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Balance analysis of the influence of GDP contribution on Number of Prosperous Families (NPF) and Human Development Index (HDI) using K-mean Clustering in East Kalimantan Province

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Abstract. *The Number of Prosperous Families (NPF) is the number of households that fulfillPFI (Prosperous Family Index) requirements. PFI present the ability of families to fulfill (1) basic needs, (2) social-psychological needs, (3) development needs, (4) the need to donate material-finance and actively participate as administrators in social activities, (5) tangible and sustainable social contributions. Human Development Index (HDI) consisting of: (1). Life expectancy at birth, (2). Education as measured by a combination of school registration and adult literacy, and (3). Standard of living as measured by variations in GDP per capita that adjusts for differences in prices between countries. GDP as an indicator to measure the economic performance of a country.GDP also as a reflection of the success of the government in moving the economic sector. The GDP contribution per district is the percentage of district GDP to the total GDP of all districts in a province. This study evaluates the balance of the effect of GDP contribution on NPF and HDI through grouping datasets into three levels of groups (Low, Medium, High) using K-mean clustering. The analysis was carried out on the required datasets in the 2017-2022period taken from 9 districts in the East Kalimantan province - Indonesia. There are two subsets of data that have used in the clustering process, namely GDP contribution, NPF) and (GDP contribution, HDI). If a cluster member is at the same level in both subsets of data, GDP contribution gives a balanced influence on the NPF and HDI of the cluster member, and vice versa. The results of this study showed that the low level of the cluster has the potential to have a balanced influence on the lowest GDP contribution. Furthermore, the centroid values in the data subsets* (X, Z) *were in ascending order following the order of the grade level of the cluster, in contrast to data subsets* (X, Y)*. It means that the balanced influence of GDP contribution on HDI was more consistent than on NPF. The balanced influence in* Low *level of cluster consistently occurs in Paser, Kutai Barat, Berau, and PPU districts during the 2017-2022period, whereas in* Medium *level of cluster consistently occurs inKutaiTimur district. High level clusters during the 2019-2022 period occurred in KutaiKartanegaradistrict.During the 2017-2022 period, the balanced influence of GDP contribution never occurred in the cities of Balikpapan, Samarinda and Bontang.*

Keywords: *the balance of influence, GDP contribution, NPF, HDI, K-mean clustering*

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I. Introduction

The economic development of a country can be measured by economic growth, which shows the growth of the production of goods and services in an economic region within a specified time interval. The production should be measured in the concept of value-added created by economic sectors in the area concerned, which are known as Gross Domestic Product (GDP). Therefore, GDP as an indicator to measure the economic performance of a country. GDP also as a reflection of the success of the government in moving the economic sector [1]. GDP is the value of goods and services produced by the country's economy minus the value of goods and services used in production. GDP is also equal to the amount of personal consumption expenditure, gross domestic private investment, net exports of goods and services, and government consumption expenditure and gross investment. The concept of GDP is related to welfare, or more specifically to a rather narrow concept which we call "aggregate economic welfare". This aggregate is often used to measure living standards [2]. Although the level of GDP is correlated with indicators of living standards, the correlation is not universal, and the increase does not directly reflect the benefits for some representative societies. The real household income is an income measure which is more closely related to living standards, has quite differently from GDP per capita growth [3].

Measurement of population quality is one way to measure the overall results of development efforts. Some measurement indices that commonly used are (1) Physical Quality of Life Index (PQLI), (2) Human Development Index (HDI), (3) Social Health Index (SHI), (4) FPI (Family Prosperity Index) [4]. Unlike GDP, FPI recognizes the vital and central role played by the family as the engine of the economy. FPI provides a complete picture of prosperity and cultural welfare. However, FPI measurements are very complex. HDI provides a global perspective on the question of how well people live. The United Nations designed HDI in the 1990s, consisting of: (1). Life expectancy at birth, (2). Education as measured by a combination of school registration and adult literacy, and (3). Standard of living as measured by variations in GDP per capita that adjusts for differences in prices between countries [5]. HDI is the geometric mean of the normalization index for each of those three variables. Theoretically, one factor that can accelerate HDI is an increase in per capita income. The results of the research in [6] show that an increase in GDP per capita will increase the purchasing power of the community and will ultimately improve the quality of education and health. However, the high growth sector does not always reflect fair prosperity for everyone in a region [3].

There is a strong correlation between GDP per capita and living standard of the population. This relation strengthened when it linked to competitiveness among countries/regions [7]. A decent standard of living is an adequate right of everyone for himself and his family, including adequate food, clothing and housing, and the improvement of sustainable living conditions [8]. The family is a natural and fundamental group unit of society and is entitled to protection by society and the state. The General Assembly Resolution of the United Nations outlines the main functions of the family as a vehicle to educate, nurture and socialize children, develop the ability of all members to carry out their functions in society properly and provide satisfaction and a healthy social environment for the achievement of a prosperous family [9]. BKKBN (National Population and Family Planning Agency) Indonesia formulates the definition of a Prosperous Family as (1) a family that can fulfill the needs of its members both the needs of clothing, food, housing, social and religious, (2) a family that has a balance between family income and the number of family members , (3) families that can fulfill the health needs of family members, living together with the surrounding community, worship solemnly in addition to meeting basic needs. Prosperous Family Index (PFI, different from FPI) presents the ability of families to fulfill (1) basic needs, (2) social-psychological needs, (3) development needs, (4) the need to donate material-finance and actively participate as administrators in social activities, (5) tangible and sustainable social contributions. Conversely, the Pre-Prosperous Family (Poor Family) is a family that has not been able to fulfill their basic needs [4].

The GDP contribution per district is the percentage of district GDP to the total GDP of all districts in a province. The Number of Prosperous Families (NPF) is the number of households that fulfill PFI requirements. In this study evaluates the balance of the effect of GDP contribution on NPF and HDI through grouping datasets into three clusters represents the levels of groups (Low, Medium, High) using K-mean clustering.

II. Methods

One component of HDI is the standard of living as measured by variations in GDP per capita that adjust prices between districts. NPF independently can be assumed as an indicator of increasing/decreasing HDI or GDP. This study uses assumptions that are contrary to some of the results of studies that have been conducted. GDP contribution is assumed to have an influence on HDI and NPF. This section presents how K-mean clustering is used to prove this assumption.

2.1 K-mean Clustering

K-mean clustering classified as the most popular and widely used partitioning clustering. This technique requires user-specified parameters such as the number of clusters and cluster centre initialization [10-14]. First, it needs to measure the distance between the centroid (cluster centre) and each data in the dataset. Data that has the closest distance to a cluster centre stated as a member of the cluster. Next, calculate the average of a cluster based on its members. The average member yield is the new cluster centre. The process continues until there are no more cluster member changes [12].Suppose the datasets stated by:

$$Data(x, y) = \begin{bmatrix} x_1 & x_2 & \dots & x_N \\ y_1 & y_2 & \dots & y_N \end{bmatrix} \quad (1)$$

where$x$ and y are the attribute of data, and N is the number of data in datasets. Suppose the dataset will be grouped into K clusters, then *K*-mean clustering requires a number of K centroids as initial cluster centres. One of the easiest ways to initialize cluster centres is to use random numbers in intervals that are limited by minimum and maximum data from datasets. However, this method gives inconsistent results when the clustering process repeated from the beginning. In this study, the cluster centre initialization process uses the scattered averaging technique. Suppose there are 6 data has two attributes (*X* and *Y*) as follows:

X	6	3	2	3	4	5	1	8	7
Y	1	5	8	7	2	5	3	4	7

Firstly, the dataset is sorted ascending by all its attributes (by *X*, then by *Y*) as follows:

X	1	2	3	3	4	5	6	7	8
Y	3	8	5	7	2	5	1	7	4

If the dataset will be grouped into two clusters then the initial cluster centre as follows:

X	1	2	3	3	4	5	6	7	8
Y	3	8	5	7	2	5	1	7	4

1st centroid 2nd centroid

Mathematically, the scattered averaging technique expressed by:

$$Data_{sort} = sort(Data)_{ascending}$$
$$kk = floor(N/K) \quad (2)$$
$$c(i,:) = Data_{sort}(:, floor(kk/2) + (i-1) * kk)$$

Suppose the centroid as the cluster centre stated by $c = \{(c_{x1};\ c_{x2}; \dots; c_{xk}) \quad (c_{y1};\ c_{y2}; \dots; c_{yK})\}$. The distance between centroid and each data in the dataset is expressed by [13]:

$$D_{ij} = \sqrt{(x_j - c_{xi})^2 + (y_j - c_{yi})^2} \quad j = 1 \dots N \quad i = 1 \dots K \quad (3)$$

where x_j and y_j are the attribute of the data number j, c_{xi} and c_{yi} are the attribute of the centroid number i, and D_{ij} is the matrix of distance between data number j and the centroid number i. Suppose $Data$ stated by:

$$Data = \begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \end{matrix}$$
$$\begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} 6 & 3 & 2 & 3 & 4 & 5 & 1 & 8 & 7 \\ 1 & 5 & 8 & 7 & 2 & 5 & 3 & 4 & 7 \end{bmatrix}$$

By using the scattered averaging technique, the centroids obtained are:

$$C = \begin{matrix} X & Y \end{matrix}$$
$$\begin{bmatrix} 2 & 8 \\ 6 & 1 \end{bmatrix}$$

By using Eq. (3) then obtained:

$$D = \begin{bmatrix} 8.06 & 3.16 & 0.00 & 1.41 & 6.32 & 4.24 & 5.10 & 7.21 & 5.10 \\ 0.00 & 5.00 & 8.06 & 6.71 & 2.24 & 4.12 & 5.39 & 3.61 & 6.08 \end{bmatrix}$$

Data that has the closest distance to a cluster centre stated as a member of the cluster and denoted by 1, and vice versa. So that:

$$G = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix}_{member} = \begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

Hence, the members of cluster 1 are the data number 2, 3, 4, 9, and the members of cluster 2 are the data number 1, 5, 6, 7, 8. The new centroids are generated from the average of all the member of each cluster. So that:

$$c_{x1} = \frac{(3+2+3+7)}{4} = 3.75 \quad c_{y1} = \frac{(5+8+7+7)}{4} = 6.75 \quad c_1 = [3.75 \quad 6.75]$$

In the same way, then obtained:

$$C = \begin{matrix} X & Y \end{matrix}$$
$$\begin{bmatrix} 3.75 & 6.75 \\ 4.80 & 3.00 \end{bmatrix}$$

The process continues until there are no more cluster member changes (matrix *G*).

Because GDP contribution is assumed to have an influence on HDI and NPF, it is necessary to examine its effects separately. Let the GDP contribution is denoted by X, NPF and HDI respectively denoted by Y and Z. The balance of the effect of GDP contribution on NPF and HDI is evaluated using K-mean clustering applied to two pairs of datasets, $(X, Y)$and (X, Z). Three clusters determined to represent *Low*, *Medium*, and *High* levels. If a cluster member is at the same level in both datasets, GDP contribution gives a balanced influence on the NPF and HDI of the cluster member, and vice versa.

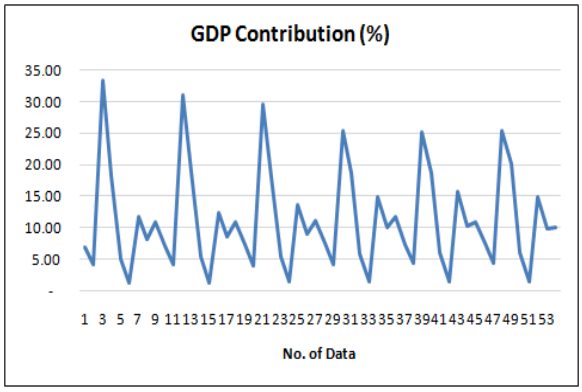
2.2 Datasets

In this study, the datasets of GDP contribution, NPF, and HDI from 9 districts in period 2017-2022 have been taken from the catalogue of Kalimantan Timur Province in Figures, 2022[15]. The dataset was arranged successively by year and district number. An example has shown in 0Graphically, dataset shown in Fig. 1.Both subsets of data that used in the clustering process shown in Fig. 2.All the data need to be normalized within interval {0 ... 1} by using the following formula:

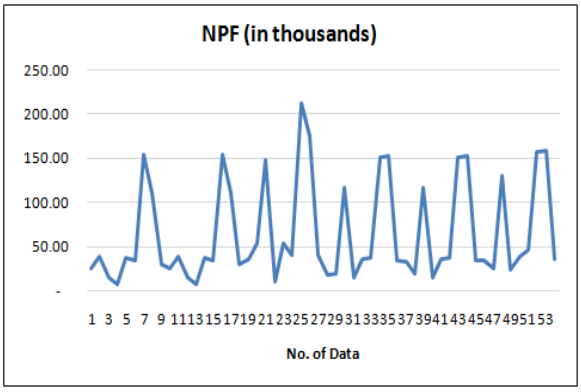
$$x_{i(norm)} = x_i / max(X) \quad X = x_1, x_2, \dots, x_N \quad (4)$$

Table 1. An example of Datasets

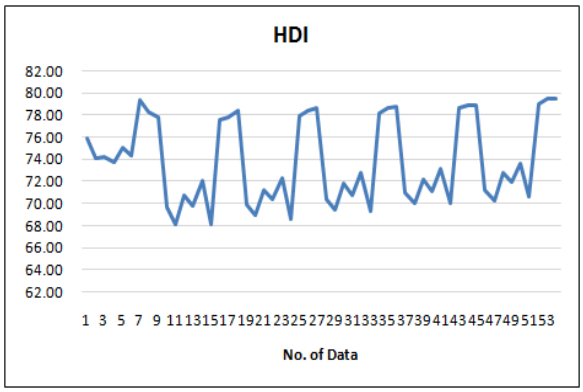
Year	District	No. of Data	GDP contribution (%)(X)	NPF (in thousands) (Y)	HDI (Z)
2017	Paser	1	6.97	25.97	75.85
	Kutai Barat	2	4.27	38.86	74.05
	KutaiKartanegara	3	33.24	15.93	74.24
	KutaiTimur	4	18.30	7.80	73.75
	Berau	5	4.95	38.36	75.05
	PPU	6	1.28	34.66	74.35
	Balikpapan	7	11.66	154.17	79.38
	Samarinda	8	8.19	110.36	78.26
	Bontang	9	10.83	29.82	77.85
	.....	.....	.....	.....	.....
2022	Paser	46	7.49	34.16	71.16
	Kutai Barat	47	4.37	25.49	70.18
	KutaiKartanegara	48	25.33	129.46	72.75
	KutaiTimur	49	20.12	24.86	71.91
	Berau	50	6.11	38.88	73.56
	PPU	51	1.44	46.02	70.59
	Balikpapan	52	14.81	157.58	79.01
	Samarinda	53	9.89	158.39	79.46
	Bontang	54	10.04	36.45	79.47



(a)

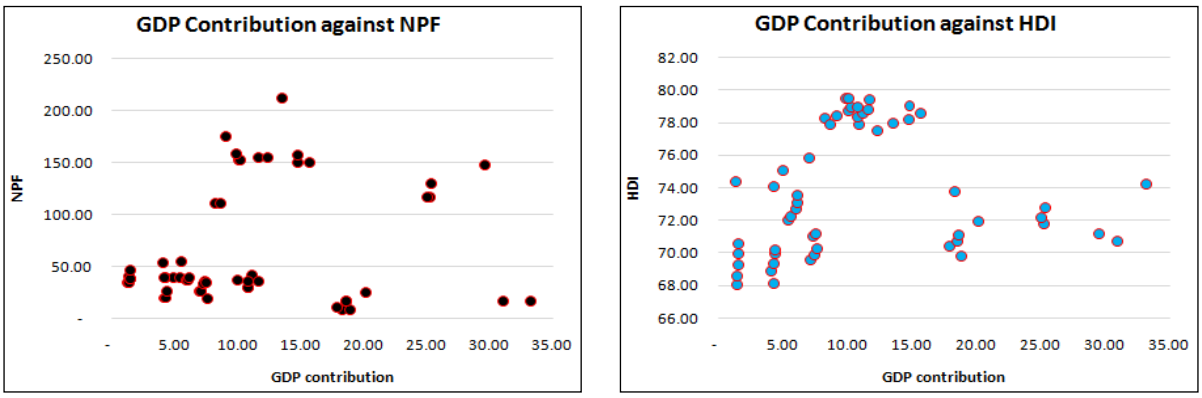


(b)



(c)

Fig. 1. Datasets

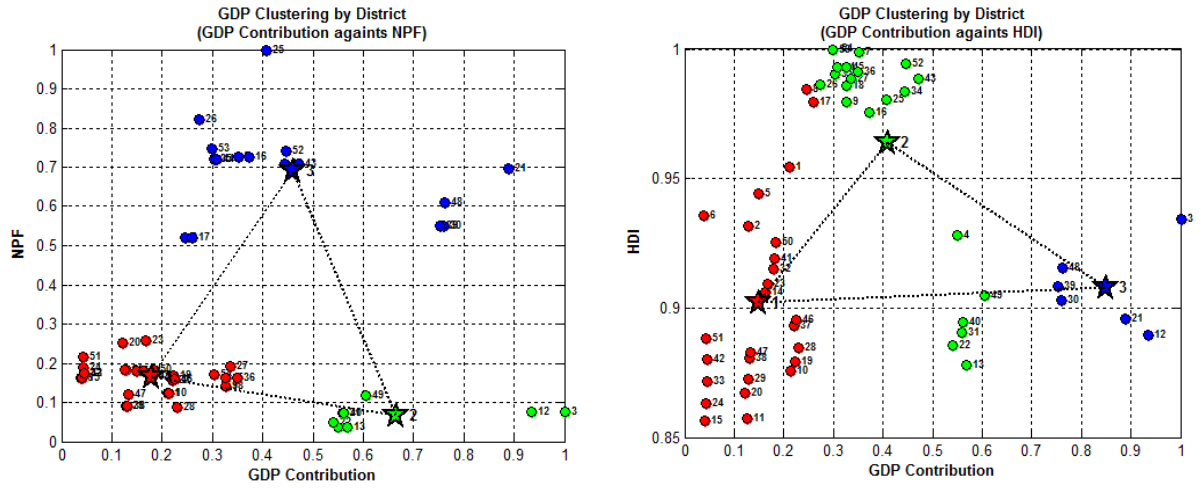


(a) (b)

Fig. 2. Subsets of data

III. Results and Discussion

Firstly, all datasets were normalized using Eq. (4). The results of applying K-mean clustering to two pairs of datasets, (X, Y) and (X, Z) shown in Fig. 3.In this Figure, each pair of data represented by a small circle, whereas a star represents each centroid. Each small circle with the same colour as the centroid colour represents the cluster member in question.



(a) (b)

Fig. 3. The results of the K-mean clustering

Theoretically, the smaller the distance between the centroids of a certain level between both subsets of data, the higher the potential of balanced influence of GDP distribution on NPF and HDI. It is because both centroids of a certain level of both subsets of data are almost in the same cluster. The final centroids were shown in 0This Table showed that the *Low* level has a higher potential of balanced influence compared to other levels. It evidenced by the distance between centroids for the *Low* level, which is smaller than the others. Furthermore, the centroid values in the data subsets (X, Z) were in ascending order following the order of the grade level of the cluster. In contrast to the centroid values in the data subsets (X, Y). It means that the balanced influence of GDP contribution on HDI was more consistent than on NPF.

Table 2. The final centroids

Attribute	**GDP contribution against NPF (X, Y)**			**Attribute**	**GDP contribution against HDI (X, Z)**		
	Low	Medium	High		Low	Medium	High
X	5.90	22.09	15.25	X	4.94	13.63	28.24
Y	34.92	14.28	146.80	Z	71.69	76.62	72.15
Distance between centroids between both subsets of data ((X, Y) and (X, Z)) using Eq. (3)					**36.78**	62.91	75.77

From the results of the application of K-mean clustering in both pairs of data subsets obtained a balanced and unbalanced influence of the GDP contribution to NPF and HDI.These results shown in 0and0Table 3. showed that the balanced influence in *Low* level cluster consistently occurs in Paser, Kutai Barat,

Berau, and PPU districts during the 2017-2022period, whereas in *Medium* level cluster consistently occurs in KutaiTimur. During the 2017-2022 period, the balanced influence of GDP contribution never occurred in the cities of Balikpapan, Samarinda and Bontang. 0 showed the unbalanced influence of GDP contribution on NPF and HDI with very diverse pairs of the grade-level of the cluster.

Table 3. The balanced influence of GDP contribution to NPF and HDI

Level	2017	2018	2019	2020	2021	2022
Low	Paser Kutai Barat Berau PPU	Paser Kutai Barat Berau PPU	Paser Kutai Barat Berau PPU	Paser Kutai Barat Berau PPU	Paser Kutai Barat Berau PPU	Paser Kutai Barat Berau PPU
Medium	KutaiTimur	KutaiTimur	KutaiTimur	KutaiTimur	KutaiTimur	KutaiTimur
High			KutaiKartanegara	KutaiKartanegara	KutaiKartanegara	KutaiKartanegara

Table 3 shows that the balanced influence of GDP contribution to NPF and HDI in low-level clusters consistently occurs in Paser, Kutai Barat, Berau, and PPU districts during the 2017-2022 period, this shows that GDP contribution has a balanced influence at low levels on NPF and HDI in Paser, Kutai Barat, Berau and PPUdistricts. This condition shows that Paser, Kutai Barat, Berau, and PPU districts have the lowest level of welfare and human development index compared to the 9 district/city in East KalimantanProvince due to the influence of the balanced GDP contribution during the 2017-2022 period. To be able to increase the level of welfare and human development index, it is very important to increase the contribution of GDP in a balanced manner to NPF and HDI. Increasing the influence of GDP's contribution to NPF and HDI in a balanced way can be done if the sectors in GDP which are related to the level of welfare and human development index can continue to be improved and developed, such as the industrial, trade, services (finance, education, and health) sectors so that they will be able to.

Meanwhile, the middle-level cluster consistently occurs in Kutai Timur district during the 2017-2022 period, this shows that the contribution of GDP to NPF and HDI has a balanced influence at the middle level on NPF and HDI in Kutai Timur district during the 2017-2022 period. This condition shows that Kutai Timur district has a moderate level of welfare and human development index (quite high) due to the influence of the balanced GDP contribution during the 2017-2022 period.

The high level cluster for the balanced influence of GDP contribution to NPF and HDI is in Kutai Kartanegara district during the 2019-2022 period, this shows that the balanced contribution of GDP can have a high influence on the level of welfare and human development index in Kutai Kartanegara district only during the period 2019-2022. This condition can be interpreted as meaning that Kutai Kartanegara district has the highest balanced GDP contribution to the level of welfare and human development index compared to 9 district/city in East Kalimantan Province during that period.

During the 2017-2022 period, the influence of a balanced GDP contribution to NPF and HDI never occurred in the cities of Samarinda, Balikpapan and Bontang. Because the cities of Samarinda, Balikpapan and Bontang are classified as cities that are disproportionately influenced by GDP contributions to NPF and HDI, this can be seen in table 4.

Table 4. The unbalanced influence of GDP contribution to NPF and HDI

Year	District	GDP contribution to		Year	District	GDP contribution to	
		NPF	HDI			NPF	HDI
2017	KutaiKartanegara	Medium	High	**2020**	Balikpapan	High	Medium
	Balikpapan	High	Medium		Samarinda	High	Medium
	Samarinda	High	Low		Bontang	Low	Medium
2018	KutaiKartanegara	Medium	High	**2021**	Balikpapan	High	Medium
	Balikpapan	High	Medium		Samarinda	High	Medium
	Samarinda	High	Low		Bontang	Low	Medium
	Bontang	Low	Medium				
2019	Balikpapan	High	Medium	**2022**	Balikpapan	High	Medium
	Samarinda	High	Medium		Samarinda	High	Medium
	Bontang	Low	Medium		Bontang	Low	Medium

Table 4 shows the unequal influence of GDP contribution to NPF and HDI with very diverse pairs of cluster class levels during the 2017-2022 period. The unequal influence of GDP contribution during the 2017-2022 period on NPF for the highest level cluster is in the cities of Samarinda and Balikpapan, meaning that the cities of Samarinda and Balikpapan have the highest level of welfare because the influence of GDP contribution is unequal when compared to the district/city in Kalimantan Timur Province during the 2017-2022 period, this is because the cities of Samarinda and Balikpapan are classified as large cities in East Kalimantan Province which have quite high levels of population density and progress in the field of trade in both the formal and informal sectors. Meanwhile, the district/citywhich is classified as a low level cluster due to the unequal influence of

GDP contribution to NPF during the 2017-2022 period is Bontang City, so the unequal influence of GDP contribution has not been able to increase the level of welfare in Bontang City during the 2017-2022 period.

IV. CONCLUSION

This study has applied the K-mean clustering method to two data subsets, (contribution of GDP, NPF) and (contribution of GDP, HDI). Three clusters have been assigned to represent the grade level of the cluster (Low, Medium, High). If a cluster member is at the same grade level cluster in both data subsets, GDP contribution gives a balanced influence on NPF and HDI, and vice versa. The results of this study showed that the low level of the cluster has the potential to have a balanced influence on the lowest GDP contribution. Furthermore, the centroid values in the data subsets (X, Z)were in ascending order following the order of the grade level of the cluster, in contrast to data subsets (X, Y). It means that the balanced influence of GDP contribution on HDI was more consistent than on NPF.

The balanced influence in *Low* level of cluster consistently occurs in Paser, Kutai Barat, Berau, and PPU districts during the 2017-2022period, whereas in *Medium* level of cluster consistently occurs in KutaiTimurdistrict. During the 2017-2022 period, the balanced influence of GDP contribution never occurred in the citiesof Samarinda, Balikpapan and Bontang.

For further studies, the proposed method will be used to predict NPF and HDI for each district to fulfill the balanced influence of their GDP contribution.

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