



Use of K-Means Clustering and Analytical Methods Hierarchy Process in Determining the Type of MSME Financing in Semarang City

Irahayu Sukmadewanti¹, Riza Arifudin², Endang Sugiharti³

^{1,2,3}Department of Computer Science, Faculty of Mathematics and Natural Sciences,
Universitas Negeri Semarang, Indonesia

Email: ¹yayairahayu@gmail.com, ²riza.arifudin@gmail.com, ³endangsugiharti@mail.unnes.ac.id

Abstract

The Indonesian government launched an entrepreneurial program to encourage economic growth, one of which is MSME (micro, small and medium enterprises). The constraints commonly faced by MSME are limited enterprises capital. The government has also tried to provide assistance financing for MSMEs in the form of CSR (Corporate Social Responsibility), KUR (Kredit Usaha Rakyat) and KTA (Kredit Tanpa Agunan). For this type of financing or credit determined based on the type of enterprises accompanied by criteria including number of assets, turnover annually, number of employees, current enterprises period and net income. Based on background behind this research aims to help provide recommendations on types MSME capital financing based on assets, turnover, number of employees, enterprises period and net income of a MSME. This research uses data from MSME in the Semarang City, which has been registered with the Semarang City Cooperatives and MSME Office. K-Means Clustering Method is used to cluster net profit criteria. Then, the Analytical Hierarchy Process (AHP) method is used to search recommendations on the types of MSME financing based on each weighted criterias. The results of this application are recommendations for types of capital financing MSME is based on assets, turnover, number of employees, enterprises period and every net profit of MSME. For testing of the system being built, it is carried out by means of a blackbox test. From the test results obtained show that the actual results are appropriate with the expected results so that the functional system is running well. Suggestions from this research, it is necessary to develop further systems regarding grouping data to be more specific.

Keywords: K-Means Clustering, Analytical Hierarchy Process, MSME, Decision Support System

1. INTRODUCTION

Taking a decision involves intelligence, wisdom and creativity to help humans solve problems in meeting needs or for survival [1]. In general, the decision support system (DSS) is interactive computer-based system, which helps decision makers utilize data and models of solving problems that are not structured and semi-structured [2]. There are several models that can be used for build a Decision Support System (DSS) one of which is Analytical Hierarchy Process (AHP). AHP can be used in retrieval multicriteria decisions and good enough to solve problems customer funding identification that requires many criteria. This

method also combining predictive power and the logic involved in various problem, and then synthesize various considerations into matching results which intuitively estimates as presented at the consideration has been made [3].

Clustering is the process of organizing data objects into a set of mutual classes relate from a cluster [4]. Clustering is used to analyze different data groupings, similar to classification, but grouping not defined before data processing is carried out [5]. K-means Clustering is one of non-hierarchy data clustering methods that try partition the data into one or more clusters/groups. Cluster analysis is one multivariate analysis used to group objects in such a way that objects in one cluster that is very similar and objects in various clusters are quite different [6].

Indonesia is a country that implements a mixed economic system where there is a role for the government and the private sector who become economic actors [7]. To encourage economic growth the government launched the program entrepreneurship, one of which is MSME (micro, small and enterprises medium). MSME is regulated in Law Number 20 of 2008 which explains that a company is classified as a MSME is a small company owned and managed by someone or owned by a small group of people with a certain amount of wealth and income. The problems faced by entrepreneurs to start their own production is capital, because from the beginning they only use private capital [8]. The government has also attempted to provide financing assistance for MSMEs are in the form of CSR (Corporate Social Responsibility) for micro enterprises, KUR (People's Enterprises Credit) for small enterprises and KTA (Unsecured Credit) for medium enterprises.

The type of enterprises is determined based on the criteria of each MSME. According to Article 6 of Law No. 20 of 2008 concerning the criteria of MSME, namely Micro Enterprises have the most assets a lot of Rp. 50.000.000,00 and has a maximum turnover of Rp. 300.000.000,00. Small enterprises have assets of more than Rp 50.000.000,00 to the most Rp. 500.000.000,00 and has a turnover of more than Rp. 300.000.000,00 up to at most Rp. 2.500.000.000,00. Medium Enterprises have more than assets Rp. 500.000.000,00 up to a maximum of Rp. 10.000.000.000,00 and turnover more than Rp. 2.500.000.000,00 up to a maximum of Rp. 50.000.000.000,00. The Central Statistics Agency (BPS) limits the definition of MSMEs based on quantity of labor, namely small enterprises have a total of 5 workers with 19 people, while medium-sized enterprises have a workforce of 20 to with 99 people [9]. Definition of MSME based on enterprises period, that is for enterprises micro is a visible enterprises with a enterprises run of 0-6 months, for small enterprises is a visible enterprises that has a running enterprises for 1-2 years, while medium-sized enterprises are visible enterprises but not yet bankable with a enterprises period of 3-5 years. Whereas regarding net income, the more sources of income a person is, the greater its ability to pay credit or in other words the greater the profit a MSME, the greater the opportunity to get more capital big [10].

From these criteria, the type of capital financing or credit must be in accordance with the characteristics and categories of MSME, so that they are well targeted and appropriate with the ability of the MSME itself. But the reality on the ground is based MSME's data registered by the Semarang City Cooperatives and MSME Office, there are many MSME that are classified into several types of MSME, such as "MSME A" has so many turnover classified as medium-sized enterprises, but "MSME A" has been running for many years which is classified as a small enterprises, while an asset is owned by "MSME A" is classified as a type of micro enterprises. This kind of problem makes determining the type of financing for MSME is not well targeted. So, it needs a decision support system to help determine the type of capital financing from every MSME, especially for Semarang City. Therefore, the author tries to implement the K-Means Clustering and AHP methods for get recommendations on the types of MSME's financing based on criteria which has been set. In the AHP method, each criterion has a weight on in this case the weight value is obtained from the results of the interview with the Department of Cooperatives and MSME in the MSME sector.

2. METHOD

Data processing is done by analyzing the cluster in advance for profit attributes clean using the K-means Clustering method. Then determine the weight of each attribute that will be calculated in the AHP process. Weight value obtained from the results of interviews with researchers with the Department of Cooperatives and MSME in the MSME sector. The following is a flow diagram of the K-Means Clustering algorithm for net profit data is shown in Figure 1. From the calculation of K-means Clustering will get a cluster attribute of net income. The cluster results will be accumulated together with other attributes for the AHP process to determine the type of financing MSME as in Figure 2.

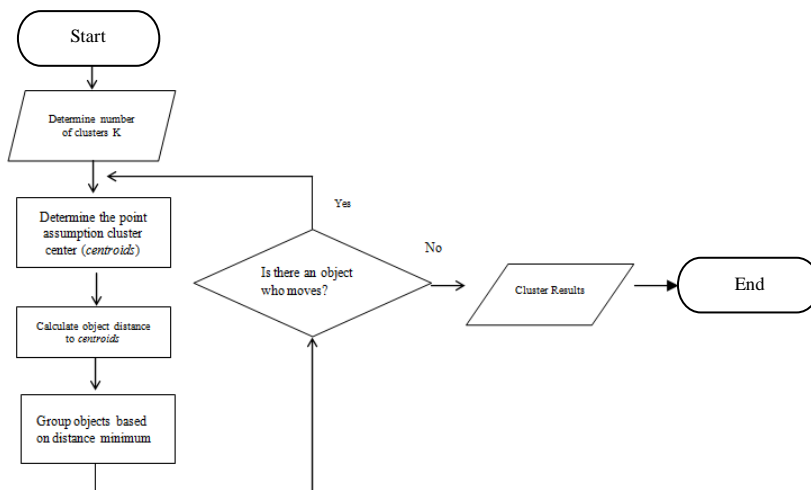


Figure 1. K-Means clustering flowchart

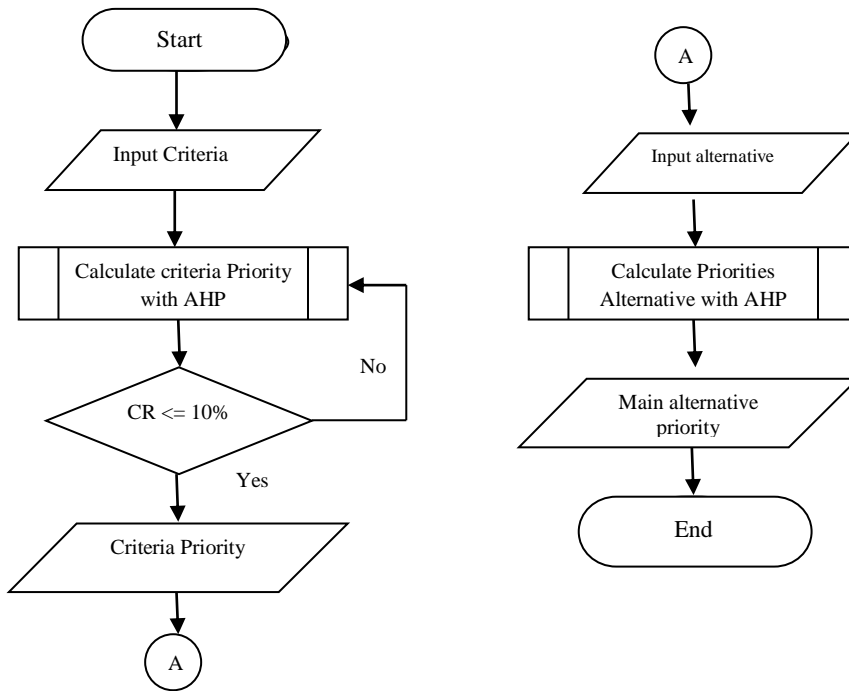


Figure 2. AHP calculation diagram

3. RESULT AND DISCUSSION

The data used is MSME's data in the Semarang City that has been registered at Department of Cooperatives and MSME Semarang City. The data contains turnover, assets, amount employees, enterprises period and net income of each MSME. This data will then be K-Means Clustering is carried out and the AHP process is to get the type of financing capital for each MSME. The first thing to do is cluster data net profit with the K-Means Clustering method. Beginning with determining the amount cluster, which in this study there are 3 clusters because there are 3 alternative types financing. Next determine the center of the cluster, then calculate each the center distance of the cluster with the data of the net income of each MSME. The distance is then selected closest to the smallest value. The smallest value is the profit position clean a MSME in a cluster. Then the next iteration is done with the distance of the new cluster by means of calculating the average distance value of the cluster against the data in each cluster. Iteration is repeated until it is found the data position in the cluster does not change. Here are the results of the K-Means Clustering net income Semarang City MSME shown in Table 1.

Table1. Results of K-means clustering of Semarang city MSME net income

Code	Net Profit	Cluster Result
MSME01	12000000	Cluster_1
MSME02	25000000	Cluster_1
MSME03	50000000	Cluster_1
MSME04	48000000	Cluster_1
MSME05	30000000	Cluster_1
MSME06	100000000	Cluster_2
MSME07	39600000	Cluster_1
:	:	:
MSME255	85000000	Cluster_2

From the results of K-Means Clustering in Table 1, it can be seen that there are 176 data entered in the first cluster, 67 data entered in the second cluster and 12 data enter the third cluster. The results of the cluster will be accumulated together another attribute for the AHP process.

The steps in the AHP calculation process can be described as follows:

- 1) Determine the criteria, which in this study use 5 criteria, namely turnover (C1), asset (C2), number of employees (C3), enterprises period (C4) and profit clean (C5). Next compile the 5 criteria in the form paired matrix using equation 1.

$$a_{ij} = \frac{w_i}{w_j}, \quad i, j = 1, 2, \dots, n \quad (1)$$

Which n are the number of criteria were compared, w_i is weights for the i criteria, and a_{ij} is a comparison of i and j criteria weighting. Value comparison of criteria can be seen in Table 2.

Table 2. Value of criteria comparison

	C1	C2	C3	C4	C5
C1	1	3	5	7	7
C2	0,33	1	7	5	7
C3	0,2	0,14	1	3	5
C4	0,14	0,2	0,2	1	0,3
C5	0,14	0,2	0,2	3	1
	1,81	4,54	13,4	19	20,3

- 2) Normalize each column and row by dividing each value on column i and line j with the biggest value in column i . Next determine w_i is the priority weight of each criteria i , by dividing each value with the number of criteria compared (n). Weight value priorities are shown in Table 3.

Table 3. Priority weight value

Normalization				a_{ij}	amount	w_i	
0,552486	0,660793	0,373134	0,368421	0,344828	2,299662	2,29966	0,45993
0,18232	0,220264	0,522388	0,263158	0,344828	1,532958	1,53296	0,30659
0,110497	0,030837	0,074627	0,157895	0,246305	0,620161	0,62016	0,12403
0,077348	0,044053	0,014925	0,052632	0,014778	0,203736	0,20374	0,04075
0,077348	0,044053	0,014925	0,157895	0,049261	0,343482	0,34348	0,0687

- 3) Calculate the value of lamda max (eigen value) by using equation 2.

$$\lambda \max = \frac{\sum a}{n} \quad (2)$$

The value of $\lambda \max = 28,5864 / 5 = 5,71729$.

- 4) Then calculate the consistency of the index (CI), which is counting deviation from the consistency of values using Equation 3.

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (3)$$

Value of CI = $(5,71729 - 5) / (5-1) = 0,17932$.

- 5) Next, calculate the CR or Consistency Ratio, which is comparison between CI (consistency index) and RI (random index). RI is an index random. The random index value can be seen in Table 4.

Table 4. Value of random index

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R	0	0	0.5	0.	1.1	1.2	1.3	1.4	1.4	1.4	1.5	1.4	1.5	1.5	1.5
I			8	9	2	4	2	1	5	9	1	8	6	7	9

This research uses 5 criteria, so that the value of RI is 1,12. Matrix comparison can be accepted if the consistency ratio (CR) ≤ 0.1 in this case, the CR value = $0.17932 / 1.12 = 0.16011$ so the comparison matrix what has been counted can be said to be accepted.

- 6) Calculating the comparison of alternative weight values that are the basis for determine alternative decisions. In this case there are 3 alternatives types of capital financing, namely Unsecured Credit (A1), People's Enterprises Loans (A2), Corporate Social Responsibility (A3). To find value alternative weights, starting with determining the value of the paired matrix each alternative shown in Table 5.

Table 5. Alternative comparison matrix

	A1	A2	A3
A1	1	2	5
A2	0,5	1	3
A3	0,2	0,3	1
	1,7	3,3	9

- 7) Normalization of alternative comparisons, adding up the value of each column to determine the priority weights of each alternative. The calculation results this can be seen in Table 6.

Table 6. Normalization and alternative priorities

	Normalization	a_{ij}	w_i	
0,588235	0,606061	0,555556	1,749851	0,583284
0,294118	0,30303	0,333333	0,930481	0,31016
0,117647	0,090909	0,111111	0,319667	0,106556

- 8) Normalization of MSME data. This is done because in inputting the value turnover, assets, number of employees, enterprises period and net income have value different so that it is normalized using principles calculation of frequency distribution. From 255 MSME data with 5 attributes namely the value of turnover, assets, number of employees, enterprises period and net income, which There have been 91 calculations for MSME with this type of financing Corporate Social Responsibility capital, 107 MSME with types capital financing for People's Enterprises Credit and 57 MSME with types Unsecured Credit capital financing.

This research is implemented in a decision-based support system the web is developed with the PHP programming language and utilizes Laravel framework. The system consists of 2 parts, namely the admin who plays a role in the process K-Means Clustering for attributes of net income and users who play a role in the process AHP. The context diagram of system is shown in Figure 3.

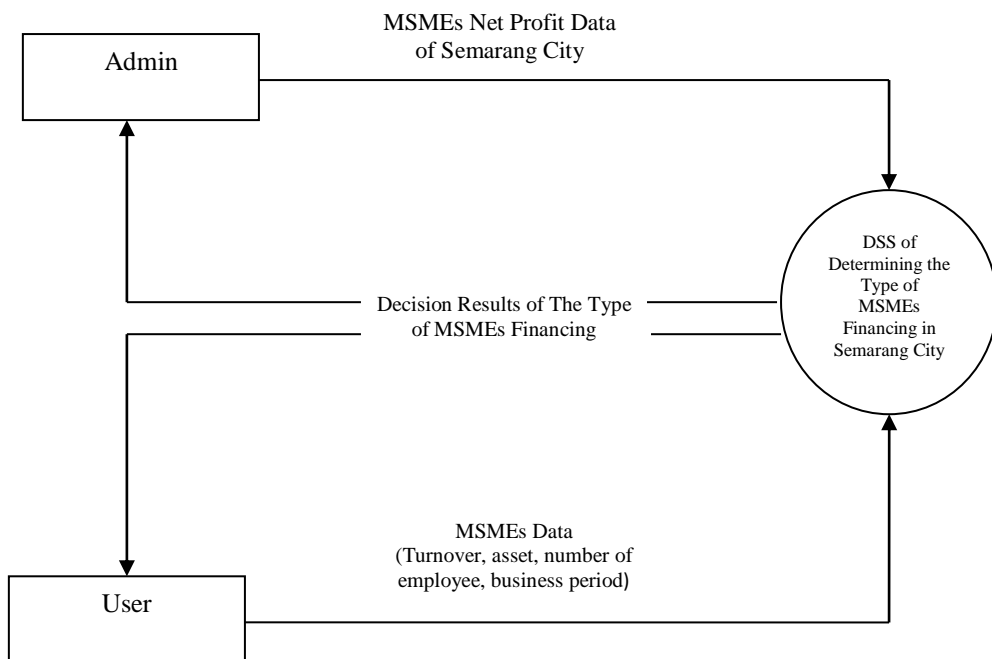


Figure 3. Context diagram

In Figure 3 describes the process carried out by the admin. The process is the net income data input and performs the calculation process of K-Means Clustering which results will be combined with other criteria for the next process, namely AHP. It also describes the process carried out by the user, which is input data MSME criteria that are coupled with cluster results. Next do calculation to look for alternative decision outcomes, namely the type of MSME financing with the AHP method, where the results can be known and seen by the admin and user. The system design in the form of ERD from the system is shown in Figure 4.

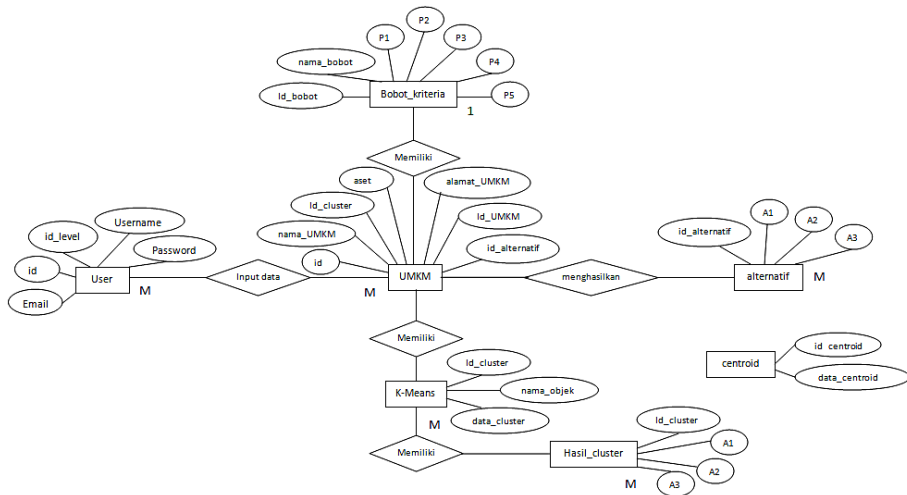


Figure 4. ERD system

For the display of the calculation results of the K-Means Clustering on the system shown in Figure 5 and the results of AHP & K-Means calculation are shown in Figure 6.

SPKUMKM

Search

Hasil Proses Clustering Algoritma K-Means Terhadap Data UMKM

ITERASI 1	Data 1	Cluster 1	Cluster 2	Cluster 3
Objek 1	120	Null	OK	Null
Objek 2	250	Null	OK	Null
Objek 3	500	Null	Null	OK
Objek 4	15	OK	Null	Null
Objek 5	180	OK	Null	Null
Objek 6	50	OK	Null	Null
Objek 7	120	Null	OK	Null
Objek 8	300	Null	Null	OK
Objek 9	300	Null	Null	OK
Objek 10	250	Null	OK	Null
Objek 11	60	OK	Null	Null
Objek 12	75	OK	Null	Null
Objek 13	5	OK	Null	Null
Objek 14	48	OK	Null	Null
Objek 15	10	OK	Null	Null
Objek 16	20	OK	Null	Null
Objek 17	120	Null	OK	Null

Navigation: Beranda, User, K-Means, AHP, Hasil AHP dan K-Means

Figure 5. K-means results

Data UMKM								
	Nama UMKM	Alamat UMKM	OMSET	ASET	Jumlah Karyawan	Masa Usaha	Laba Bersih	Hasil
Criteria	Top Ten	Semarang Tengah	420000000	300000000	29	30	380000000	Kredit Usaha Rakyat
	Lafas Batik	Genuk	200000000	100000000	20	8	80000000	Corporate Social Responsibility
-Means	J-Stand	Genuk	320000000	200000000	40	11	198000000	Kredit Usaha Rakyat
	An Najim Teknik	Gayamsari	220000000	80000000	18	20	180000000	Corporate Social Responsibility
	Abel Cell & Gallery	Gajahmungkur	400000000	150000000	12	10	320000000	Kredit Usaha Rakyat
	Salon Cahaya Muda	Pedurungan	120000000	96000000	5	13	112000000	Corporate Social Responsibility
	Edwin Halal Food	Tembalang	380000000	160000000	20	14	270000000	Kredit Usaha Rakyat
	Barokah Mandiri	Tembalang	188000000	102000000	10	6	168000000	Corporate Social Responsibility
	Axel Studio	Semarang Selatan	420000000	300000000	12	8	345000000	Kredit Usaha Rakyat

Figure 6. AHP K-means results

For testing of the system being built, it is done by blackbox testing. From these tests obtained results that show actual results in accordance with expected results so that the functional system is running well.

4. CONCLUSION

From the results of research and discussion, it can be concluded that there are four steps of the calculation process of the K-Means Clustering method. Start determining number of clusters, determine the center of the cluster, then calculate each center distance cluster with net income data. Next, the closest distance to the value is chosen the smallest is the position of the net profit of an MSME in a cluster. Then the next iteration is done with the new cluster distance by means of calculate the average cluster distance value for data in each cluster. Iteration done repeatedly to find the data position on the cluster does not change. The resulting cluster is then accumulated to the next process with AHP method. From the calculation of the combination of the K-Means Clustering and AHP methods the final value is used to determine the type of MSME financing according to each alternative value. From 255 MSME data in Semarang City with 5 attributes that are turnover value, assets, number of employees, enterprises period and net income, are found 91 MSME with the type of capital financing for Corporate Social Responsibility, 107 MSME with the type of capital funding for People's Enterprises Credit and 57 MSME with type of unsecured credit.

5. REFERENCES

- [1] Alexander, M. (2012). Decision-Making Using The Analytic Hierarchy Process (AHP) and JMP ® Scripting Language. *SESUG 2012*. 4, 1-4.
- [2] Turban, E; & Aronson, J. (2001). *Decision Support Systems and Intelligent Systems*; 7th edition. New Jersey: Prentice Hall.
- [3] Josaputri, C. A., Sugiharti, E., & Arifudin, R. (2016). Decision Support Systems For The Determination of Cattle with Superior Seeds Using AHP and SAW Method. *Scientific Journal of Informatics*, 3(2), 21–30.

- [4] Yedla, M., Pathkota, S, R., & Srinivasa T. M. 2010. Enhancing K-Means Clustering Algorithm with Improved Initial Center. *International Journal of Computer Science and Information Technologies*, 1,121-125.
- [5] Sugiharti, E., & Muslim, M. A. (2016). On-Line Clustering Of Lecturers Performance Of Computer Science Department Of Semarang State University Using K-Means Algorithm. *Journal of Theoretical and Applied Information Technology (JATIT)*, 83(1), 64-71.
- [6] Olenrewaju, O., Olufunke, O., & Obagbua, I. C. (2010). Application of K-Means Clustering Algorithm For Prediction Of Student's Academic Performance. *International Journal of Computer Science and Information Security*, 7(1), 293.
- [7] Roy, M. I. (2017). Analisis Pertumbuhan Pembiayaan MSME Terhadap Pertumbuhan Laba Bersih BPRS di Indonesia. *Islamiconomic*, 8(1), 47-58.
- [8] Riyandi, A. O., Dengen, N., & Islamiyah. (2017). Bantuan Dana atau Kredit untuk Usaha Kecil Menengah (UKM) pada Bank Negara Indonesia (BNI). *Prosiding Seminar Ilmu Komputer dan Teknologi Informasi*, 2(1), 8-13.
- [9] Badan Pusat Statistik. (2012). *Kebijakan Antisipasi Krisis Tahun 2012 Melalui Program Kredit Usaha Rakyat*. Jakarta: Badan Pusat Statistik.
- [10] Kustina, K. T., Dewi, I. G. A. A. O., Prena, G. D., & Utari, I. G. A. D. (2018). MSMEs Credit Distribution and Non-Performing Loan towards Banking Companies Profit in Indonesia. *International Journal of Social Sciences and Humanities (IJSSH)*, 2(1), 10-23.