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Islamic CAPM based on Cluster Analysis for Portfolio Selection

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ABSTRACT

This research combines portfolio management and cluster analysis as an alternative diversification strategy to reduce risk. The method used is a comparative approach to compare the performance of the formed portfolio. The object of this research was taken purposively from JII stocks for January 2018 to June 2023. Portfolio selection is based on two hierarchical clustering techniques, namely Ward's algorithm and Complete Linkage. Meanwhile, the portfolio formation uses Islamic CAPM by replacing the risk-free rate with a sukuk coupon. The results of the analysis show that cluster analysis can be an effective tool for investors to select stocks. Each clustering technique produces 4 clusters, and then from each cluster, the most representative stock is selected so that the portfolio consists of 4 stocks each. Based on the Sharpe index, the Complete Linkage clustering technique is proven to outperform in portfolio formation compared to Ward's algorithm.

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INTRODUCTION

The Indonesian Islamic capital market is a safe and potential investment environment for investors because it provides a relatively stable rate of return and has a more dominant bullish pattern with a relatively long duration than a bearish one (Lesmana, 2023). There are many benefits that can be obtained by investors in using the Sharia concept in investment, one of which can increase public awareness to consider the Islamic system which has a positive impact on the banking system and stock market (Subekti et al., 2020). Law No. 3 of 2006 concerning amendments to law No. 7 of 1989 concerning religious courts is a form of government support in implementing an economic system based on Islamic law. This is the basis for the development of the Islamic capital market in Indonesia as a solution to the enforcement of Islamic law in investment (Tomi et al., 2019).

As one of the countries with the largest Muslim population in the world, Islamic-based investments are growing rapidly in Indonesia. This can be seen from the development of market capitalization value and the number of stocks in the Sharia Securities List. Islamic capital market statistics for 2023 show that the Jakarta Islamic Index (JII) market capitalization has increased from Rp. 1.999.749,80 billion in May to Rp. 2.270.624,17 billion in June. Likewise, the Indonesian Sharia Stock Index (ISSI) market capitalization has increased from Rp. 4.562.904,16 billion in May to Rp.

5.031.624,09 billion in June. In addition, the number of Sharia stocks has also increased rapidly from 2018 to mid-2023 as can be seen in the following figure:

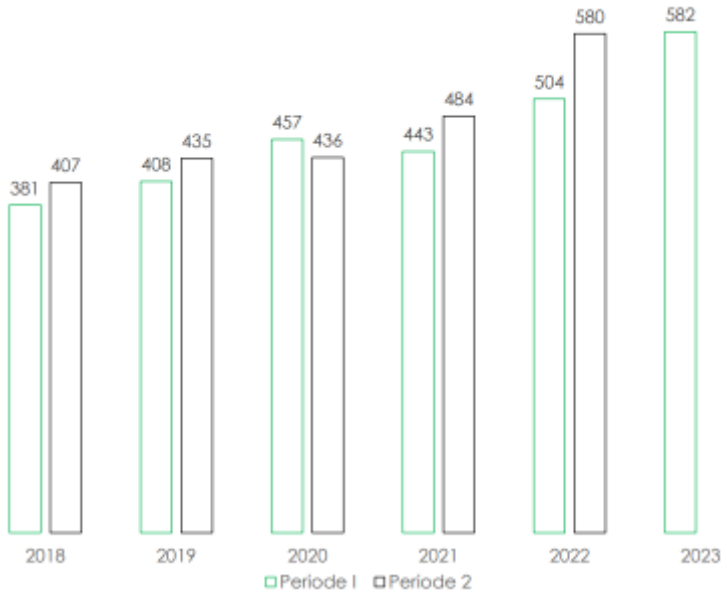

Figure 1. Number of Sharia Stocks
Source: IDX (2023)

When entering the realm of capital markets, two key elements demand attention: the potential for returns and the associated level of risks. A fundamental principle suggests that investors generally lean towards seeking returns while being cautious about exposure to risks, often displaying a tendency to avoid unnecessary risk (risk aversion). This inclination leads investors to direct their resources into assets that offer a certain degree of assurance in their investments. Investors commonly anticipate achieving the highest returns within a specific risk threshold or minimizing risk when targeting a particular level of return. The relationship between return and risk is substantiated by empirical evidence, indicating that to attain higher returns, investors must be willing to assume increased risks. Within the framework of Islamic finance, a dynamic risk and return distribution exists among economic participants. As a result, regardless of their capital surplus or deficiency, all agents assume a certain degree of risk when making investment choices (Selim, 2008).

Portfolio theory asserts that asset diversification is the optimal strategy for achieving a favorable equilibrium between risk and return. The concept of diversification involves distributing investments across a company's stocks, ensuring that other stocks are not affected in the event of a decline in certain stocks, thereby reducing potential losses. In the 1960s Treynor, Sharpe, and Lintner introduced the Capital Asset Pricing Model (CAPM) which provided investors with a strong basis for estimating the theoretically expected rate of return for an asset. This asset should represent a diversified portfolio, so that only systematic risk (β) is taken into account. Meanwhile, the unsystematic risk of these assets is assumed to be zero because the assets included in the portfolio can be eliminated through diversification. CAPM is an expansion of the Mean-Variance Model that includes the assumptions of risk-free asset lending (R_f) and investor expectation homogeneity (Hakim et al., 2016). In various studies, the equilibrium excess return from the CAPM can be used as input in the Black-Litterman model to produce an optimal portfolio (Wiharno et al., 2023).

Stock is a financial instrument with high volatility. The purpose of investing in stocks is to get an expected return that is greater than the risk-free interest rate (Angraini et al., 2022). The risk-free rate is related to the concept of the time value of money, reflecting how an investor sets aside their immediate requirement for future expenditure (Sadaf & Andleeb, 2014). The risk-free rate reflects the lowest guaranteed rate of return with the lowest risk. In Indonesia, risk-free assets are usually proxied by the interest rate on Bank Indonesia Certificates or government bond yield. Based on the Islamic finance principle, such a risk-free rate is not permissible as it includes usury (riba`) which is

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forbidden in Islam. Usury is a loan on condition that the borrower will pay more than the amount borrowed to the lender. As stated in the Qur'an Surah Al-Baqarah verse 275 "… but Allah has permitted trade and has forbidden usury …". Likewise in the Hadith Ibn Majah No 2267, the Prophet Muhammad said: "… so leave usury and doubt" (Nurhadi, 2019). This is the reason for the development of the Islamic CAPM concept as a solution to address the problem of usury in conventional CAPM. Mahastanti et al. (2021) makes adjustments to the Islamic-based CAPM theory by introducing new variables, namely the barakah risk premium and barakah return variable. This is because, in Islamic-based investment, investors will receive a monetary return as well as blessings from Allah for compliance with Sharia principles.

Many studies have recommended the Islamic concept as a replacement for risk-free rates in the CAPM. Tomkins & Karim (1987) proposed the first model by removing the risk-free rate. As a result, the expected return is determined only by market risk. El-Ashker (1987) developed the second model, which replaces risk-free rates with zakat, which is equal to 2.56% of wealth according to Islamic regulations. Shaikh (2009) proposes a third model in which the risk-free rate is replaced with the Nominal Gross Domestic Product (NGDP) rate, which measures the average growth in consumption value. Hanif (2011) offered a fourth model that substitutes inflation for interest rates. Investors will see inflation as a risk because it describes adverse economic conditions. When the CAPM's expected return exceeds the risk-free rate, it indicates that the return on investment can outperform inflation. The fifth model developed by Hakim et al. (2016) substitutes the sukuk yield for the risk-free rate. Sukuk represents investments in various asset types, particularly those devoid of usury or non-permissible business. The recent research was conducted by Faisol et al. (2022) which used the Mudharabah variable as an alternative to risk-free assets.

Forming a portfolio by selecting stock from a large number of stocks that are actively traded in the capital market is an important financial decision. Due to the extensive range of stocks offered within the Indonesian Islamic capital market, establishing the appropriate allocation for each stock proves challenging. Effective diversification requires good research and understanding of financial markets and instruments. This can take significant effort. Too complex diversification can incur additional costs, especially if investors have to purchase numerous types of assets. In addition, managing a diverse portfolio can also be time and resource-consuming. A more effective approach to address the portfolio selection issue involves categorizing stocks into clusters and subsequently choosing stocks from these clusters to construct an efficient portfolio. Cluster analysis can be a powerful tool in portfolio management, especially when investors own many assets with varying characteristics. In this study, cluster analysis serves as the initial stage for identifying potential stocks that can constitute an optimal portfolio based on the stock characteristics Gubu et al. (2020). Stocks with similar expected returns will be in the same cluster, while stocks with varying expected returns will be in different clusters.

There are two clustering techniques, namely hierarchical clustering and non-hierarchical clustering. Portfolio management based on cluster analysis has been developed by several researchers with a variety of different techniques, including Gubu et al. (2019) and Gubu et al. (2020) comparing several clustering procedures, namely complete linkage, ward's algorithm, KAMILA method, and weighted k-means clustering for grouping LQ-45 stocks in the robust Mean-Variance framework. Subekti et al. (2019) use cluster analysis as a first step to form an optimal portfolio in the Black-Litterman model. Puerto et al. (2020) combine clustering and portfolio optimization techniques through a global solution of mixed integer linear programming problems. Patalay & Bandlamudi (2020) and Chen (2022) use machine learning and artificial intelligence algorithms to predict return and volatility and classify stocks. Meanwhile, Aslam et al. (2023) clustered stocks into different groups with the k-means clustering method based on the Three-Factor model. Even though these studies used various clustering techniques, the results showed that forming an optimal portfolio based on cluster analysis gives a better output. This relates to increased efficiency, which can potentially reduce risk and boost portfolio reliability in terms of the predicted-to-realized risk ratio, which is affected by errors in sample mean and standard deviation estimators of returns (Gularte et al., 2021).

Based on the above background, this study will combine cluster analysis procedures to select potential stocks to form an optimal portfolio using the Islamic CAPM. Clustering procedures in the Islamic CAPM framework can provide recommendations for stock selection quickly, thereby

increasing the effectiveness of asset management in terms of time. This research can provide new insights for both academics and professionals regarding the concept of investment and asset management in the Sharia environment. The results of stock clustering can be used as a guide for investors to choose potential stocks according to their preferences and the application of Islamic CAPM can keep investors away from profits that contain usury.

RESEARCH METHOD

This study uses a comparative quantitative approach to select the best Islamic CAPM portfolio based on cluster analysis. As for the research sample, 30 stocks were taken purposively in the JII. The data used is the closing price of monthly stocks in the period January 2018 to June 2023. The data analysis technique is divided into two stages. In the first stage, estimation of the stock beta coefficient and expected return using the model developed by Hakim et al. (2016). As proven in the research by Subekti et al. (2020), the Islamic CAPM which uses yields on sukuk as a substitute for the risk-free rate has better performance than other models.

$$E(R_i) = R_{\text{sukuk}} + (E(R_M) - R_{\text{sukuk}})\beta_i \quad (1)$$

Where E(R_i) is expected return of stock i, R_sukuk is yield on sukuk, E(R_M) is expected return of the market index (JII), and β_i is systematic risk of stock i.

In the second stage, stock selection was carried out based on cluster analysis using two hierarchical clustering methods as used in Gubu et al. (2019), namely Ward's algorithm and complete linkage. Ward's algorithm uses an iterative procedure to form clusters and then calculates the Within Sum of Square (WSS) value for each cluster as the sum of each observation to the cluster center value. The clusters that produce the smallest WSS will be taken and combined to form one complete dendrogram. Whereas Complete Linkage, also known as Maximum Linkage, uses the highest (maximum) distance as a measure of similarity between clusters. The dendrogram will be formed from clusters that have the smallest similarity, so that the dendrogram formed is more separated between the clusters (Fauziyyah & Sholikhah, 2021). This study uses Euclidean distance to measure the similarity between stocks based on the expected return of the Islamic CAPM. Each stock representing each cluster will be selected based on the largest Sharpe ratio index to form an optimal portfolio (Bodie et al., 2018).

$$S = \frac{E(r) - r_{\text{sukuk}}}{\sigma} \quad (2)$$

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RESULTS AND DISCUSSION

In the first stage, we estimate the stock beta which reflects the tendency of the stock to move up or down according to the market. The beta coefficient is an index of stock relative volatility to average stock risk. To estimate the beta coefficient, a market model is used. The market model does not use the assumption that the error terms for each stock are not correlated with each other. This stock beta then becomes the input for calculating the expected return. As mentioned in the research method, we use the Islamic CAPM by replacing the risk-free asset return with SR018 Retail Sukuk with a 6.4% coupon per year or 0.53% coupon per month. The result of stock beta estimation and expected return can be seen in the following table:

Table 1. Beta and Expected Return Islamic CAPM

Stock	Beta	Expected Return	Stock	Beta	Expected Return
ACES	0.4383	-0.0293	INTP	1.1253	0.0131
ADRO	2.1684	0.0621	ITMG	1.7217	0.0370
AKRA	1.1750	0.0198	KLBF	1.2708	0.0294
ANTM	0.8954	0.0067	MIKA	0.4500	-0.0260
BRIS	1.1435	0.0147	MTEL	0.3940	-0.0491
BRMS	1.7437	0.0384	PGAS	1.3874	0.0348
BRPT	1.0719	0.0111	PTBA	1.8658	0.0596
CPIN	0.7841	-0.0090	SCMA	0.6818	-0.0122
EXCL	0.7598	-0.0102	SIDO	0.0680	-0.0570
HEAL	0.8837	0.0059	SMGR	0.8158	-0.0055
HRUM	1.4387	0.0356	TINS	1.0331	0.0108
ICBP	0.2596	-0.0506	TLKM	0.7910	-0.0074
INCO	0.5335	-0.0184	TPIA	0.8205	-0.0030
INDF	0.0299	-0.0766	UNTR	1.7669	0.0472
INKP	1.1003	0.0127	UNVR	0.4158	-0.0477

Table 1 shows that INDF produces the lowest stock beta (0.0299) and the lowest expected return (-0.0766), while ADRO produces the highest stock beta (2.1684) and the highest expected return (0.0621). Beta is interpreted as the sensitivity of stock returns to market returns. A beta greater than 1 is called aggressive stocks because the stock's return increases/decreases more than the market return. Meanwhile, stocks with beta less than 1 are called defensive stocks, because stock returns increase/decrease less than market returns. The greater the stock's beta, the greater the market risk, so the greater the investor's expected return. The relationship between stock beta and expected return is reflected in the Security Market Line (SML):

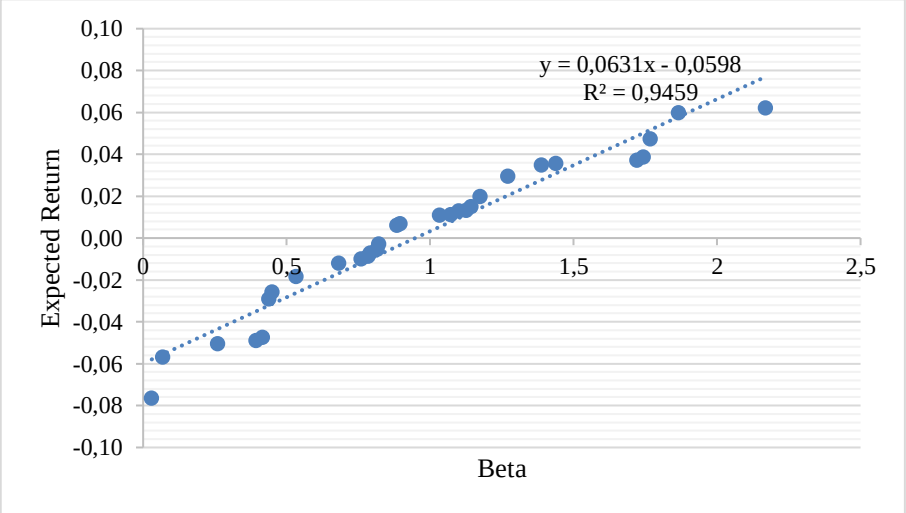

Figure 2. Security Market Line
Source: Result of data analysis

SML empirically confirms the positive relationship between stock beta and Islamic CAPM expected return with a fairly large contribution (R-Square = 94.59%). This means that stock beta is able to explain 94.59% of the expected return in CAPM, while 5.41% is explained by other factors. Thus, the higher the stock beta, the higher the expected return. Based on the expected return value, these stocks will be grouped using Ward's and Complete Linkage algorithms. The result of hierarchical clustering on stocks is presented in a dendrogram which is a structure that describes the similarities between stocks.

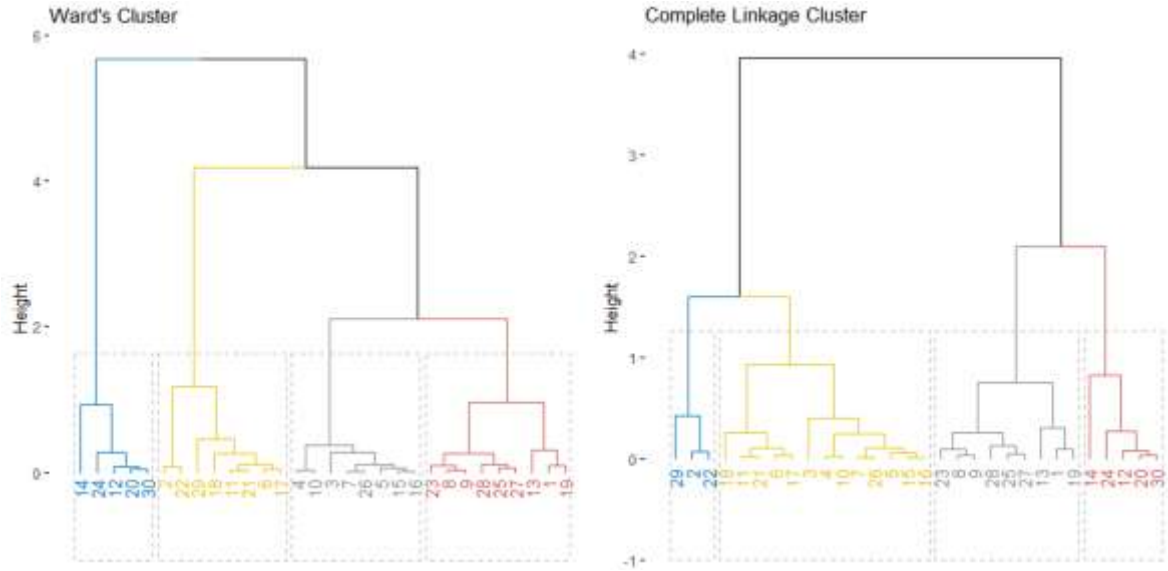

Figure 3. Dendrogram
Source: Result of data analysis

In the dendrogram, every stock that has similarities will be connected by a line and united at a point. The length of the line is different for each stock which illustrates the similarity between stocks. The longer the line between stocks, the more different the stocks are, and the shorter the line between stocks, the more similar the stocks are. Figure 3 shows that the dendrogram generated by Ward's algorithm and Complete Linkage is quite compact, where each cluster has a fairly clear partition. Both techniques produce 4 clusters with the following details:

Table 2. Number of Stock in Each Cluster

	Ward's Algorithm		Complete Linkage	
Cluster	Number of Stocks	Stocks	Number of Stocks	Stocks
1	5	ICBP, INDF, MTEL, SIDO, UNVR	3	ADRO, PTBA, UNTR
2	8	ADRO, BRMS, HRUM, ITMG, KLBF, PGAS, PTBA, UNTR	13	AKRA, ANTM, BRIS, BRMS, BRPT, HEAL, HRUM, INKP, INTP, ITMG, KLBF, PGAS, TINS
3	8	AKRA, ANTM, BRIS, BRPT, HEAL, INKP, INTP, TINS	9	ACES, CPIN, EXCL, INCO, MIKA, SCMA, SMGR, TLKM, TPIA

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4	9	ACES, CPIN, EXCL, INCO, MIKA, SCMA, SMGR, TLKM, TPIA	5	ICBP, INDF, MTEL, SIDO, UNVR

Source: Result of data analysis

To obtain the benefits of risk reduction through diversification, investors need to place their investment funds in several investment instruments with different characteristics. In this case, what is meant by characteristic is the expected return of the stock. Because the characteristics of stocks in one cluster are relatively similar while the characteristics of stocks between clusters are relatively different, in each cluster the most representative stock will be selected based on the highest Sharpe ratio index.

Table 3. Representative Stock

	Ward's Algorithm		Complete Linkage	
Cluster	**Representative Stock**	**Sharpe Ratio**	**Representative Stock**	**Sharpe Ratio**
1	INDF	2.0768	UNTR	-0.0286
2	KLBF	-0.0145	HEAL	0.0076
3	HEAL	0.0076	MIKA	0.0773
4	MIKA	0.0773	INDF	2.0768

Source: Result of data analysis

Table 3 shows that the representative stocks for each cluster are relatively the same in both Ward's algorithm and Complete Linkage. Therefore, there are two different portfolio schemes, each consisting of 4 stocks. Portfolio 1 consists of HEAL, INDF, KLBF, and MIKA. While portfolio 2 consists of HEAL, INDF, MIKA, and UNTR.

The next stage in portfolio management is calculating the asset allocation weight for each stock in the two portfolio schemes and then calculating the potential return and risk of the portfolio. The performance of the two portfolio schemes will be evaluated using the Sharpe ratio measure.

Table 4. Stock Weight on Portfolio

Portfolio 1		Portfolio 2	
Stock	**Weight**	**Stock**	**Weight**
INDF	8.17%	UNTR	32.04%
KLBF	52.46%	HEAL	43.21%
HEAL	26.28%	MIKA	15.98%
MIKA	13.09%	INDF	8.77%

Source: Result of data analysis

Table 5. Portfolio Performance

Portfolio	Return	Risk	Sharpe Ratio
1	0.0073	0.0143	0.1399
2	0.0161	0.0144	0.7500

Source: Result of data analysis

All stock weights in the portfolio are positive. This means that there are no short-selling. Implementation of CAPM refers to Sharia principles. In this regard, Islam views short-selling activity as gambling because it contains speculation and usurious practices, whereby in short-selling the loan repayments are not worth the time they borrowed them. Table 4 shows that in Portfolio 1 the stock

with the largest allocation weight is KLBF (52.46%) while in Portfolio 2 HEAL (32.21%). The stocks with the smallest allocation weight in either portfolio 1 or 2 are INDF, 8.17%, and 8.77% respectively. Evaluation of portfolio performance by considering the portfolio return and risk is carried out using the Sharpe ratio. Table 5 shows that Portfolio 2, which involves the Complete Linkage technique, produces relatively higher returns, risks, and Sharpe ratios than Portfolio 1, which involves Ward's algorithm technique.

This research empirically shows that stock clustering using the Complete Linkage technique is better than Ward's algorithm. The results of this research are different from the results of Gubu et al. (2019) which stated that War's algorithm outperformed Complete Linkage. This difference is caused by differences in the portfolio formation model. Gubu et al. (2019) use the Mean-Variance Model with robust estimation on LQ-45 Index stocks while this research uses Islamic CAPM on JII stocks. In other words, in forming a portfolio, the different objects and models/methods used will give different results.

CONCLUSION

Based on the research results, two portfolio scenarios were formed using two different clustering techniques. Namely Ward's algorithm and Complete Linkage. The formation of an Islamic CAPM-based portfolio produces the same number of stocks, namely 4 in each cluster based on the largest Sharpe ratio. Portfolio evaluation shows that the portfolio formed through Complete Linkage clustering produces better performance compared to the portfolio formed through Ward's clustering. This research provides comprehensive guidance for investors in implementing the right investment strategy in the Islamic capital market starting from stock selection to portfolio performance evaluation. Investors can use cluster analysis as a more efficient alternative for stock selection in order to get the benefits of reducing risk through diversification. The application of Islamic CAPM in investment not only teaches investors to focus on the monetary return-risk trade-off but also on compliance with Islamic values.

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