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Application of Principal Component Method Analysis in Identifying Factors that Influence the Occurrence of Inflation in the Bandung City in 2023

Muklas Rivai[1], Elifas Hani Christien Saragih[2], K. Haris Chandra Sumarta[3], Larasyaty Dwynanda AR[4], M. Arief Lubis[5], M. Naufalatha[6], Nabila Mentari Putri[7]

[1] Lecturer of the Actuarial Science Study Program, Sumatra Institute of Technology, Indonesia
[2,3,4,5,6] Student of the Actuarial Science Study Program, Sumatra Institute of Technology, Indonesia

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ABSTRACT

This study discusses the city of Bandung which is one of the regions that has a fairly high contribution to the national inflation rate. Bandung City is the city with the third highest contribution to the formation of West Java inflation after Bogor City and Bekasi City. Based on BPS data (2009) the combined inflation that occurred in 3 cities in West Java Province (Bandung, Cirebon, Tasikmalaya) contributed 8.33% of national inflation. Because there are many factors behind inflation, research is conducted using principal component method to identify these factors. The principal component method is multivariate statistical analysis which can be used to reduce some of the original variables to new orthogonal variables while maintaining the total diversity of the original variables and correlating with others. The variables analyzed include Food, Beverages, and Tobacco (X1), Clothing and Footwear (X2), Housing, Water, Electricity, and Household Fuel (X3), Health (X4), Transportation (X5), Information, Communication, and Financial Services (X6), Food and Beverage / Restaurant Provision (X7), Personal Care and Other Services (X8). The results showed that there were 3 components formed from 8 variables analyzed, namely personal care factors and other services, health and housing, water, electricity and fuel.

Keywords : Inflation, Principal Component Method

I. INTRODUCTION

The main goal of all countries' economies is the welfare of society. However, in order to achieve societal well-being, there are several main problems, one of which is inflation. Inflation is a continuous and sustained process of rising prices of goods and services in a country over the long term. It can also occur when the increase in the price of one good is influenced by the increase in the price of another, due to the imbalance between the availability of goods and money [1]. The dynamics and development of the economy that impact the increase in demand for goods and services

in a limited economic capacity are one of the causes of inflation [2].

Inflation is a common issue experienced by all countries, including Indonesia. It is a common occurrence in the economy due to changes in the demand and supply of goods and services. When the demand for goods and services increases faster than their supply [3], it leads to an increase in prices from the demand side. Conversely, if there is an increase in production cost factors, it can drive an increase in prices from the supply side. One factor causing inflation is the consumer price index.

The consumer price index is an index that depicts the changes in the prices of goods and services consumed by the general population during a specific period with a predetermined time frame [4]. According to data from BPS (2014), the consumer price index calculates the average price changes in a period for a set of goods and services consumed by the population.

Bandung, as one of the cities in Indonesia with a large population and an area of 16,730 hectares, has 30 sub-districts with a population of over 2.4 million in the first semester of 2018. Based on data from the Central Statistics Agency (BPS) in 2022, the population of Bandung according to the 2021 population census is 2,527,854, consisting of 1,267,661 males and 1,260,193 females [6].

Bandung is one of the cities with the highest economic growth in West Java. In 2017, the economic growth rate of Bandung reached 7.21%, significantly higher than the economic growth of West Java at 5.29% and the national growth rate at 5.07% during the same period. However, this high economic growth is accompanied by a high inflation rate. Bandung contributes the third-highest to the inflation formation in West Java after Bogor and Bekasi [7]. According to BPS data in 2009, the combined inflation in three cities in West Java (Bandung, Cirebon, Tasikmalaya) contributed 8.33% to national inflation. In 2011, Bank Indonesia reported that three provinces—DKI Jakarta, West Java, and Banten—played a crucial role in the national inflation rate, contributing up to 47% to the overall national inflation [8].

II. METHODS AND MATERIAL

2.1 The theoretical foundation

Principal Component Analysis (PCA) is a multivariate statistical analysis used to reduce several original variables into new orthogonal variables while retaining the total variability of the original variables [9]. In its application, PCA is used to transform high-dimensional data sets into low-dimensional ones using the first few principal components, thereby reducing the data dimensions after conversion. According to the Kaiser Index, the number of important principal components is equal to the relative sum of eigenvalues of the matrix with values greater than 1. Principal Component Analysis is a method to find a new coordinate system, so that most of the data information is concentrated on a few coordinates, while the rest carry little information. After simplification, Principal Component Analysis will reveal that the orthogonal basis becomes the new basis.

2.1.1 Varians, Kovarians and Correlation

The sample mean is typically obtained from n measurements for each of the p variables. Therefore, there will be p sample means, namely [10].

$$\bar{X}_k = \frac{1}{n}\sum_{j=1}^{n} x_{jk}$$

In general, the measure of dispersion is represented by various examples, indicating n measurements of p variables, namely:

$$S_k^2 = \frac{1}{n-1}\sum_{j=1}^{n}(x_{jk} - \bar{X}_k)^2$$

Where $\bar{X}_k$ is the sample mean of x_{jk} and is the sample variance

$$S_{ik} = \frac{1}{n-1}\sum_{i=1}^{n}(x_{ik} - \bar{X}_k)(x_{ik} - \bar{X}_k)$$

The sample correlation coefficient for the i-th variable with the k-th variable is described as follows [11]:

$$r = \frac{s_{ik}}{\sqrt{s_{ii}}\sqrt{s_{kk}}} = \frac{\sum_{i=1}^{n}(x_{ik} - \bar{X}k)(x_{ik} - \bar{X}k)}{\sqrt{\sum_{j=1}^{n}(x_{ji} - \overline{x_i})^2}\sqrt{\sum_{j=1}^{n}(x_{jk} - \overline{x_k})^2}}$$

If the data is expressed in matrix form, it can be written as follows:

Sample mean:

$$\bar{X} = \begin{matrix} x1 \\ \dots. \\ xp \end{matrix}$$

Covariance matrix [12]:

$$S = \begin{bmatrix} s11 & s12 & \dots & s1p \\ \vdots & : & & \vdots \\ sp1 & sp2 & \dots & spp \end{bmatrix}$$

Correlation matrix:

$$S = \begin{bmatrix} 1 & s12 & \dots & s1p \\ \vdots & 1 & & \vdots \\ sp1 & sp2 & \dots & 1 \end{bmatrix}$$

2.1.2 Eigenvalues and Eigenvectors

If A is an n x n matrix, then a non-zero vector x in R^n is called an eigenvector of A if Ax is a scalar multiple of x, that is [12]:

$$A\underline{x} = \lambda\underline{x}$$

The scalar λ is called the eigenvalue of A, and x is referred to as the corresponding eigenvector for λ

2.1.3 Determining the Number of Principal Components

Three commonly used methods are employed to determine the number of principal components. The first method is based on the cumulative proportion of total variance explained. There is no standard threshold, with some suggesting 70%, 80%, or even 90%. The second method involves selecting principal components based on the eigenvalues, specifically values greater than 1. The third method utilizes a graphical approach known as a scree plot [11].

2.2 Data

In this study, secondary data is utilized, and the data coverage for the research is from the year 2023. The data is obtained from the Central Statistics Agency (Badan Pusat Statistik or BPS) through records or archives created and published by relevant institutions related to this research, accessible via internet-based information media, and will be processed using R-Studio software. There are 8 variables used in this study, namely Food, Beverage, and Tobacco ($X1$), Clothing and Footwear ($X2$), Housing, Water, Electricity, and Household Fuel ($X3$), Health ($X4$), Transportation ($X5$), Information, Communication, and Financial Services ($X6$), Provision of Food and Beverages / Restaurants ($X7$), Personal Care and Other Services ($X8$). This research employs 8 factors influencing inflation in the city of Bandung.

The table 2.2 below shows the data for the year 2023 obtained from the Central Statistics Agency (Badan Pusat Statistik or BPS) [12]. Here are the research data:

Table 2.2

Data Research

No.	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
1.	0,87	0,40	0,34	0,23	-0,71	0,00	0,33	0,80
2.	0,89	0,05	0,03	0,11	-0,01	0,00	0,33	0,97
3.	0,57	0,15	-6,36	0,20	0,34	0,00	0,45	1,27
4.	0,56	0,04	0,25	0,07	0,32	0,08	0,78	1,81
5.	0,37	-0,19	0,00	0,02	-0,14	0,00	0,78	2,08
6.	0,59	-0,07	0,10	0,00	-0,57	-0,03	0,78	1,82
7.	0,78	0,10	-0,16	0,25	0,26	0,00	0,78	1,96
8.	-0,06	0,06	-0,12	-0,01	0,07	-0,06	0,86	2,08
9.	0,06	0,07	-0,03	0,22	0,60	0,26	0,91	2,54

The research variables can be observed in the following table 2.2.1.

Table 2.2.1

Variables Research

Variables	Description
Y	Inflation
X_1	Food, Beverage, and Tobacco
X_2	Clothing and Footwear
X_3	Housing, Water, Electricity, and Household Fuel
X_4	Health
X_5	Transportation
X_6	Information, Communication, and Financial Services
X_7	Provision of Food and Beverages / Restaurants
X_8	Personal Care and Other Services

2.3 Research Procedure

The research procedure is as follows.

1. Collecting data from BPS Kota Bandung in the year 2023.
2. Describing the characteristics of the data using descriptive statistics.
3. Performing Principal Component Analysis with the following steps.

a. Determining the correlation matrix.
b. Determining eigenvalues.
c. Determining eigenvectors.
d. Determining the number of principal components, by choosing one of the following criteria.

1) Using eigenvalues > 1
2) Using cumulative variance proportion to the total.
3) Using a scree plot, where the number of components is selected at the point before the curve sharply declines or begins to plateau.

4. Interpreting the research results.
5. Drawing conclusions and recommendations from the research findings.

III. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

The following table 3.1 shows the descriptive statistics of the research variables obtained from the analysis results.

Table 3.1
Descriptive Statistics

No.	Variable	Min.	Maks.	Mean	St.Dev
1.	X_1	-0.0600	0.8900	0.5144	1.9133
2.	X_2	-0.19000	0.40000	0.06778	1.4375
3.	X_3	-6.3600	0.3400	-0.6611	1.0462
4.	X_4	-0.0100	0.2500	0.1211	0.7431
5.	X_5	-0.71000	0.60000	0.01778	0.5735
6.	X_6	-0.06000	0.26000	0.02778	0.4758
7.	X_7	0.3300	0.9100	0.6667	0.2646
8.	X_8	0.800	2.540	1.703	0.0089

Based on Table 1, the standard deviation is an interpretation of the amount of variation in the data. In other words, if the standard deviation value is larger, the mean value represents poor data representation, indicating higher variability in the data, and vice versa.

3.2 Determining Correlation

The correlation matrix is used to measure the strength of the relationship between two variables. Therefore, Table 3.2 below is the correlation matrix between indicators obtained from the analysis results.

Table 3.2
Correlation Matrix

Variable	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	1.0000	0.3566	-0.0281	0.3749	-0.4203	-0.3232	-0.7319	-0.7727
X_2	0.3566	1.0000	-0.1588	0.6835	-0.1677	0.0244	-0.5751	-0.5897
X_3	-0.0281	-0.1588	1.0000	-0.2748	-0.3160	0.1120	0.3162	0.2401
X_4	0.3749	0.6835	-0.2748	1.0000	0.2739	0.4144	-0.3488	-0.2392
X_5	-0.4203	-0.1677	-0.3160	0.2739	1.0000	0.5808	0.3947	0.5112
X_6	-0.3232	0.0244	0.1120	0.4144	0.5808	1.0000	0.3301	0.4622
X_7	-0.7319	-0.5751	0.3162	-0.3488	0.3947	0.3301	1.0000	0.9697
X_8	-0.7727	-0.5897	0.2401	-0.2392	0.5112	0.4622	0.9697	1.0000

Based on the above Table 3.2, there are variables that exhibit both positive and negative covariances. However, in this study, there are no variables that are not linearly related to each other (covariance = 0). However, the covariance values of some variables are

very small and nearly approach 0, indicating that there is no strong relationship between those variables.

3.3 Determining Eigenvalues

Table 3.3 below shows the results of the eigenvalue decomposition obtained from the analysis.

Components	eigenvalue	Proportion of Variance (%).	Cumulative Proportion (%).
1	3.6609	0.4576	0.4576
2	2.0664	0.2583	0.7159
3	1.0947	0.1368	0.8528
4	0.55233	0.06904	0.92182
5	0.32891	0.04111	0.96293
6	0.22642	0.0283	0.9912
7	0.07005	0.00876	0.99999
8	0.00008	0.000010	1.000000

Table 3.3 indicates that there are 8 variables or components analyzed in this factor analysis. For components 1 to 3, the eigenvalues are > 1, and their cumulative proportion is 85.28%. Meanwhile, for components 4 to 8, the eigenvalues are < 1.

3.4 Determining Eigenvectors

Table 5 below shows the results of the eigenvector calculation using varimax rotation obtained from the analysis.

Variables	Components.							
	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
X_1	-0.4322	0.0369	0.1545	0.6575	-0.3208	0.0382	0.4485	0.2233
X_2	-0.3525	-0.3237	0.2387	0.6556	-0.0853	0.2332	0.3998	0.2484
X_3	0.1287	0.2846	0.8127	0.0819	0.0250	0.4269	-0.2245	-0.0416
X_4	-0.2109	-0.5801	0.2019	0.0490	-0.4525	0.2101	-0.5096	-0.2588
X_5	0.2742	-0.4798	-0.2764	0.2805	-0.0015	0.7331	0.0423	0 .0137
X_6	0.2307	-0.4905	0.3563	0.1930	0.5895	0.3601	0.2539	-0.0121
X_7	0.4920	0.0377	0.0993	-0.1082	-0.4726	0.1008	0.4988	-0.5023
X_8	0.5065	-0.0618	0.0668	-0.0315	-0.3367	0.2007	-0.1164	0.7529

Based on the eigenvector results, component 1 absorbs the majority of all variables, component 2 absorbs most of the remaining variance after absorbing component 1, and so on.

3.5 Scree Plot

In addition to eigenvalues and cumulative proportions, to determine the number of components formed, we can also examine its scree plot. Figure 3.5 below shows the results of the scree plot obtained from the analysis.

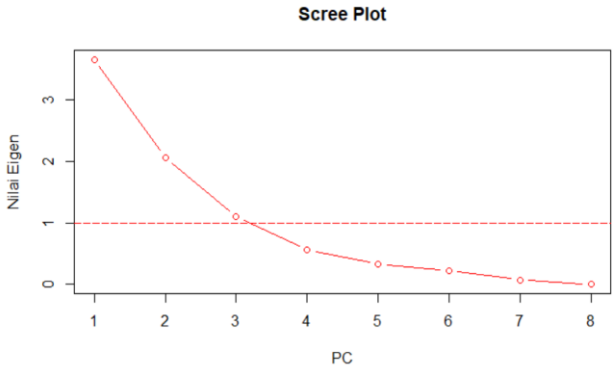

Figure 1: Scree Plot

3.6 Determining the Number of Principal Components

In this study, the criterion used to determine the principal components is based on the cumulative proportion values. Therefore, we select 3 components as they can explain a variance of 85.28% or equivalently 85%. Moreover, if the cumulative proportion approaches 100%, the information generated will be more accurate.

3.7 Principal Component Equations

After obtaining the 3 principal components selected, the next step is to create the equations for the principal components using the loadings syntax, which represents the coefficients of the principal component equations. Table 3.7 below shows the loading results, which are the coefficients of the principal components obtained from the analysis.

Table 3.7
coefficients of the principal components

Variables	Components.		
	K_1	K_2	K_3
X_1	0.432		0.155
X_2	0.354	-0.324	0.239
X_3	-0.129	0.285	0.813
X_4	0.211	-0.580	0.202
X_5	-0.274	-0.480	-0.276
X_6	-0.231	-0.491	0.356
X_7	-0.492		
X_8	-0.507		

From Table 3.7, the equations for the formed principal components are as follows:

1) $\boldsymbol{KU_1 = 0.432X_1 + 0.352X_2 - 0.129X_3 + 0.211X_4 - 0.274X_5 - 0.231X_6 - 0.492X_7 - 0.507X_8}$
2) $\boldsymbol{KU_2 = -0.324X_2 + 0.285X_3 - 0.580X_4 - 0.480X_5 - 0.491X_6}$
3) $\boldsymbol{KU_3 = 0.155X_1 + 0.239X_2 + 0.813X_3 + 0.202X_4 - 0.276X_5 + 0.356X_6}$

3.8 Interpretation of Equation Results

Interpreting the results of the principal component equations can be done by examining the correlation values between the formed principal components and the original variables. Table 3.8 below shows the correlation values obtained from the analysis.

Table 3.8
correlation values

Variables	Components		
	K_1	K_2	K_3
X_1	0.8269	0.0531	0.1617
X_2	0.6764	-0.4654	0.2498
X_3	-0.2463	0.4091	0.8503
X_4	0.4035	-0.8340	0.2112
X_5	-0.5246	-0.6897	-0.2891
X_6	-0.4414	-0.7052	0.3728
X_7	-0.9415	0.0541	0.1039
X_8	-0.9691	-0.0888	0.0698

In interpreting the formation of principal components, it is based on the absolute correlation values between the principal components and the original variables. Thus, from Table 3.8, it is obtained that for the first principal component, the original variable with the largest absolute correlation value is variable X_8. For the second principal component, the original variable with the largest absolute correlation value is variable X_4. Finally, for the third principal component, the original variable with the largest absolute correlation value is variable X_3.Therefore, the interpretation of each principal component is as follows: Personal Care and Other Services, Health, and Housing, Water, Electricity, and Household Fuel.

IV. CONCLUSION

This research utilized the principal component analysis method to identify factors influencing inflation in the city of Bandung in 2023. The analysis results indicated three main factors that significantly contributed to the inflation rate, namely personal care and other services, health, and housing, water, electricity, and household fuel factors.

V. SUGGESTIONS

The results of this research are expected to contribute to the understanding of inflation in the city of Bandung and its influencing factors. Particularly for those interested in using this method for research, it is essential to ensure that the data used in the analysis is current and of high quality. There may be a need for modifications to the independent variables, either by adding variables or extending the time series data, to make the research more objective and varied. Additionally, it is recommended for the government and related institutions to take strategic measures in managing prices for personal care and other services, improving access to healthcare services, and monitoring the housing, water, electricity, and household fuel markets to maintain economic stability

in the city. With the implementation of appropriate policies, it is hoped that a stable inflation rate can be achieved as a foundation for the development of more effective and sustainable economic policies in the future.

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