusion, this was related to the selection of sample data used in 2020, when the COVID-19 pandemic occurred, making the data produce less-than-perfect calculation analysis results.

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