The impact of COVID-19 pandemic on non-cyclical consumer companies based on their series of financial performance using fuzzy c-means clustering

Dodi Devianto1*, Fajrul Ichsan Kamil1, Maiyasstri1, and Yudiantri Asdi1

1Department of Mathematics and Data Science, Universitas Andalas, Padang 25163, Indonesia

Abstract. The increasing interest in investment among the younger generation, most as primary consumer goods, requires understanding how to invest properly. During COVID-19 pandemic, many consumers non-cyclical companies of the young generation have affected their sustainability in market places. This study aims to discuss the impact of COVID-19 pandemic on the clustering of consumer non-cyclical companies based on the ratio of financial performance using the fuzzy c-means clustering. The data was obtained from the Indonesia stock exchange, which is a series up to December 2021 that measures the financial performance of 84 companies engaged in the consumer non-cyclical sector. The variables used in this study are PER, DER, ROA, ROE, and NPM which are the company's profitability ratios. The optimum number of clusters is determined from the largest value of the modified partition coefficient. Based on the results of the fuzzy c-means test, 79 companies are included in the first cluster, while in the second cluster there are five companies. The second cluster is the best cluster based on their ratio of financial performance. The result confirmed that fewer companies had better financial performance during the COVID-19 pandemic, and this situation affected the younger investments during the pandemic.

1 Introduction

The current investment in the market place with the rapid development time, most people no longer view the investment as a desire but as a necessity. Based on data during the COVID-19 pandemic from the Indonesia Stock Exchange (IDX) on January 29, 2021, it was recorded that 75% of the total investors are young investors who are in the 18-25 year age group. This mapping is expected to continue to increase in the coming years. A research result related to interest investment of the younger generation concludes that the younger generation does not completely understand how to invest so that they can cause loss [1, 2]. Therefore, being very knowledgeable about investing is an important view for young investors.

Before investing, the potential investors need to analyze and choose a company that has the potential to make a profit. In carry out this analysis, investors need relevant information regarding the company's financial condition through annual financial reports. In the financial statements, there are several ratios that describe the level of efficiency and effectiveness of the company in get profit, one ratio which is often considered by investors in investing is the ratio of profitability.

The profitability ratio consists of several ratios, including Price to Earning Ratio (PER), Debt to Equity Ratio (DER), Return On Assets (ROA), Return On Equity (ROE), and Net Profit Margin (NPM). This ratios describe the company's ability in making a profit [3, 4]. The companies in IDX have a varying ratios of profitability, however, there are only several companies that have a similarity in these ratios. Based on the similarity of company characteristics, the company is clustered into several clusters. This clustering is used as a reference to help young investors in choosing a company as a place of investment, especially during the pandemic. One of the methods that is used for clustering is the analysis cluster by considering several variables as their attributes.

Cluster analysis is adapted by hierarchical methods and non-hierarchical methods. Fuzzy c-means clustering is a new approach to adjusting a non-hierarchical method, so it can be ascertained that the results have at least two clusters. The Fuzzy c-means method uses degrees membership and fuzzy set as the basis of the weighting so that objects do not occupy only one cluster but they are identified by degrees membership for each cluster [5-7].

The refinement of Fuzzy clustering methods has made the mathematical computation process shorter and more efficient. This is implied many applications of this method, such as modeling in clustering stock exchange [8, 9], bankruptcy prediction [10], mobile user classification [11], automobile insurance fraud detection [12], warehouse loading operations [13], consumer power load data [14], Credit risk evaluation [15], and seeding method [16]. These research results have confirmed the popularity of fuzzy methods clustering in some instances.

The fuzzy clustering method is suitable to be applied in grouping the ratio of financial performance of a

* Corresponding author: ddevianto@sci.unand.ac.id

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company, especially for consumers non-cyclical. This consumer is very influenced by young investors as primary consumer goods. Non-cyclical consumer company is a company characterized by the production or distribution of goods and services as primary needs. Consumer non-cyclical is chosen because the movement of the company's stock index is not very influenced by economic conditions such as the effect of a pandemic [17], since the products from this company have a relatively stable demand for goods, it has a small investment risk [1]. This condition is suitable for the psychological factors of nascent investors who tend to choose companies that have stable stock prices and risky small investments.

2 Methodology

The cluster analysis for consumer non-cyclical is approached by using Fuzzy C-Means methods. The data was obtained from the IDX, which is a series up to December 2021 that measures the financial performance of 84 companies engaged in the consumer non-cyclical sector. The following describes the concept as method and operational variables to be used to make clusters based on Fuzzy C-Means clustering methods.

Company Stock. Stock are documents showing ownership of a company or limited liability company. The percentage of ownership is determined by the amount of capital invested in the company. Every shareholder is entitled to a share of profits or dividends if the company obtains a profit by the proportion of share ownership. In stock transactions, the selling price can be different from the purchase price, so there is potential for profit and loss in buying and selling shares.

Profitability Ratio. The profitability ratio as the company’s financial performance is a ratio that measures the company’s ability to earn profits. The company's ability to generate high profits during a period will attract investors to invest. Otherwise, a low level of profitability will cause investors to withdraw their assets or shares from the company. Investors often consider profitability ratios before investing, including PER, DER, ROA, ROE, and NPM. These operational variables are stated as follows:

1) Price Earning Ratio (PER). The PER compares stock price and earnings per share (EPS). The higher PER value indicates the prospect of the stock price being valued higher by investors. Value of PER is calculated by using the formula:

\[
PER = \frac{\text{Stock Price}}{\text{Earning Per Share}}
\]  

This study uses the special case of PER variable with adjustments as per mile formulated to the following notation PER-A = PER/100.

2) Debt Equity Ratio (DER). This ratio is a comparison between total debt and total capital. This ratio measures the extent to which the amount of debt can be covered by own capital. DER can be calculated as perpendicularly:

\[
\text{DER} = \frac{\text{Amount of Debt}}{\text{Amount of Capital}}
\]  

3) Return On Asset (ROA). This ratio is used to calculate the net profit of the asset. The productivity of assets in generating net profits increases as this ratio rises. ROA can be calculated as follows:

\[
\text{ROA} = \frac{\text{Net Profit}}{\text{Amount of Asset}}
\]  

4) Return On Equity (ROE). This ratio describes the company's ability to generate profits by utilizing capital. A high ROE will reflect that the company has succeeded in generating profits on the company's capital. ROE can be calculated as follows:

\[
\text{ROE} = \frac{\text{Net Profit}}{\text{Amount of Capital}}
\]  

5) Net Profit Margin (NPM). This ratio measures the company's ability to generate net income to total sales. The more the company generates sales profit, the more investors receive income. NPM can be calculated as follows:

\[
\text{NPM} = \frac{\text{Net Profit}}{\text{Amount of Sale}}
\]  

Based on the explanation of the profitability ratio, it can be concluded that the higher the PER-A, DER, ROA, ROE, and NPM values, the better the company generates profits.

Consumer Non-Cyclical. Consumer Non-Cyclical Companies are companies that produce or distribute goods and services as primary needs. The demand for goods or services in the Consumer Non-Cyclical sector is relatively stable because economic conditions influence it less, so this sector is categorized as a safe sector for investment and has stable profitability. This sector is also classified into several sub-sectors, such as medicines, food, beverages, basic needs, and household products.

Fuzzy Set. Fuzzy set theory is a mathematical framework used to explain uncertainty, ambiguity, and imprecision. Fuzzy set theory was introduced after firm set theory emerged because not all cases can be stated in the proper or false form but can only be stated in the form of almost true, somewhat true, and words that contain uncertainty.

Cluster Analysis. By using the cluster analysis technique, items are grouped according to how similar their traits are. The degree of similarity between features of items in the same cluster is high, whereas the degree of similarity between characteristics of objects in a cluster with other clusters is low. That is minimum diversity within a cluster and maximum diversity between clusters. The difference between one cluster and another is measured using a distance system (Nazar et al., 2018). This study uses the Euclidean distance. The Euclidean distance is formulated as follows:

\[
d_{ij} = \sqrt{\sum_{k=1}^{p}(x_{ik} - x_{jk})^2}
\]
where \( d_{ij} \) is the distance between the \( j \)-th object and the \( j \)-th object, \( x_{ik} \) is the value of the \( i \)-th object on the \( k \)-th variable, \( x_{jk} \) is the value of the \( j \)-th object to the \( k \)-th variable, and \( p \) is the number of observed variables.

**Fuzzy C-Means.** Fuzzy C-Means is a data clustering approach in which the degree of membership determines the existence of each data in a cluster. The primary idea behind Fuzzy C-Means is to find the cluster's center, which will represent the average position for each cluster. Iterations are performed in the Fuzzy C-Means approach to improve the cluster center and the degree of membership so that the cluster center moves to the correct place. The objective function that defines the distance between the data and the cluster's center is minimized in this loop. The following is the Fuzzy C-Means algorithm:

1. Determine the data to be clustered in the form of matrix \( X_{ij} \) where \( i \) is the number of data samples, and \( j \) is the number of variables to be used.
2. Determine the initial parameter values, namely the number of clusters \( c \) with the weighting rank (\( w \)-1).
3. Determine the maximum iteration and the slightest error (\( \xi \)).
4. Generate random numbers \( \mu_{ik} \) as elements of the initial partition matrix \( U \). The partition matrix in fuzzy clustering satisfies the conditions \( \mu_{ik} \in [0,1] \) and \( \sum_{k=1}^{c} \mu_{ik} = 1 \).
5. Calculating the \( k \)-th cluster center \( V_{kj} \) with the following formula:

\[
V_{kj} = \frac{\sum_{i=1}^{n} (\mu_{ik})^w x_{ij}}{\sum_{i=1}^{n} (\mu_{ik})^w} \tag{7}
\]

6. Calculating the objective function in the \( t \)-th iteration \( J_{FCM}(U,V)^t = \sum_{i=1}^{n} \sum_{k=1}^{c} \left( (\sum_{j=1}^{m} (X_{ij} - V_{kj})^2)^{(\mu_{ik})^w} \right) \)

7. Calculating partition matrix changes as follows:

\[
\mu_{ik} = \frac{[\sum_{j=1}^{m} (x_{ij} - V_{kj})^2]^{\frac{1}{p-1}}}{[\sum_{j=1}^{m} (x_{ij} - V_{kj})^2]^{\frac{1}{p-1}}} \tag{9}
\]

8. Checks the stop condition, if \( |J_{FCM}(U,V)^t - J_{FCM}(U,V)^{t-1}| < \xi \) or \( t > \) maximum iteration, then the iteration stops, otherwise \( t = t + 1 \) and repeats back to step 5.

**Cluster Validation.** Calculating the cluster validity index in the Fuzzy C-Means method has two categories: based on the value of the degree of membership and directly using the value itself. One of the validity indexes that uses membership values is the Modified Partition Coefficient (MPC). MPC is a validity index developed from the Partition Coefficient (PC) method. The PC method tends to experience a significant change in the value of constant \( c \). The equation defines the MPC value as follows:

\[
MPC = 1 - \frac{c}{c-1}(1 - PC) \tag{10}
\]

The equation for the PC coefficient is defined as follows:

\[
PC = \frac{1}{n} \sum_{k=1}^{c} \left( \frac{\mu_{ik}}{w} \right)^2 \tag{11}
\]

where \( n \) is the number of data, \( c \) is the number of clusters, and \( \mu_{ik} \) is the membership value of the \( i \)-th data in the \( k \)-cluster. The MPC value is between \( 0 \leq MPC \leq 1 \). The optimal cluster is determined based on the most significant MPC value.

### 3 Results and discussion

#### 3.1. Optimum cluster number

The best number of clusters is determined based on the value of the cluster validity index. The cluster validity index that is often used is the MPC index. The MPC shows that the most significant value is the optimal value. The results of the cluster validity index using the Fuzzy C-Means method for each possible number of clusters can be seen in Table 1. Based on Table 1, the highest MPC index value is the number of two clusters with a value of 0.87632. Based on this, the optimal number of clusters used is two clusters.

<table>
<thead>
<tr>
<th>Number of Clusters</th>
<th>MPC value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.87632</td>
</tr>
<tr>
<td>3</td>
<td>0.59246</td>
</tr>
<tr>
<td>4</td>
<td>0.51359</td>
</tr>
<tr>
<td>5</td>
<td>0.49248</td>
</tr>
</tbody>
</table>

After the optimal cluster is obtained, membership in each optimal cluster will be determined based on the degree of membership, which can be seen in Table 2.

<table>
<thead>
<tr>
<th>No</th>
<th>Company</th>
<th>Cluster 1</th>
<th>Cluster 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PMMPP</td>
<td>0.99590</td>
<td>0.00410</td>
</tr>
<tr>
<td>2</td>
<td>VICI</td>
<td>0.99325</td>
<td>0.00675</td>
</tr>
<tr>
<td>3</td>
<td>AMRT</td>
<td>0.98642</td>
<td>0.01358</td>
</tr>
<tr>
<td>82</td>
<td>TCID</td>
<td>0.97283</td>
<td>0.02717</td>
</tr>
<tr>
<td>83</td>
<td>UCID</td>
<td>0.99987</td>
<td>0.00043</td>
</tr>
<tr>
<td>84</td>
<td>WMUU</td>
<td>0.99916</td>
<td>0.000684</td>
</tr>
</tbody>
</table>

Based on the membership degree, each company's clusters can be determined. The highest degree of membership indicates that a company has the highest tendency to become a cluster member. For example, the fourth company becomes a member of cluster 1 because the value of the degree of membership in cluster 1 is greater than the value of the degree of membership in cluster 2, which is 0.98125. In comparison, the 81st company becomes a member of cluster 2 because the value of the degree of membership in cluster 2 is greater than the value of the degree of membership in cluster 2. The degree of membership in cluster 1 is 0.97317. Thus, the results of the clustering can be seen in Table 3.
Table 3. Clustering results.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Company Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>PMMP, VICI, AMRT, DAYA, DMND, KMDS, MIDI, MPPA, PCAR, RANC SDPC, WICO, AGAR, AISA, ALTO, ANDI, ANJT, BEEF, BISI, BOBA BTEK, BUDI, CAMP, CEKA, CLEO, CMRY, COCO, CPRO, CSRA, DPUM, DSFI, DSNG, ENZO, FAPA, FOOD, GOLL, GOOD, GZCO, HOKI, ICBP JAWA, KEJU, MAOG, MAIN, MGRO, MLBI, MYOR, CEKA, OILS, PGUN PSDN, PSGO, ROTI, SGR0, SIMP, SISP, DLTA, SKLT, SSMS, STTP TAPG, TAYS, TBLA, EPMT, ULTJ, UNSP, WAP0, WMP0, HMSP, ITIC WIIM, FLMC, KINO, KPAS, MBTO, ADES, TCID, UCID, WMUU, ICBP TAPG, DMN0, SMPS, SGR0, SIMP, WICO, AGAR, AISA, ALTO, ANDI, ANJT, KINO, KPAS, MBTO, ADES, TCID, UCID, WMUU, ICBP TAPG, DMN0, SMPS, SGR0, SIMP</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>MRAT, NASI, TGKA, CPIN, SKBM</td>
</tr>
</tbody>
</table>

3.2. Best cluster determination

After obtaining cluster results, the average of each variable of the financial performance ratio of companies in the Consumer Non-Cyclical sector is determined, where the variables are PER-A, DER, ROA, ROE, and NPM. Furthermore, each cluster also determined the average of each variable \( \bar{X}_c \). Each variable in the cluster is marked. If \( \bar{X} > \bar{X}_c \), then it is given a positive sign (+), whereas if \( \bar{X} < \bar{X}_c \), then it is given a negative sign (−). The characteristics of the clustering results are presented in Table 4.

Table 4. Cluster characteristics based on average sign of profitability ratio.

<table>
<thead>
<tr>
<th></th>
<th>PER-A</th>
<th>DER</th>
<th>ROA</th>
<th>ROE</th>
<th>NPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Based on Table 4, it can be seen that all variables in cluster 2 are favorable compared to cluster 1, which means that cluster 2 is very good at making profits and paying debts. Another way to determine the best cluster is to determine the average value of all variables in each cluster and then visualize it with a radar chart plot. The results of the radar chart plot are presented in Figure 1.

The radar chart is formed from the relationship between data points from the average value of each variable. The higher the average value of each variable, the wider the graph formed so that determining the best cluster on the radar chart is based on its area. In Fig. 1, it can be seen that the graph formed by cluster 2 is wider than the graph formed by cluster 1, so based on the figure, it can be concluded that the best cluster in this study is cluster 2. The consumer non-cyclical companies in this study are clustered to be good on ratio financial performance into Cluster 2, and only 5 companies come from the total of 84 companies. This indicates that only a few companies have a stable financial performance during the COVID-19 pandemic.

This situation confirms young investors as consumer non-cyclical companies have trouble to develop their financial performance as affected by the COVID-19 pandemic, where stocks fluctuate in value along with the change in the economy. Cyclical stocks perform better when the economy is doing well. It may also be time to seek the best cyclical equities to sell when conditions are tightening. Businesses that sell goods that people will buy regardless of economic growth make up the majority of non-cyclical equities. These include food (beverages, food, and staples), household products, utilities, pharma, consumer goods, retail and healthcare.

The grouping five companies with better financial performance from consumer non-cyclical is obtained as MRAT manufactures, trades, and distributes herbal medicine and traditional cosmetics, as well as healthy drinks, and engages in other relevant economic activities. NASI is a well-known rice producer and supplier that implements a plasma farming system in collaboration with experienced farmers and then distributes its rice throughout Indonesia online and offline. TGKA is engaged in trade, industry, transportation and warehousing, construction, agriculture and plantations, office administration and services. CPIN is in the business of animal feed, broiler breeding and cultivation, as well as processing, processed food, chicken and beef preservation, including cold storage units, sale of feed for poultry, chicken, and beef, and animal-sourced products. While SKBM is engaged in the fishery, agriculture, and cattle breeding industry.

These better financial performance of non-consumer cyclical companies because whatever happens to economic conditions, whether in the form of a recession or boom, this need must exist and cannot be eliminated from daily use. Another term is consumer staples. Key points from this sector are companies producing goods or services that are always in demand and needed by consumers, stable growth and not soaring high, and being a stock that is targeted during a recession. Because even when the economic condition is down, this type of stock continues to grow, and some have even increased many times, such as herbal medicine companies, which are much needed during the pandemic. For safe or beginner investors, this type of stock is suitable for long-term investments because income and profits tend to be more stable.
4 Conclusion

Clustering of financial performance ratios of companies in the consumer non-cyclical sector using the fuzzy c-means method grouped companies into 2 clusters. This clustering performance describes the impact of COVID-19 pandemic on non-cyclical consumer companies based on their series of financial performance. This number of clusters is the maximum number obtained from the calculation of the largest modified partition coefficient index. Their membership determines the placement of members for each cluster. Based on cluster characteristics and radar chart analysis, cluster 2 is the best-listed company based on their ratio of financial performance. The results of this non-cyclical companies clustering can be used as a reference for nascent investors in choosing stocks investment. Businesses that sell goods that people will buy regardless of economic growth make up the majority of non-cyclical equities. The effect of the COVID-19 pandemic has a little fluctuation since the stability of supply and demand. The kinds of products that are very interesting for consumer non-cyclical companies include food, household products, utilities, pharma, consumer goods, retail, and healthcare. This is suitable for long-term investments because income and profits tend to be more stable even during the pandemic.

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