Determination of Inflation Sistercity in Riau Province by Using K-Means Clustering Method

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Abstract. At the present time, the government is placing a significant emphasis on the regulation of inflationary pressures. The government's approach is multifaceted, ranging from the Minister of Home Affairs' direct leadership of coordination meetings on Monday mornings to providing fiscal incentives for regions that can control inflation and removing local government officials who cannot. However, note that BPS-Statistics Indonesia (BPS) does not calculate inflation in all Indonesian regencies and cities. The calculation of inflation only includes four out of the 12 regencies/cities in Riau Province. Therefore, we must establish an inflation sister city to allow regencies/cities not included in BPS's calculations to independently calculate the inflation rate. This study is pioneering in its analysis of Sister City Inflation in Riau Province. The k-means cluster analysis indicates that the city of Pekanbaru and the city of Tembilahan form distinct clusters, with no regencies or cities within their respective clusters that are associated with either of the two cities. Subsequently, the Dumai cluster forms a cluster with Bengkalis, Siak, and Pelalawan. Conversely, Kampar Regency formed a cluster with Kuantan Singingi, Indragiri Hilir, Indragiri Hulu, Rokan Hulu, Rokan Hilir, and the Meranti Islands. Consequently, regions that are not included in the inflation calculation may utilize the data from the cost of living survey in inflation regencies/cities within the same cluster to perform their calculations. Furthermore, if the local government requires the inflation rate as a reference for determining the regional minimum wage, it may employ it from the sister cities that have been established.
Keyword: Inflation, K-Means Cluster, Sister City.

1. Introduction

Presently, inflation has emerged as a pivotal concern for the government, commanding its primary economic agenda. This phenomenon is exemplified by the regular meetings convened by the Ministry of Home Affairs on Monday mornings. "On a weekly basis, we convene to deliberate on a range of issues that exhibit a persistent and continuous overlap. The Minister of Home Affairs has indicated that the government's primary focus at this time is on price increases, with a secondary emphasis on anticipation [1]. The Minister of Home Affairs also elaborated on the potential consequences of inadequate inflation control by regional heads, stating that such heads might be removed and replaced by acting officials (PJ). At present, two categories of regional heads are recognized: those who have been elected in regional elections and those who serve in an acting capacity (PJ). A total of 514 regencies and cities are currently under the administration of acting officials. These Acting Officials (PJ) are evaluated based on their ability to manage inflation as a factor in determining whether their term will be extended or replaced" [2]. Furthermore, governments that effectively manage inflation are eligible to receive fiscal incentives from the central government, the amount of which is contingent on the specific needs of the government in question [3]. This evidence underscores the government's commitment to curbing inflation and highlights its significance for regional economic stability. According to the BPS-

Statistics Indonesia (BPS), inflation is defined as the percentage increase in the prices of a number of goods and services that are generally consumed by households [4]. Changes in the prices of food commodities have been identified as the primary contributor to the inflation rate in Indonesia. The population explosion has led to a concomitant increase in demand for food [5].

Inflation is a prevalent economic phenomenon that manifests in various economic systems. Inflation will become a serious economic problem in the long term and at high levels [6]. From an economic perspective, inflation exerts a considerable influence on individuals' perceptions of socio-economic issues and their day-to-day lives [7]. Given the persistent rise in inflation rates, it is reasonable to anticipate a protracted period of rising prices for goods and services in the country. Consequently, there will be a decline in people's purchasing power, and inflation will also lead to a decline in national income [8]. The predominant factors contributing to inflation, which are frequently experienced, include government actions, particularly increases in foreign aid, including war-related expenditures, and rises in production costs, oil price volatility, and supply chain disruptions [9]. Therefore, it is imperative for the government to exercise effective control over inflation to mitigate its impact on living costs and ensure the sustainability of benefits to producers, thereby maintaining the optimal functioning of the economy. Inflation expectations, which reflect the future inflation rate anticipated by individuals and market participants, play an important role in the transmission of monetary policy [10].

Presently, BPS is responsible for the monthly calculation of inflation. However, it should be noted that the inflation rate calculated by the BPS does not encompass all regions. Riau Province, like many other provinces, has only four regencies or cities whose inflation rates are calculated. The selected areas for observation include Pekanbaru, Dumai, and Tembilahan, with a focus on urban inflation, and Kampar Regency, which will provide insights into rural inflation. Conversely, the remaining eight regencies and cities, in conjunction with a substantial region, specifically Indragiri Hilir, have not experienced inflation. However, these rates are imperative for the local government to effectively monitor the economic development of the region. These rates will also have an impact on poverty rates in a region and the implementation or determination of minimum wage increases in a region. Therefore, it is imperative to measure inflation rates in all regencies and cities within Riau Province.

The approach adopted by BPS to continue to generate inflation values for regencies/cities where inflation calculations are not performed is the Sister City approach [11]. At present, regencies or cities for which inflation values have not been calculated are assessed based on their Price Development Index, which is calculated on a weekly basis. The Price Development Index, calculated in all regencies and cities in Indonesia, employs the Sister City approach as the calculation weighting diagram [12]. The term "Sister City" in this context denotes regions or areas that exhibit comparable characteristics, as determined by specific parameters. This approach entails the examination of several socio-economic parameters, including population, community or household consumption. The expenditure approach is employed for food and non-food items, and a number of additional parameters are taken into account. These parameters include cities/regencies with inflation and regencies/cities whose inflation figures are not calculated. Subsequent analysis will demonstrate that the regencies/cities for which inflation is not calculated exhibit equivalent characteristics to those for which inflation is calculated based on predetermined parameters. Following the acquisition of Sister City for regencies/cities where inflation is not calculated, the weighting diagram and commodities from the regencies/cities that are designated as inflation calculation areas can be utilized. The Sister City approach has been demonstrated to be a more cost-effective alternative for local governments seeking to calculate inflation. This approach obviates the necessity of conducting a Cost of Living Survey over the course of a year, which can incur substantial expenses. The Sister City approach will utilize clustering with the K-Means method, where the value of k is determined based on the inflation-calculated regencies/cities. A seminal study was conducted by [13] on the subject of "Determining Sister Cities for the Weighted Diagram in East Nusa Tenggara using the K-Means algorithm." The results obtained from the analysis revealed the presence of three distinct clusters, with each cluster corresponding to an urban area characterized by elevated inflation rates. The Kupang City cluster was found to have no members, indicating the absence of other cities in NTT that could be considered analogous to Kupang. Consequently, the designation of a sister city is unfeasible. This phenomenon can be attributed to Kupang's status as the capital of inflation.

Another study, conducted by [14], entitled "On Clustering Consumption Patterns in West Java to Determine Sister Cities for the Non-Sampled Area Cost of Living Survey," obtained results showing that the biclustering parameter with parameter tuning $\theta = 0.1$ is the best bicluster. This bicluster consists of three biclusters, which have an MSR/V=0.02433 with identical characteristic variables. These variables include average fish consumption, average meat consumption, average egg and milk consumption, average vegetable consumption, average fruit consumption, average oil and coconut consumption, average housing and household facilities consumption, average miscellaneous goods and services consumption, and average tax consumption, levies and insurance.

This study represents a pioneering endeavour in the field, as it is the inaugural study of its kind to be conducted in the province of Riau. To the best of the author's knowledge, no previous studies have examined sister city inflation in Riau Province. Furthermore, the present study employs a dummy variable, namely the regencies/cities that function as inflation sample areas, utilising the results of the Cost of Living Survey (SBH). The present study will also utilise three characteristics: economic characteristics, population characteristics, and consumption pattern characteristics. The ultimate finding of this study is that the regencies/cities whose inflation rates are calculated can be grouped or have the same cluster as the regencies/cities added as dummy variables so that the clusters formed can be said to be good or have good validity.

2. Research Method

2.1. K-Means Clustering

K-Means is a data mining algorithm that utilizes clustering techniques based on distance division and employs centroids as the center point of each cluster [15]. The K value must be specified in advance in K-Means, and the convergence results are directly influenced by the choice of K value [16]. Clustering algorithms are predominantly utilized in applications such as pattern recognition, natural language processing, and medical diagnosis. The K-means algorithm's popularity can be attributed to its simplicity and efficiency [17]. The utilization of K-means clustering in this study is predicated on the capacity to specify the K value with a high degree of flexibility. In this study, a K value of 4 was used, representing the number of regencies/cities that were included in the inflation calculation for Riau Province. The number of clusters was determined with the aim of grouping all regencies/cities in Riau into areas with characteristics similar to those of inflationary cities. This approach is in line with previous research by [13], who also determined the number of clusters based on the number of inflationary cities in a study conducted in East Nusa Tenggara Province.

The K-means algorithm necessitates that all data be assigned to a particular cluster. In this manner, all data belonging to a specific cluster in one phase of the process can be transferred to another cluster in the subsequent phase. The K-Means algorithm necessitates data with numeric attributes for implementation. In the sister city approach analysis, the application of data mining clustering methods using the K-Means algorithm is facilitated by R-Studio software. The following section delineates the steps for conducting data analysis using the clustering method to identify sister cities :

1. Collect data to be used before performing clustering analysis.
2. Explore data with descriptive statistics.
3. Convert data types into numerical form if there are non-numerical data types.
4. Separate district variable data and convert these variables into index names.
5. Standardize data if data units differ.
6. Calculate the distance between regencies/cities using the Euclidean distance method.
7. Group each data based on its proximity to the centroid or find the smallest distance.
8. Determine the number of K to be used (because the research objective is to use the sister city approach, the number of K to be used is the number of regencies/cities in the province included in the SBH calculation).
9. Apply the K-Means Clustering algorithm to obtain cluster results.
10. Repeat steps 6 to 10, iterate until the objects do not move clusters
11. Interpret the results of the K-Means Cluster analysis

2.2. *Euclidean distance*

The Euclidean distance between two points in space is the straight-line distance between them. It is a method for calculating the distance between two variables. It is often used because it is simple, fast, and efficient. It refers to the process of determining the relationship between angles and distances, as well as calculating the distance between two points in Euclidean space. It is used to calculate distances in one dimension and provides results for Pythagorean calculations [18]. The general formula for Euclidean distance is as follows:

$$d_{ij} = \sqrt{\sum_{p=1}^{n}(v_{pj} - x_{pj})^2} \qquad (2)$$

with Explanation:

d_{ij} : Euclidean distance between centroid i and object j.

v_{pj} : centroid i on variable p.

x_{pj} : object j on variable p.

2.3. *Data and Data Sources*

This study will use secondary data from the Riau Province Central Statistics Agency, which is the result of the 2020 Population Census, the 2022 National Socioeconomic Survey (SUSENAS), and the 2022 Cost of Living Survey (SBH). The year 2022 was chosen because the Cost of Living Survey, which is the basis for calculating the latest inflation, was conducted in 2022. The research was conducted in 12 regencies/cities in Riau Province with the addition of 4 dummy regions, which are the regions used to calculate inflation. Later, these regions whose inflation will be calculated will use food and non-food expenditure data from the results of the Cost of Living Survey. The following are the variables/characteristics used in grouping sister cities in this study:

Table 1. Variables used in the study.

Variables	Description	Unit	Data Sources	References
X_1	Total Population	Person	BPS-Statistics Indonesia	[14]
X_2	Purchasing Power Parity	Rupiah	BPS-Statistics Indonesia	[19]
X_3	household consumption expenditure Per Capita	Rupiah	BPS-Statistics Indonesia	[14]
X_4	GRDP Per Capita	Rupiah	BPS-Statistics Indonesia	[20]
X_5	Average Food Expenditure Per Capita	Rupiah	BPS-Statistics Indonesia	[13]
X_6	Average Non-Food Expenditure Per Capita	Rupiah	BPS-Statistics Indonesia	[14]
X_7	Population Density	Person/Km	BPS-Statistics Indonesia	[14]

3. Result and Discussion

3.1. *Overview of Population Characteristics in Regencies/Cities throughout Riau Province*

Population profile of the region reveals that in 2022, the regency/city with the largest population was Pekanbaru City, which had an estimated population of approximately one million. Concurrently, Meranti Islands Regency exhibited the most modest population, with approximately 210 thousand individuals. An analysis of the demographic data from the inflation area revealed that the Tembilahan area, which is part of Indragiri Hilir, had a population of 79 thousand. This indicates that the inflation calculation in the Tembilahan region encompasses approximately 79,000 individuals, a figure that does

not reflect the demographic size of the Indragiri Hilir regency, which has an estimated population of 669,000. The population of Dumai City is approximately 325,000 inhabitants, while Kampar Regency, a recently established administrative division, has a population of approximately 867,000 inhabitants.

Moreover, with regard to population density, the city of Pekanbaru stands as the most densely populated area, exhibiting an approximate population density of 1,500 inhabitants per square kilometer. Conversely, Pelalawan stands as the regency with the most sparse population density, exhibiting an average of approximately 31 inhabitants per square kilometer. Tembilahan, the geographical area utilized for the calculation of inflation, exhibits a population density of approximately 467 inhabitants per square kilometer. This figure is significantly different from that of Indragiri Hilir, which is a large regency with a population density of only 49 people per square kilometer.

Table 2. *Overview of population characteristics in regencies/cities throughout Riau Province*

Regencies/Cities	Total Population	Population Density
Kuantan Singingi	341 874.00	63.37
Indragiri Hulu	455 958.00	58.95
Indragiri Hilir	669 482.00	48.87
Pelalawan	402 040.00	30.99
Siak	470 309.00	61.18
Kampar	866 942.00	84.83
Rokan Hulu	576 766.00	76.09
Bengkalis	577 700.00	67.66
Rokan Hilir	654 522.00	72.60
Kepulauan Meranti	209 817.00	58.93
Pekanbaru	1 005 658.00	1 578.40
Dumai	324 678.00	161.11
Tembilahan*	79 309.00	467.7
Kampar 1*	866 942.00	84.83
Pekanbaru 1*	1 005 658.00	1 578.40
Dumai 1*	324 678.00	161.11

3.2. Overview of Economic Characteristics of Regencies/Cities in Riau Province

Economic characteristics are viewed from the variables of per capita GRDP and purchasing power parity. Based on the characteristics of GRDP at current prices, Bengkalis Regency is the region with the highest GRDP value in Riau Province, with a GRDP of 304.6 thousand. Furthermore, when viewed from Purchasing Power Parity or adjusted per capita expenditure, which is also used in calculating the Human Development Index (HDI), Pekanbaru City is the region with the highest adjusted per capita expenditure among other regions. Meanwhile, Meranti Islands Regency is the region with the lowest value.

Table 3. Overview of economic characteristics in regencies/cities throughout Riau Province

Regencies/Cities	Purchasing Power Parity	GRDP Per capita
Kuantan Singingi	10 647.00	131 363.61
Indragiri Hulu	10 472.00	118 837.15
Indragiri Hilir	10 234.00	124 221.03
Pelalawan	12 163.00	163 051.46

Siak	12 230.00	227 499.52
Kampar	11 394.00	119 442.33
Rokan Hulu	9 841.00	86 021.67
Bengkalis	11 857.00	304 608.72
Rokan Hilir	9 906.00	146 800.95
Kepulauan Meranti	8 246.00	118 657.12
Pekanbaru	14 804.00	143 745.96
Dumai	12 249.00	138 761.51
Tembilahan*	10 234.00	124 221.03
Kampar 1*	11 394.00	119 442.33
Pekanbaru 1*	14 804.00	143 745.96
Dumai 1*	12 249.00	138 761.51

3.3. Overview of Consumption Patterns in Regencies/Cities throughout Riau Province

In terms of per capita expenditure, Pekanbaru is the region with the highest per capita expenditure among other regions, reaching 2.07 million per capita per month. This shows that in Pekanbaru, it takes approximately 2.07 million to obtain food per month for one person. Meanwhile, Indragiri Hilir Regency has the lowest per capita expenditure among other regions, amounting to 1.19 million per capita per month. A subsequent analysis of data from the National Economic Survey (SUSENAS) for 12 regencies and cities in Riau Province reveals that, from a holistic perspective encompassing both food and non-food expenditures, Pekanbaru City stands as the region with the highest expenditures. The value of food expenditures in Pekanbaru City is 882 thousand rupiah per capita. Concurrently, non-food expenditure in Pekanbaru City amounts to 1.19 million rupiah per capita. Concurrently, Meranti Islands Regency exhibits the lowest food expenditure among the regencies within Riau Province, with a value of 600 thousand rupiah per capita. Conversely, the lowest non-food expenditure is observed in Indragiri Hilir Regency, with a value of 502 thousand rupiah per capita. Subsequently, an analysis was conducted of the inflation data in conjunction with the results of the Cost of Living Survey, revealing that the city of Pekanbaru exhibited food expenditures amounting to 809 thousand rupiah per capita, along with non-food expenditures amounting to 1.24 million rupiah. Concurrently, the Tembilahan region, which is part of Indragiri Hilir, has been identified as the region with the highest food expenditure, with a value of 1.01 million rupiah per capita. With regard to non-food expenditures, Tembilahan has a value of 1.12 million rupiah per capita.

Table 4. Overview of Economic Characteristics in Regencies/Cities throughout Riau Province

Regencies/Cities	household consumption expenditure Per capita	Average Food Expenditure Per capita	Average Non-Food Expenditure Per capita
Kuantan Singingi	1 285 317.50	694 586.51	590 730.99
Indragiri Hulu	1 196 240.73	624 631.27	571 609.46
Indragiri Hilir	1 113 775.46	611 584.97	502 190.49
Pelalawan	1 377 819.15	733 591.05	644 228.10
Siak	1 462 752.19	732 539.88	730 212.31
Kampar	1 378 394.07	750 559.04	627 835.03
Rokan Hulu	1 292 051.87	720 495.97	571 555.90
Bengkalis	1 255 434.03	697 052.95	558 381.08

Rokan Hilir	1 238 712.94	698 860.28	539 852.66
Kepulauan Meranti	1 138 440.96	599 580.40	538 860.56
Pekanbaru	2 072 398.49	882 294.31	1 190 104.18
Dumai	1 578 115.80	804 160.59	773 955.21
Tembilahan*	1 113 775.46	1 007 816.33	1 122 466.64
Kampar 1*	1 378 394.07	602 413.86	705 481.70
Pekanbaru 1*	2 072 398.49	809 961.60	1 241 838.53
Dumai 1*	1 578 115.80	524 873.00	784 399.65

3.4. Result of Euclidean Distance and K-Means Cluster

The measurement of distance is conducted for the purpose of determining sister cities, with this determination being made based on data patterns. The determination of sister cities can be achieved through the consideration of the consistency of multiple methods employed and the formation of distances in clustering. The following visualizes the concept of the Euclidean distance:

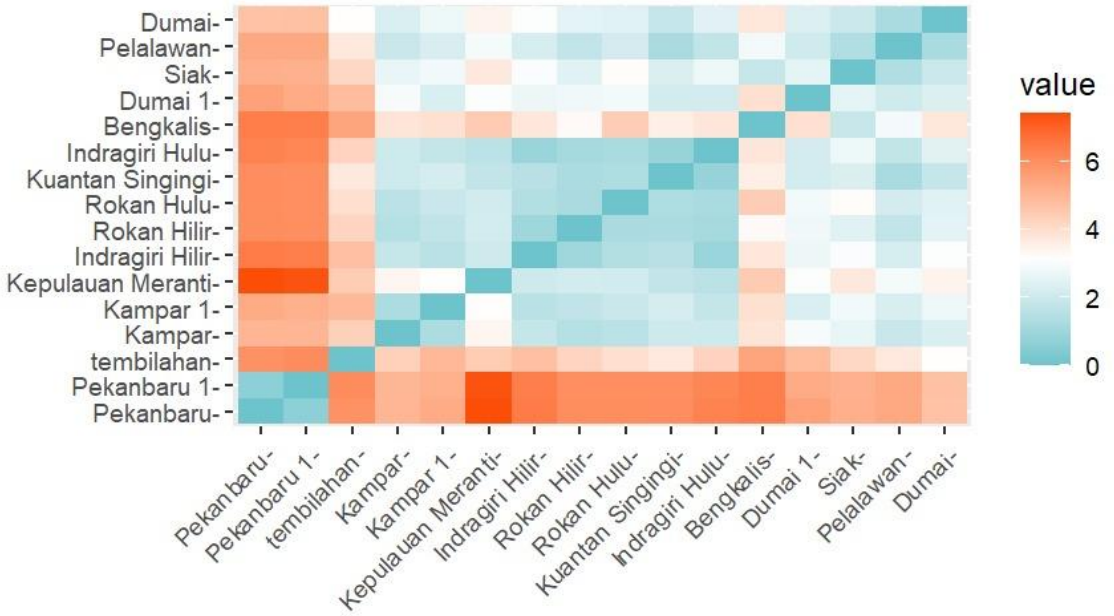

Figure 1. Euclidean distance results.

The visualization in Figure 1 is the Euclidean Distance created in the form of a heatmap. The heatmap is divided into two colors, orange and blue. The more orange the color, the greater or farther the distance, and the more blue the color, the smaller or closer the distance. Pekanbaru and Tembilahan dominate the greatest distances, while other regencies/cities have distances that are close to each other, except for Pekanbaru and Tembilahan. After determining the distance using Euclidean Distance, a clustering plot was formed using the K-Means method as follows:

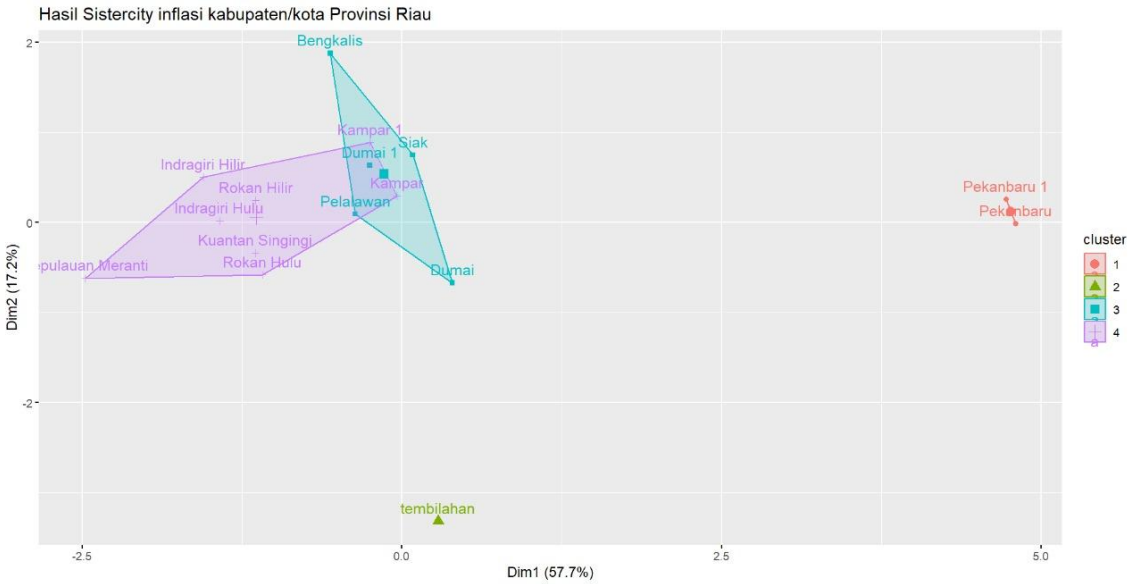

Figure 2. K-Means cluster result

Based on the cluster results in Figure 2, it can be seen that the city of Pekanbaru, with data from the SUSENAS results, forms a cluster with Pekanbaru 1, which has data from the SBH results. This shows that both the SUSENAS and SBH results are consistent. This result can also be seen from the Euclidean Distance results, where Pekanbaru based on SBH data and Pekanbaru based on SUSENAS data have a close distance compared to other regencies/cities. This is because Pekanbaru, as the capital of Riau Province, has a dense population and is also the economic center of Riau Province, which of course has an impact on the higher per capita income and per capita expenditure of the community compared to other regencies/cities in Riau Province. A significant increase in income affects consumption variation, particularly in the food and non-food categories [21]. These results are also in line with the data used, which shows that Pekanbaru does not have characteristics that are similar or almost the same as other regencies/cities in Riau Province. Meanwhile, Tembilahan forms its own cluster without any other regencies/cities following the socioeconomic characteristics of the two inflationary regions. These results are in line with the Euclidean Distance, which shows that Tembilahan is not close to other regencies/cities. These results also show that the inflation rate in Tembilahan, which is part of Indragiri Hilir Regency, cannot be used as the overall inflation rate for Indragiri Hilir Regency. This is because the inflation data sample calculated in Tembilahan based on the Cost of Living Survey is not considered representative enough to describe the conditions of the entire Indragiri Hilir region.

Indragiri Hilir itself forms a cluster with Kampar Regency (dummy variable from SBH results), Kampar Regency (from SUSENAS results), Indragiri Hulu, Kuantan Singingi, Rokan Hilir, Rokan Hulu, and Meranti Islands. These results show that in terms of population and economic characteristics, these regencies have similar characteristics. Therefore, if these regencies want to create or calculate inflation figures, they can use the commodity package and weighting diagram available in Kampar Regency. Meanwhile, Dumai City formed a cluster with Dumai from SUSENAS, Siak, Bengkalis, and Pelalawan based on SBH results. This shows that these regencies/cities have almost identical characteristics in terms of population and economy. Therefore, if Siak, Bengkalis, or Pelalawan Regencies want to calculate inflation, they can use the cost of living survey results from Dumai City and use the commodity package available in Dumai City. These results can be considered to have sufficient validity, as seen in inflation areas such as Pekanbaru City, Dumai City, or Kampar Regency, where SUSENAS results can be grouped with the same area in terms of population and economic characteristics using data from the Cost of Living Survey.

Following the acquisition of the sister city results, local governments can calculate inflation using the commodity package and weighting diagrams from regions that are included in the same cluster whose inflation rates are calculated. This approach has the potential to result in significant budget

savings. Furthermore, in accordance with Government Regulation No. 16 of 2024 [22] concerning the determination of minimum wages, the inflation rate can be calculated using the inflation rate of the sister city.

4. Conclusion

It is imperative for each region to have access to inflation figures in order to accurately measure the percentage increase in the price of goods or services. Moreover, it is imperative to note that these inflation figures are instrumental in determining the minimum wage within a specific region. However, it should be noted that not all regions have their inflation figures calculated, nor are they included in the Cost of Living Survey sample. The regions that are calculated are those adjacent to the provincial capital in each province of Indonesia. The determination of the inflation rate of non-SBH cities is achieved through the utilisation of the sister city approach. The sister city approach utilises a weighting diagram of SBH cities that exhibit analogous consumption patterns and are geographically proximate to each other. The results of the study are divided into four clusters, namely: 1) Pekanbaru dummy variables using Cost of Living Survey (SBH) data combined into one group with Pekanbaru using data from the National Socioeconomic Survey (SUSENAS). Tembilahan, a constituent of Indragiri Hilir, constitutes an independent cluster, unassociated with its parent regency, Indragiri Hilir Regency. Indragiri Hilir is part of a cluster that also includes Kampar Regency, Indragiri Hulu Regency, Kuantan Singigi Regency, Rokan Hilir Regency, Rokan Hulu Regency, and Meranti Islands Regency. Finally, Siak Regency, Bengkalis Regency, Pelalawan Regency, and Dumai City are combined into one cluster.

This study is the first study conducted in Riau Province on the Determination of Sister City Inflation. Therefore, based on these results, it is hoped that local governments whose inflation rates are not calculated can adopt commodity packages and weight diagrams from regions that are included in the same cluster whose inflation rates are calculated. Additionally, when determining the minimum wage for regencies/cities, one of the references being the inflation rate, the inflation rate of regions within the same cluster can also be used. This study is subject to several limitations. One such limitation is the determination of the number of clusters based solely on the number of regencies or cities that have inflation calculations. Consequently, further research is recommended to employ a more suitable methodology in determining the optimal number of inflation clusters. Furthermore, the household consumption variable employed in this study is still in the form of total aggregate consumption. For future research, it is recommended to use more detailed consumption data per commodity, either from the National Socioeconomic Survey (SUSENAS) or the Cost of Living Survey (SBH), so that clusters can be formed with a higher level of accuracy and are able to reflect interregional inflation patterns more comprehensively.

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