



Grouping Manufacturing Companies Based on Factors Affecting Firm Value Using C-Means Clustering

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Abstract— Every company aims to maximize firm value, a crucial goal in various industries. Key determinants of firm value include firm size, sales growth, Debt to Equity Ratio (DER), business age, Return On Assets (ROA), and total asset turnover. Understanding the interplay of these variables in shaping firm value is of utmost importance. This study delves into the 2021 firm value of manufacturing companies, utilizing the c-means clustering method to group them based on these value-influencing factors. The c-means method is a potent tool for data clustering, enabling the identification of meaningful patterns within datasets. Analysis reveals that configuring the c-means method with two distinct groups is the optimal approach for clustering these manufacturing companies. Group 1 represents a moderate firm value, while Group 2 boasts a significantly higher firm value. The results have multifaceted implications. Categorizing manufacturing companies into these two groups based on performance and value-affecting factors provides valuable insights for businesses and stakeholders. This information informs strategic decisions and interventions aimed at enhancing firm value, fostering growth, and ensuring long-term sustainability.

Keywords—clustering, c-means, firm value, manufacturing

I. INTRODUCTION

Along with the development of the industry followed by advances in technology and information in Indonesia, each company competes to advance its company. Each company has the main objective of developing its business and obtaining optimal profits to ensure the future viability of the business. Based on the company's objectives, it may be inferred that the corporation's major objective is to increase the firm value of the company.

The stock price is frequently correlated with firm value, which is how investors see the business. The worth of the firm is increasing, and this is crucial since it also improves the owner's well-being. Firm value is depicted by a stable stock price and tends to increase. The worth of the firm increases as share prices rise. Management will think creatively to improve company performance. Managers must have the ability and be able to see opportunities to maximize company performance. Stock prices on the market will rise for businesses that perform at their highest levels. This is an indication that investors should put money into the business in the form of investments. Ideally, companies are expected to be able to identify and controls that may impact the value of a company.

Factors that affect firm value include firm size, sales growth, Debt to Equity Ratio (DER), business age, Return On Assets (ROA), and total asset turnover. Profitability as measured using ROA and company size affects firm value [1], [2], [3]. Firm size, company age and profitability affect firm value [4], [5]. Capital structure measured using DER and company age affects firm value [6]. Sales growth and the debt to equity ratio (DER) have a favorable impact on a company's worth [7]. Total asset turnover affects firm value [8].

Cluster analysis is one of the multivariate analyses used to group objects based on the similarity of their characteristics. Objects in a group (cluster) have a very high similarity while the level of similarity of object characteristics between clusters is low [9]. One non-hierarchical data clustering approach is C-means, which divides existing data into one or more groups. Some previous studies that also use the C-means method include Grouping Regencies and Cities Based on Road Infrastructure Conditions Using Hierarchical Clustering [10], Grouping Regions Based on Teacher-Student Ratio at the Education Level Using the K-Means Algorithm [11], and the C-Means Method for Grouping Regions based on Human Development Index (HDI) Indicators in East Java Province [12]. In the two studies, the determination of the optimum cluster has not been carried out because it only uses one cluster and also has not tested the clustering results obtained. Then, one study determined the optimum cluster and also tested the grouping results obtained. Therefore, this research is carried out using the same method, namely C-means, then determining the optimum group and testing the grouping results obtained. In addition, this research focuses on clustering manufacturing companies using 2021 data.

II. METHODS

Secondary data are used in this research. The 174 manufacturing firms that were listed on the Indonesia Stock Exchange (IDX) in 2021 fill up the utilised data. The factors used in this study are firm size, sales growth, Debt to Equity Ratio (DER), business age, Return On Assets (ROA), and total asset turnover.

Cluster analysis is one of the multivariate analyses that aims to group objects based on the similarity of their characteristics. The level of similarity of characteristics in question is that the objects in a group (cluster) are very high while the level of similarity of object characteristics between groups with one another is low [9]. C-means is the most

frequently used non-hierarchical clustering method [13]. The algorithm or steps of the c-means method are as follows.

1. Determine the number of groups to be formed (magnitude c).
2. Randomly assign data to c groups.
3. Determine each group's average centroid value.
4. Using Euclidean distance, group each set of data to the closest centroid.
5. If there is still data transfer from one group to another, go back to step 3 [14].

The ideal number of groups is determined using the pseudo F-statistic [15]. The multivariate normal test can be performed using the correlation coefficient test. The homogeneity test is used to determine whether the covariance variance matrix is homogeneous or not.

One-way MANOVA is used to compare the means of two or more populations with more than one dependent variable or to examine the effect of a treatment on the response [13]. If the multivariate normal test and homogeneity test are met, the One-Way MANOVA used is Wilk's Lambda. However, if the multivariate normal test and homogeneity test are not met, the Pillai's Trace test statistic is used. Furthermore, One-way ANOVA is used to test group differences when only one dependent variable is used or to test differences in variables between group members [13].

III. RESULT AND DISCUSSION

Grouping manufacturing companies based on factors that affect firm value in 2021 makes use of the c-means approach. The number of manufacturing companies used in this study is 174 and will be grouped into several groups. Grouping is done by using the number of groups as many as 2 to 5 groups and the most optimal number of groups will be selected. The clustering results for each group are shown in Table 1.

TABLE I. CLUSTERING WITH C-MEANS METHOD

Group	Number of Groups			
	2	3	4	5
1	70	2	74	10
2	104	102	33	2
3		70	65	69
4			2	91
5				2

a. Source: Data processed (2023)

Table 1 provides information on the number of members of each group in the results of clustering manufacturing companies with 2 to 5 groups with c-means. Determination of the optimum group is determined using the pseudo f-statistic value which is the highest value among the 2 to 5 groups. Below is the pseudo-f-statistic value in each group.

TABLE II. PSEUDO F-STATISTIC VALUE

Number of Groups	Pseudo F-Statistic
2	541.8159
3	348.9598
4	339.2774
5	290.5853

b. Source: Data processed (2023)

The pseudo-f-statistic values for 2 to 5 groups with the c-means method are shown in Table 2. The optimum number of groups selected is 2 groups. This is in accordance with the pseudo f-statistic value in 2 groups which is the highest value of 541.8159. The results of clustering using 2 groups are presented in Table 3.

Table 3 shows the members of each group. In grouping manufacturing companies based on factors that affect firm value using the c-means method, it is expected that there are differences in the characteristics of each group on all factors that affect firm value. To find out whether there are differences in the characteristics of the groups formed, it can be done using the one-way MANOVA method. Before the test is carried out, a multivariate normal test is first carried out to determine whether the data has a multivariate normal distribution or not and a homogeneity test is to determine whether the variance between groups is homogeneous or not.

TABLE III. LIST OF MANUFACTURING COMPANIES IN 2 GROUP

Group	Manufacturing Companies				
1	AGII	COCO	INOV	MOLI	SMKL
	ALDO	CPRO	IPOL	NIKL	SRIL
	ALTO	ESIP	ISSP	PANI	STAR
	AMIN	ESSA	ITIC	PBID	SWAT
	ARKA	FOOD	JSKY	PCAR	TALF
	BAJA	GDST	KEJU	PEHA	TPIA
	BELL	GGRP	KINO	POLU	TRIS
	BOLT	GMFI	KMTR	PTSN	UCID
		GOO			
	BTEK	D	KRAS	ROTI	WIIM
					WOO
	CAKK	HOKI	MAIN	SIDO	D
			MAR		
	CAMP	HRTA	K	SINI	WSBP
2	CCSI	ICBP	MASA	SKBM	WTON
	CINT	IFII	MBTO	SLIS	YPAS
	CLEO	IMPC	MDKI	SMBR	ZONE
	ADES	CPIN	INAI	LMSH	SMGR
	ADMG	CTBN	INCF	LPIN	SMSM
	AISA	DLTA	INCI	MERK	SPMA
	AKPI	DPNS	INDF	MLBI	SRSN
	ALKA	DVLA	INDR	MLIA	SSTM
	ALMI	EKAD	INDS	MRAT	STTP
	AMFG	ERTX	INKP	MYOR	SULI
	APLI	ESTI	INRU	MYTX	TBLA
	ARGO	ETWA	INTP	PBRX	TBMS
	ARNA	FASW	JECC	PICO	TCID
	ASII	FPNI	JKSW	POLY	TFCO
	AUTO	GDYR	JPFA	PRAS	TIRT
	BATA	GGRM	KAEP	PSDN	TKIM
	BIMA	GJTL	KBIL	PYFA	TOTO
	BRAM	HDTX	KBLM	RICY	TRST
	BRNA	HMSP	KDSI	RMBA	TSPC
	BRPT	IGAR	KIAS	SCCO	ULTJ
	BTON	IUKP	KICI	SCPI	UNIC
	BUDI	IKBI	KLBF	SIPD	UNVR
	CEKA	IMAS	LION	SKLT	VOKS
	CNTX	INAF	LMPI	SMCB	

c. Source: Data processed (2023)

The multivariate normal distribution test is used to determine whether the data is multivariate normally distributed or not. In the multivariate normal test, a correlation value of 0.702 is obtained, which is as follows.

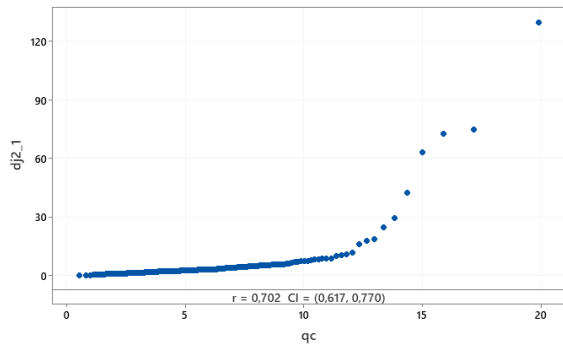


Fig. 1. The Multivariate Normal Plot (Source: Data processed (2023))

This value will be compared with the critical point from the normal probability plot correlation coefficient (PPCC) distribution. The critical point obtained using 5% alpha is 0.9919, so the decision to reject H_0 is obtained, which means that the data does not follow the multivariate normal distribution.

Homogeneity testing of the covariance variance matrix can be done using the Box's M test. Testing is done using a 5% significance level. The test results obtained Box's M value of 214.236, which is as follows.

TABLE IV. BOX'S M TEST RESULTS

	Value
Box's M	214.236
F	9.802
df1	21
df2	80668.455
Sig.	0.000

d. Source: Data processed (2023)

The value of $\chi^2_{\frac{1}{2}(g-1)p(p+1)}$ with 5% alpha, and 21 degrees of freedom is 32.6706. The Box's M value obtained is more than $\chi^2_{\frac{1}{2}(g-1)p(p+1)}$. So the decision to reject H_0 is obtained and it is concluded that the covariance variance matrix is heterogeneous.

After the multivariate normal test and homogeneity test, it was found that the data did not follow a multivariate normal distribution and had a heterogeneous covariance variance matrix. So testing for differences in characteristics using One-Way MANOVA used Pillai's Trace test statistics.

TABLE V. ONE-WAY MANOVA TEST RESULTS

Pillai's Trace Value	F	Hypothesis degree of freedom	Error degree of freedom	Sig.	Partial Eta Squared
0.856	164.885	6	167	0.00	0.856

e. Source: Data processed (2023)

In Table 5, it is known that the One-Way MANOVA test results have a Pillai's Trace test statistic value of $F = 164.885$. While the value of $F_{36;1002;0.05}$ is 1.429. When compared between the two values, the value of F is greater than $F_{36;1002;0.05}$ and results in a decision to reject H_0 , which means there are differences in the groups formed.

Grouping manufacturing companies based on factors that affect firm value with the c-means method found that the

number of groups formed was 2 groups. The results of one-way MANOVA testing show that there are differences in the two groups formed. Below is a description of each group formed.

TABLE VI. AVERAGE OF EACH GROUP

Group	1	2
Number of Groups	70	104
Firm Size	14.3837	14.8768
DER	0.9090	0.5830
Company Age	7.3714	30.0481
Sales Growth	0.2027	0.2773
ROA	0.0129	0.0349
Asset Turnover	0.8999	1.0082

f. Source: Data processed (2023)

Based on Table 6, the average of each group formed based on the factors that affect firm value in 2021 is obtained. It is known that group 2 on average has a higher value than group 1 in each variable except the DER variable. This indicates that group 2 is a group with a high company value so it can be said that the factors in this group are good. Group 1 is the group with the second highest average in each variable after Group 1, which has a higher DER value than Group 2. So group 1 needs to be handled or focused on improvements on all these factors. Based on the average of each indicator, the ranking status of each group of manufacturing companies formed can be given as shown in Table 7.

TABLE VII. STATUS OF EACH GROUP

Group	Status
1	High firm value
2	Moderate firm value

g. Source: Data processed (2023)

IV. CONCLUSION

Grouping manufacturing companies based on factors that affect firm value with the c-means method obtained optimum grouping results in as many as 2 groups. These results are obtained based on the largest pseudo-f-statistic value. The one-way MANOVA test with Pillai's Trace test statistics shows that there are differences in the groups formed. Group 2 is a group with high firm value. Group 1 is a group with moderate firm value so that there is a need for improvement in all variables. Other regional clustering methods such as fuzzy c-means that have been carried out by [16] can also be carried out for further research. Furthermore, the selection of the best method also needs to be done so that the clustering results can be used as a reference in making the right policy as has been done by [17], [18], [19] and [20].

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