Mathematical Study: The consumer price index in the expenditure sub group using factor analysis

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Abstract. Inflation is very important monetary event and is often found in almost all countries in the world. In this research, it will be known what factors influence the inflation rate of Central Java in 2019. The method used is the Factor Analysis method with the Principal Component Analysis technique. Factor Analysis is one of the interdependent multivariate analysis techniques by reducing data to create a new variable (called a factor) and conducting an independent variable analysis into variables that correlate with other variables in the factor. The results of this factor analysis research, obtained two factors formed from 11 variables (expenditure sub-groups) with the largest contributor to inflation in Central Java in 2019. Factor 1 consists of Preserved Fish variable (X1), vegetables variable (X2), Fruits variable (X3), Seasonings variable (X4), and Non-Alcoholic Drinks variable (X5). Furthermore, this factor is named foods and beverages factor. Meanwhile, factor 2 consisted of Tobacco and Alcoholic Beverage variable (X6), Household Management variable (X7), Education Services variable (X8), Educational Equipment variable (X9), Courses/Training variable (X10), and Support Facilities for Transport variable (X11), was then given the name of the Tobacco, Services and Facilities factor.

Keyword: Inflation, factor analysis, consumer price index,

1. Introduction

Inflation is a monetary event that is used as a measure of a country's progress. Inflation has an influence on economic growth [1, 2]. Inflation is analyzed regionally, nationally, and internationally. Global inflation analysis is carried out to determine the development of the world economy. Several global inflation analyzes such as modeling the effect of global factors on inflation trends [3], the effect of inflation and investment on GDP in 76 countries [4], analysis of sources of inflationary pressure that affect inflation expectations and actual inflation [5], analysis of inflation in the future. through the relationship between inflation expectations and actual inflation [6], evaluating the inflation target [7], analyzing the relationship between the inflation target and inflation deviation [8], analyzing the effect of inflation on investment [9].

Inflation analysis is also carried out nationally. An analysis of inflation in a country needs to be carried out to prevent and control inflation, to determine the causes of inflation, and as a basis for economic policy making to prevent an economic crisis, to maintain economic stability and to ensure the welfare of society. Inflation is studied from various aspects because inflation has a major impact on a country's economy. Country-specific inflation studies, including analysis of inflation dynamics in Turkey [10], analysis of oil price dynamics and inflation expectations in New Zealand and Great
Inflation is influenced by several factors, including the exchange rate [15 – 17], oil prices [18, 19], and the Consumer Price Index (CPI) [20 – 24]. The Consumer Price Index (CPI) has a big influence on the inflation rate, even the rate of change in the CPI is equated with the inflation rate [25]. CPI becomes an indicator to measure the inflation rate. CPI changes are modeled to determine the characteristics and extreme values of the CPI [26]. According to Unayama, if inflation approaches zero, the CPI will approach the cost of living index [27]. CPI can describe the pattern of public consumption, with the aim of a balance between production and consumption that occurs, where it is said to be inflation when there is an increase, and it is said to be deflation if there is a decrease.

Inflation tends to occur in developing countries, such as Indonesia. Indonesia, had experienced extraordinary inflation in 1966 (old order), at which time inflation reached 635%. However, slowly stabilizing in 1968, inflation fell to 112%, and in 1974 – 1975 inflation was 21%. At the beginning of 1998, Indonesia experienced another extraordinary economic shock. The drop in the rupiah against the dollar touched an all-time high of Rp. 16,650 per US dollar in June 1998. In the 2005-2014 period, Indonesia's annual inflation averaged around 8.5%.

Inflation, in Indonesia context is considered as more stable after monetary crisis in 1998. But, if compared with another developing state, Indonesia has more higher inflation rate average. In recent decade, highest inflation rate in Indonesia reach 11.06% in 2008 [28]. In 2019 the inflation rate in Indonesia was 2.72% and inflation in Central Java was 2.81% [29]. Inflation in Central Java is higher than national inflation but not much different from national inflation. Inflation in Central Java in 2019 was lower than inflation in 2018, which was 2.82% meaning that inflation in Central Java does not impact too much on national inflation rate. This inflation rate is in accordance with the inflation target set by Bank Indonesia of 3.5 ± 1%.

As in other countries, the indicator that is often used to measure the inflation rate is the Consumer Price Index (CPI). Changes in the CPI from time to time indicate price movements of packages of goods and services consumed by the public. The main use of the CPI is to assess the purchasing power of money. As prices increase, the true value of money or purchasing power decreases so that it can only buy smaller quantities of the same good or service. Trade unions/workers and employers use the CPI in negotiating wages and salaries. The CPI is also used as the basis for calculating the true value of household expenditures, payments to beneficiaries under social welfare or public assistance schemes [30].

Changes in the CPI from time to time show fluctuations in the price of a package of goods and services consumed by the public, where inflation occurs if there is an increase and deflation if there is a decrease. Another thing related to CPI and inflation is the fact that price stability is a barometer of the stability of real economic growth, because controllable inflation will guarantee an increase in people's purchasing power from time to time. However, prices in Indonesia (including in Central Java) are very volatile. At certain times, the prices of basic necessities rise and fall depending on the supply of these goods [30]. In addition, the CPI data can further illustrate the pattern of public consumption, with the aim of a balance between production and consumption that occurs. Consumer Price Index is a number that describe a comparison of consumer price that has been occured on two different time periods [30].

Every year the Central Statistics Agency/Badan Pusat Statistik (BPS) in Indonesia conducts a study on the rate of inflation in the regions and nationally. CPI is universally accepted as a general indicator of inflation because it helps policy makers to identify sources of inflation so that they can formulate economic policies. BPS uses CPI data to determine the rate of inflation in Indonesia, including in Central Java. This index is the main indicator in determining what factors affect the inflation rate in Central Java. The selection of the types of goods/services (commodity packages) in the CPI for each city is based on the results of the Cost of Living Survey (CLS).

Since January 2014, the calculation of CPI in Indonesia is based on the results of the 2012 Cost of Living Survey (CLS) which was conducted in 82 cities in Indonesia (33 provincial capitals and 49
The Cost of Living Survey (CLS) lists household expenditures, both consumption and non-consumption, with the aim of obtaining an overview of people's consumption patterns which change over time. The value of household consumption from CLS is used as the basis for selecting commodity packages and for preparing weigh diagrams in calculating inflation with the new base year. Of the 82 cities in the Cost of Living Survey (CLS), 6 of them are Consumer Price Index (CPI) cities in Central Java. Therefore, the CPI for Central Java Province is calculated based on the aggregation of the 6 cities, namely Cilacap, Purwokerto, Kudus, Surakarta, Semarang, and Tegal. The selection of the sample cities is based on the level of development in the economy which is relatively fast when compared to other cities. The determination of the consumer price index (CPI) sample in Indonesia does not cover rural areas [31].

In Central Java, CPI is calculated based on CLS for 7 expenditure groups, 35 expenditure sub-groups, and 266 - 417 commodities [30]. Based on the CPI data, the inflation rate in Central Java will be known. Of the 7 expenditure groups, 35 expenditure sub-groups, and 266 - 417 commodities, it will also be known which ones contributed to the inflation in Central Java.

The CPI calculation involves 7 expenditure groups, 35 expenditure sub-groups, and 266 - 417 commodities. There are many expenditure and commodity sub-groups that are variables in determining the CPI. These many variables can be explained and described more simply using factor analysis. Factor analysis is used to reduce data or summarize, from the old variables which have been changed to a few new variables called factors, and still contain most of the information contained in the original variables [32]. Factor analysis is used to determine the grouping of expenditure sub-groups on the CPI which affects the inflation rate in Central Java in 2019. In this study, the grouping was carried out on the expenditure sub-group variables, which amounted to 35 variables. However, only 11 variables used in this study have the largest inflation rate in Central Java in 2019. This is done so that the eigenvalue of the correlation matrix is positive and the factor analysis process can be carried out.

There are many variables in the expenditure sub-group that affect the inflation rate in Central Java. The variables could be simplified into several factors using factor analysis to find the dominant factor influencing the inflation rate. The variable grouping is intended to simplify the description of the dominant factors affecting the inflation rate. Therefore, this study aims to identify the dominant factors in influencing the Central Java inflation rate in 2019 based on the 11 expenditure sub-group variables that have the largest inflation value.

2. Method
In this research, data that has been used is Consumer Price Indeks data on expenditure sub group in Central Java on 2019. This data is a secondary data which obtained from official publication of Central Statistic Agency/Badan Pusat Statistik (BPS) Central Java 2020. Expenditure sub group data which used in CPI calculation has 35 variables. CPI is calculated per month from January to December so that there are 12 CPIs in each expenditure sub-group in 2019. Because the CPI calculation data amounts to 12, the expenditure sub-group variables to be grouped using factor analysis must be less than 12 variables. This is done so that the eigenvalue of the correlation matrix is positive. Eigenvalue values that are not positive numbers make the correlation matrix nonpositive definite. An eigenvalue value that is less than zero causes the data feasibility test using the Bartlett’s test of sphericity and the Kaiser-Meyer-Olkin (KMO) test cannot be processed, which means that factor extraction cannot be performed. Therefore, in this study only 11 expenditure sub-group variables were used that had the largest inflation rate in Central Java in 2019.

This type of research is quantitative research. The research variables used 11 expenditure sub groups, namely as in Table 1. In this study, the data analysis method used is the factor analysis method. The following are the stages in Factor Analysis:
2.1 Formulating Problems
Problem formulation in factor analysis must be identified for determining the research purposes. After that, another step is to determine the variables, in this case is expenditure sub groups. There are 11 expenditure sub groups that used in this factor analysis.

2.2 Data Feasibility Test
The 11 variables data of expenditure sub-groups used in the factor analysis must have a strong correlation between one variable and another so that it can be grouped. The correlation matrix was formed by looking for the simple correlation coefficient between the 11 subgroups of observed expenditures [33].

Table 1. Variable names of expenditure sub groups

| No | Variable Name                          | Inflation Rate (%) |
|----|----------------------------------------|--------------------|
| 1  | Preserved Fish ($X_1$)                 | 6.31               |
| 2  | Vegetables ($X_2$)                     | 7.43               |
| 3  | Fruits ($X_3$)                         | 7.24               |
| 4  | Seasonings ($X_4$)                     | 28.71              |
| 5  | Non-Alcoholic Drinks ($X_5$)           | 3.73               |
| 6  | Tobacco and Alcoholic Beverages ($X_6$)| 4.27               |
| 7  | Household management ($X_7$)           | 4.59               |
| 8  | Education Services ($X_8$)             | 3.27               |
| 9  | Educational Equipment ($X_9$)          | 3.06               |
| 10 | Courses/Training ($X_{10}$)            | 6.58               |
| 11 | Support Facilities for Transport ($X_{11}$) | 5.48            |

The data feasibility test aims to determine whether the data from the 11 expenditure sub-groups used are sufficient to meet the requirements in the factor analysis. The feasibility test of the data used the Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) test.

Bartlett's test of sphericity was used to test whether the 11 subgroups of data formed a correlation matrix or an identity matrix. If the results of Bartlett's test of sphericity are significant, the matrix formed is the correlation matrix. This means that there is a correlation between the 11 established expenditure sub groups. In other words, the grouping for the 11 expenditure sub-groups has meaning and benefits.

Statistical Test for Bartlett's test is

$$
\chi^2 = -\left[(N-1) - \left(\frac{2p+5}{6}\right)\right] \ln|R|
$$

with degree of freedom (df) = \(\frac{p(p-1)}{2}\), where \(N\) is number of observations, \(p\) is number of variables, and \(|R|\) is determinant from correlation matrix.

The KMO test is useful for measuring the feasibility of a sample. The KMO test statistic determines whether the data on 11 expenditure sub-groups is appropriate for factor analysis. The KMO Test Formula is:

$$
KMO = \frac{\sum r_{ij}^2}{\sum r_{ij}^2 + \sum a_{ij}^2}
$$

where \(r_{ij}\) is simple correlation coefficient between variables \(X_i\) and \(X_j\) and \(a_{ij}\) = partial correlation coefficient between variables \(X_i\) and \(X_j\).
The Keizer-Meyer-Olkin (KMO) value criteria are very good (KMO value $\geq 0.9$), useful (KMO value $0.8 \sim 0.89$), ok (KMO value $0.7 \sim 0.79$), adequate (KMO value $0.6 \sim 0.69$), bad (KMO value $0.5 \sim 0.59$), and unaccepted (KMO value $\leq 0.5$).

2.3 Extracting Factor
Data that has been feasible for factor analysis is then analyzed by extracting or reducing variables (partially). Factor extraction is used to reduce the 11 expenditure sub-groups to produce a smaller number of factors but can explain the correlation between the 11 expenditure sub-groups. In factor analysis, there are two extraction methods, namely Principal Component Analysis (PCA) and Confirmatory Factor Analysis (CFA) methods. In this study, the method used is Principal Component Analysis. Principal Component Analysis aims to reduce variables and interpret them as new variables in the form of variable forms. Principal Component Analysis is done by determining the value of communalities from the 11 expenditure sub-group variables. According to Santoso [34], the value of communality is the amount of variance that can be explained by a formed factor. The greater the value of communality, the more closely the relationship between the factors that are formed and the variables contained therein. If the variable communality value is above 0.5 then the variable is not reduced because the variable can have a strong correlation with the formed factors.

2.4 Determining the Number of Factors
The determination of the number of factors is based on the eigen value of each factor that appears. Eigen value is the number of variants described by each factor. Factors with Eigen value $\geq 1$ are feasible factors and are formed factors.

2.5 Rotating Factors
After the factors are formed, then look for which variables from the 11 expenditure sub-groups that are part of a certain factor and how much correlation is each one by forming a factor matrix or component matrix. If each variable has a strong correlation with a certain established factor, factor rotation is not necessary. But if there are variables that have a strong correlation with several factors so that it is difficult to interpret the factors, then factor rotation is carried out. Factor rotation is carried out if the factor extraction method has not produced a sufficiently clear factor component. The factor rotation clarifies and reinforces the loading factor in each factor. The aim is to obtain a factor structure that is easier to interpret and simpler. The factor rotation method used in this study is the Varimax Method. The Varimax Method is an orthogonal rotation method to minimize the number of indicators that have a high factor loading for each factor.

2.6 Interpreting Factor
After getting a number of formed factors, the next step is, to interpret factor names. The factor interpretation is carried out by knowing which variables from 11 expenditure sub-group that form the factor.

3. Results and Discussion

3.1 Data Feasibility Test
The results of the data feasibility test use the KMO and Bartlett's Test as in Table 2. The results in Table 2 indicate that the KMO value is 0.711. Based on the Keizer-Meyer-Olkin Criteria, the value is in the range 0.7 – 0.8 with “ok” category. The significance value (sig.) Of Bartlett's Test of Sphericity is 0.000 $< 0.05$. The results of KMO and Bartlett's Test of Sphericity show that the correlation matrix formed is not an identity matrix, so the results of this test show that the data from the 11 expenditure sub-groups are feasible for factor analysis.
Table 2. Result of KMO and Bartlett’s Test

|                      | Initial | Extraction |
|----------------------|---------|------------|
| Preserved Fish       | 1.000   | 0.962      |
| Vegetables           | 1.000   | 0.979      |
| Fruits               | 1.000   | 0.923      |
| Seasonings           | 1.000   | 0.878      |
| Non Alcoholic Drinks | 1.000   | 0.954      |
| Tobacco and Alcoholic Beverages | 1.000 | 0.879 |
| Household Management | 1.000   | 0.977      |
| Education Services   | 1.000   | 0.971      |
| Educational Equipment| 1.000   | 0.928      |
| Courses/Training     | 1.000   | 0.933      |
| Support Facilities for Transport | 1.000 | 0.945 |

3.2 Extracting Factor

Communalities value from CPI data with 11 expenditure sub group variables is shown in Table 3. The value of communality is obtained from the number of squares in each factor loading of a variable. Based on Table 3, the Preserved Fish variable has a communality value of 0.962. This means that about 96.2% of the variance of these variables can be explained by the formed factors. Furthermore, the Vegetables variable has a communality value of 0.979; The Fruits variable has a communality value of 0.923 and so on.

The results of the data feasibility/adequacy test and the output processing of the extraction results from 11 sub-groups of expenditures can be interpreted that all variables have a community value above 0.5. This shows that the 11 existing expenditure sub-group variables can explain the factors and it is feasible to carry out further processing of factor analysis. In other words, each variable can have a strong correlation with the formed factors. So, from the results of this factor extraction process, no variables are reduced/eliminated (all variables are eligible for further factor analysis).

3.3 Determination of the Number of Factors

The number of factors formed is determined based on the eigenvalue as shown in Table 4. The eigenvalue can be seen in the Total column at initial eigenvalue. Factors with eigenvalue ≥ 1 are feasible factors and factors that are formed. From the result of initial eigenvalue in Table 4, it is known that only 2 component factors are formed. The eigenvalue of the first factor is 8.928 and the second factor is 1.401. For the third to eleventh factors, because the value is < 1, these factors cannot form a factor or cannot interpret the variables contained therein. Another way to see the factors that are formed is to look at the eigenvalue on the scree plot graph as shown in Figure 1.
Table 4. Total Variance Explained

| Component | Initial Eigenvalues | Extraction Sums of Squared Loadings |
|-----------|---------------------|-------------------------------------|
|           | Total               | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1         | 8.928               | 81.161       | 81.161       | 8.928 | 81.161       | 81.161       |
| 2         | 1.401               | 12.738       | 93.899       | 1.401 | 12.738       | 93.899       |
| 3         | 0.334               | 3.039        | 96.939       | 0.334 | 3.039        | 96.939       |
| 4         | 0.201               | 1.829        | 98.767       | 0.201 | 1.829        | 98.767       |
| 5         | 0.075               | 0.682        | 99.450       | 0.075 | 0.682        | 99.450       |
| 6         | 0.031               | 0.283        | 99.733       | 0.031 | 0.283        | 99.733       |
| 7         | 0.023               | 0.211        | 99.943       | 0.023 | 0.211        | 99.943       |
| 8         | 0.005               | 0.046        | 99.989       | 0.005 | 0.046        | 99.989       |
| 9         | 0.001               | 0.005        | 99.994       | 0.001 | 0.005        | 99.994       |
| 10        | 0.001               | 0.005        | 99.999       | 0.001 | 0.005        | 99.999       |
| 11        | 0.000               | 0.001        | 100.000      | 0.000 | 0.001        | 100.000      |

From the graph, it can be seen that the components/factors that have an eigenvalue ≥ 1 are found in components 1 and 2. In other words, 2 factors are formed.

3.4 Rotating Factor

Results for component matrix is shown on Table 5. Based on results in Table 5 it can be shown that on first component/factor there are 10 variables that have high correlation value. On the other side, for second component/factor, there is only 1 variable that has high correlation value. The value
of the correlation of these variables is also referred to as factor loading, namely the simple correlation of a variable to a factor. Of the 11 variables, it turns out that all of them have very strong correlations ranging from 80 – 100% and 1 variable has a strong correlation, 0.721. However, the results of the component matrix do not clearly indicate which factor is the position of the variables. Therefore, the matrix rotation is carried out to clarify the position of a variable against the formed factors. The result of the rotation of the matrix is shown in Table 6.

**Table 5. Component Matrix**

| Variables                          | Component 1 | Component 2 |
|-----------------------------------|-------------|-------------|
| Preserved Fish                    | 0.962       | 0.191       |
| Vegetables                        | 0.677       | 0.721       |
| Fruits                            | 0.916       | 0.289       |
| Seasonings                        | 0.811       | 0.471       |
| Non Alcoholic Drinks              | 0.963       | 0.162       |
| Tobacco and Alcoholic Beverages   | 0.919       | -0.187      |
| Household Management              | 0.987       | -0.056      |
| Education Services                | 0.904       | -0.393      |
| Educational Equipment             | 0.917       | -0.294      |
| Courses/Training                  | 0.904       | -0.339      |
| Support Facilities for Transport  | 0.908       | -0.346      |

**Table 6. Rotated Component Matrix**

| Variables                          | Component 1 | Component 2 |
|-----------------------------------|-------------|-------------|
| Preserved Fish                    | 0.645       | 0.739       |
| Vegetables                        | 0.096       | 0.985       |
| Fruits                            | 0.549       | 0.788       |
| Seasonings                        | 0.354       | 0.868       |
| Non Alcoholic Drinks              | 0.664       | 0.717       |
| Tobacco and Alcoholic Beverages   | 0.841       | 0.413       |
| Household Management              | 0.815       | 0.558       |
| Education Services                | 0.956       | 0.241       |
| Educational Equipment             | 0.906       | 0.327       |
| Courses/Training                  | 0.923       | 0.284       |
| Support Facilities for Transport  | 0.931       | 0.281       |

Determining a variable to be a member of a particular factor by selecting the largest factor loading for each factor/component. The largest loading factor value of a variable if it is more inclined to a certain factor, then the variable becomes a member of that factor. The results of the rotated Component Matrix in Table 6 show that 2 factors are formed from the expenditure sub-group. Factor 1 consists of 5 variables, namely Preserved Fish ($X_1$), Vegetables ($X_2$), Fruits ($X_3$), Seasonings ($X_4$), and Non-Alcoholic Drinks ($X_5$). Factor 2 consists of 6 variables, namely Tobacco and Alcoholic Beverages ($X_6$), Household Management ($X_7$), Education Services ($X_8$), Educational Equipment ($X_9$),
Courses/Training ($X_{10}$), and Support Facilities for Transport ($X_{11}$). The Result of component transformation matrix is shown in Table 7.

| Component | 1     | 2     |
|-----------|-------|-------|
| 1         | 0.792 | 0.611 |
| 2         | -0.611| 0.792 |

Table 7. Component Transformation Matrix

In the Component Transformation Matrix table above, Component/factor 1 has a correlation of 0.792 and Component/factor 2 has a correlation of 0.792. Each correlation value of factor 1 and factor 2 is more than 0.5, meaning that the two factors formed are able to explain the 11 existing variables.

3.5 Factor Interpretation

Interpretation of analysis factor result is based on value of factor loading, from 11 expenditure sub group is arranged on 2 factor that could affect the inflation rate in Central Java in 2019 based on Consumer Price Index (CPI) indicator, namely:

1. Factor 1 consists of 5 variables which is Preserved Fish ($X_1$), Vegetables ($X_2$), Fruits ($X_3$), Seasonings ($X_4$), and Non-Alcoholic Drinks ($X_5$). Based on variable the Factor 1, This factor is named as food and beverages factor.

2. Factor 2 consists of 6 variables which is Tobacco and Alcoholic Beverages ($X_6$), Household Management ($X_7$), Education Services ($X_8$), Educational Equipment ($X_9$), Courses/Training ($X_{10}$), and Support Facilities for Transport ($X_{11}$). Based on variable on Factor 2, this Factor is named Tobacco, Services and Facilities factor.

So, there are two factors that affect the inflation rate in Central Java in 2019, namely factor 1 (the foods and beverages factor) and factor 2 (the Tobacco, Services and Facilities factor). Factor 1 has a total variance of 81.161% and factor 2 has a total variance of 12.738%, meaning that factor 1 is able to explain 81.161% of the total variance and factor 2 is able to explain 12.738% of the total variance. The two factors that were formed were able to explain 93.899% of the 11 existing variables. The dominant factor that affects the inflation rate in Central Java in 2019 is the foods and beverages factor.

4. Conclusion

There are two factors that affect the inflation rate in Central Java in 2019, namely factor 1 (the foods and beverages factor) and factor 2 (the Tobacco, Services and Facilities factor). These two factors are formed from 11 variables in the expenditure sub-group on the consumer price index. Factor 1 consists of 5 variables which is Preserved Fish ($X_1$), Vegetables ($X_2$), Fruits ($X_3$), Seasonings ($X_4$), and Non-Alcoholic Drinks ($X_5$). Factor 2 consists of 6 variables which is Tobacco and Alcoholic Beverages ($X_6$), Household Management ($X_7$), Education Services ($X_8$), Educational Equipment ($X_9$), Courses/Training ($X_{10}$), and Support Facilities for Transport ($X_{11}$). Factor 1 has a total variance of 81.161% and factor 2 has a total variance of 12.738%. The two factors that were formed were able to explain 93.899% of the 11 existing variables. The dominant factor that affects the inflation rate in Central Java in 2019 is the foods and beverages factor.

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